Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 29(3): 881 – 896 (2025)
www.ejabf.journals.ekb.eg

Morphometric Characteristics, Length-Weight Relationship, and Absolute Abundance of *Cerithidea cingulata* from the Mangrove Forest of Brgy. Ubagan, Sto. Tomas, La Union, Philippines

Marjorie M. Ramirez[1*], Ricardo A. De Guzman[1, 2], Gedielyn A. Paje[1, 3], John Nicolo V. Rojo[1], Isaias B. Mabana[1], Alvin T. Reyes[1]

[1]College of Fisheries-Central Luzon State University, 3119 Science City of Muñoz, Philippines
[2]Pangasinan State University-Binmaley Campus, 2417 Binmaley, Pangasinan, Philippines
[3]Department of Agriculture-Bureau of Fisheries and Aquatic Resources Region 2, 3500 Tuguegarao City, Cagayan, Philippines

[*]**Corresponding Author: marjorie.ramirez@clsu2.edu.ph**

ARTICLE INFO

Article History:
Received: Nov. 28, 2024
Accepted: April 24, 2025
Online: May 18, 2025

Keywords:
Abundance,
Gastropod,
Length-weight relationship,
Mangrove forest

ABSTRACT

Cerithidea cingulata is a gastropod species commonly found in the mangrove forest of Brgy. Ubagan, Sto. Tomas, La Union. This study examined the morphometric characteristics, length-weight relationship, and absolute abundance of the species to better understand its growth patterns and ecological dynamics. Among the morphometric characteristics, only diameter of the operculum, length of the body whorl, and length of the hump body whorl displayed a significant relationship with shell length (P<0.01). Linear regression analysis revealed a significant positive correlation between length and weight (b=1.79, P<0.001) with a negative allometric growth pattern (b<3). *C. cingulata* was abundant in the studied mangrove forest with a substantial estimated total stock ($\bar{x}$=21). However, the wide confidence interval highlights the need for careful interpretation and further research to refine estimates and better understand population dynamics. Information on growth patterns and relationships is essential for assessing the health of populations within mangrove habitats. Monitoring gastropod populations over time is necessary for assessing their ecological role and ensuring the health of mangrove ecosystems.

INTRODUCTION

Mangrove ecosystems are vital coastal habitats that provide a range of ecological functions including carbon sequestration, habitat provision for numerous species and shoreline protection **(Lee *et al.*, 2014; United Nations, 2022; Richard, 2024)**. Mangroves are known as highly effective carbon sinks, capable of storing substantial amounts of carbon dioxide from the atmosphere. The unique structure of mangrove roots anchored in waterlogged soils captures the organic material and nutrients from tidal flows. This process enriches the sediment and enables mangroves to impound carbon in both biomass and the underlying soil. The slow decomposition rates in anaerobic conditions beneath mangroves further enhance the retaining of carbon for extended periods. Thus, mangroves are crucial in mitigating climate change by reducing atmospheric carbon levels **(Kumar *et al.*, 2021; Akram *et al.*, 2023b; Dhaliwal, 2023; UNEP, 2023; Xiao *et al.*, 2023)**.

Moreover, mangrove forests serve as critical habitats for a diverse group of species, supporting more than 1,500 plant and animal species. They provide essential nursery grounds for juvenile fish and crustaceans, which rely on the complex root structures for shelter from predators. The intricate root systems not only offer physical habitat but also contribute to nutrient cycling by trapping organic matter that supports various trophic levels within the ecosystem Likewise, mangroves serve as nesting and feeding grounds for terrestrial wildlife, including birds and mammals **(Carrasquilla-Henao *et al.*, 2019; UNEP, 2023)**.

Mangroves also play a vital role in coastal protection by acting as natural barriers against storm surges, waves, and erosion. Their dense root systems stabilize shorelines and reduce the impact of extreme weather events such as hurricanes and tsunamis. Mangroves safeguard both human settlements and valuable infrastructure along coastlines by absorbing wave energy and reducing flooding risks **(Asari *et al.*, 2021; United Nations, 2022)**. These important functions of mangrove forests significantly contribute to environmental health, biodiversity, and human well-being **(Carugati *et al.*, 2018b)**. Hence, to sustain these significant functions, the preservation and conservation of this ecosystem is essential not only for maintaining biodiversity but also for supporting local economies and enhancing climate resilience **(Rahman *et al.*, 2023)**.

Gastropods play crucial roles as significant components of the food web in mangrove ecosystems. They function as primary consumers within the trophic structure, acting either as grazers or suspension feeders **(Jahid & Singh, 2021)**. The girdled horn shell (*Cerithidea cingulata*) is recognized as a native resident of mangrove areas, with a wide distribution in tidal flat regions across the Indo-Pacific, including the Philippines. It has been extensively studied in various ecosystems, highlighting its ecological importance **(Lantin-Olaguer & Bagarinao, 2001; Shafique *et al.*, 2015; Trianto *et al.*, 2023)**. *C. cingulata* serves as an important ecological indicator species in mangrove ecosystems, reflecting environmental conditions such as pollution levels **(Suwanjarat & Suwaluk, 2003)**.

As a deposit feeder, *C. cingulata* contributes significantly to nutrient cycling by breaking down organic detritus, which supports microbial communities and enhances ecosystem productivity **(Trianto *et al.*, 2023)**. In aquaculture settings, particularly in brackish water milkfish ponds, *C. cingulata* can become a pest due to its rapid population growth in the absence of natural predators, leading to densities ranging from 100 to 5,000 individuals per square meter **(Lantin-Olaguer & Bagarinao, 2001)**. This species reproduces year-round, with peak reproductive activity occurring between March and September when water temperatures are optimal (24 to 36°C). These snails reach sexual maturity at around 20mm in shell length. It has shown high tolerance to hypoxic conditions and can survive adverse environmental factors; however, it is susceptible to extreme salinities and certain chemical treatments **(Lantin-Olaguer & Bagarinao, 2001)**. Despite its pest status in aquaculture, *C. cingulata* has commercial value as it can be harvested for food and shell craft. Local communities often collect these snails for consumption or sale, providing an economic resource **(Lantin-Olaguer & Bagarinao, 2001)**. Interestingly, *C. cingulata* has been identified as an intermediate host for trematode parasites such as *Heterophyes heterophyes*, indicating its ecological significance beyond its role as a consumer within the food web **(Kalat-Meimari *et al.*, 2018)**.

Establishing comprehensive data on the length-weight relationship (LWR) contributes to scientific knowledge necessary for effective conservation strategies **(Cañada *et al.*, 2020)**. Examining the morphometric characteristics of a gastropod, including shell dimensions and shape enhance the understanding of its adaptations to the mangrove environment **(Trianto *et al.*, 2023)**. If information for expected weight at given lengths are provided, researchers can identify individuals that are underweight or overweight, which may signal environmental stressors or changes in food availability **(Rosli *et al.*, 2012; Abdul *et al.*, 2016)**. Additionally, monitoring changes in the abundance of species can serve as an indicator of environmental health within mangrove ecosystems **(Trianto *et al.*, 2023)**. Fluctuations in population density may reflect broader ecological changes due to factors such as climate change or habitat degradation **(Lantin-Olaguer & Bagarinao, 2001)**.

C. cingulata is an important environmental indicator species which can be found in the mangrove forest of Brgy. Ubagan, Sto. Tomas, La Union. However, there is a lack of literature concerning the status of this ecologically important species in the area. Hence, this study aimed to provide baseline information on the morphometric characteristics, length-weight relationship, and absolute abundance of *C. cingulata* in the above-mentioned mangrove forest. Results of the study would be essential for determining the health and condition of *C. cingulata* in the mangrove area. Finally, results from this study would be used as a guide for sustainable harvesting practices to ensure the viable populations of this gastropod species.

MATERIALS AND METHODS

Study area

Ubagan is a coastal barangay in the municipality of Sto. Tomas, in the province of La Union. The barangay is situated at approximately 16.2672, 120.3852 (16° 16' North, 120° 23' East) with estimated elevation at 7.5 meters or 24.6 feet above mean sea level. Its population as determined by the 2020 Census was 1,803. This represented 4.41% of the total population (40,846) of Sto. Tomas in 2020 contributing a 4.97% in the overall population of La Union. Fishing and gleaning were the primary sources of income for the coastal residents. The average temperature in the barangay throughout the year is approximately ranging from 23.18 to 28.68°C **(PhilAtlas, 2024)**.

The mangrove forest is located within the vicinity of Don Mariano Marcos Memorial State University-South La Union Campus-College of Fisheries, particularly at the southeastern part between 16° 15' 54" N and 120° 23' 00" E, encompassing an approximate area of 7,341.03 square meters (Fig. 1). The mangrove species found in the area include *Sonneratia alba, Lumnitzera racemosa, Rhizophora apiculata, Rhizophora mucronata, Bruguiera cylindrica* and *Avicennia marina*. Residents in proximity to mangrove forest engage in the practice of gleaning, which involves the collection of bivalves and gastropods from this intertidal zone.

Fig. 1. The location of the sampling stations established at the mangrove forest within Don Mariano Marcos Memorial State University-South La Union Campus-College of Fisheries

Sampling stations

Using a transect line method, a total of nine (9) sampling stations perpendicular to the shoreline were established in the mangrove area. Every 30m, a 1m x 1m quadrant was set for the collection of samples. The actual coordinates of each station were obtained using Google Maps Pro (Table 1). Stations 1 to 6 were located on the landward areas while stations 7 to 9 were located on the outward area near the inlet canal going to the fishpond of the College of Fisheries (Fig. 1).

Data collection

Data collection was done during low tide at around 6:00 AM. Based on the tide chart for Sto. Tomas, La Union, on October 7, 2024, the first low tide occurred at 06:02h at a height of 0.64m, and the second low tide was scheduled for 15:59h at a height of 0.92m. Sample collection was done through handpicking. Collected samples for each sampling station were placed in a labeled zip lock then brought to the laboratory for identification and measurement. Water quality parameters such as salinity, dissolved oxygen, temperature, and pH were also measured using a refractometer, multi-parameter kit, and pH meter, respectively. Likewise, composite soil samples were obtained and analyzed by the Department of Agriculture-Regional Soil Laboratory following the Bureau of Soil and Water Management (BSWM) Test Method manual developed in 2022.

In the laboratory, the samples were washed thoroughly before identification and measurement. Data on individual length and wet weight including morphometric measurements were recorded. A Vernier caliper with 0.01mm precision was used to measure the length and morphometric characteristics while a digital weighing scale with 0.01g sensitivity was used to measure the weight of the samples.

Table 1. Coordinates of the sampling stations (source: **Google Maps Pro, 2024**)

Station	Elevation	Latitude	Longitude
1	6.76	16° 15' 54" N	120° 23' 00" E
2	3.43	16° 15' 54" N	120° 22' 59" E
3	3.74	16° 15' 53" N	120° 22' 58" E
4	5.94	16° 15' 54" N	120° 23' 00" E
5	5.06	16° 15' 54" N	120° 22' 59" E
6	4.88	16° 15' 54" N	120° 22' 58" E
7	5.03	16° 15' 55" N	120° 23' 00" E
8	1.56	16° 15' 55" N	120° 22' 59" E
9	3.35	16° 15' 54" N	120° 22' 58" E

Data analysis

Both morphometric relationship between body parts on shell length of *C. cingulata* and LWR were analyzed using regression analysis. The patterns in allometry were described by the growth coefficient (i.e. power function exponent) in the equation $Y = aX^b$, where Y is the dependent variable (measured character) and X, the independent variable (L), a is the intercept and b, the growth coefficient **(Fuiman, 1983)**. Isometric growth occurred when b = 1. A positive allometric growth occurred when b >1 and a negative allometric growth when b <1 **(Osse & Boogaart, 2004)**. The LWR was determined using the power equation: $W = aL^b$, where W represents the total weight; *a* is the intercept, indicating the initial growth; L refers to length; and *b* represents the relative growth rates of the variables and provides information on growth **(Le Cren, 1951; Froese, 2006)**. The parameters *a*, *b*, and r^2 were estimated by linear regression analysis expressed as Log W = *b* log L + log *a* with "W" as the dependent variables for logarithm-transformed LWR expression **(Elvira & Jumawan, 2017)**. The growth pattern is determined through *b*-values. When *b* is equal to 3, growth is isometric, *i.e*., the increase in length follows an increase in weight. When *b* significantly differs from 3, growth is allometric *i.e.* increase in length may result to a decrease in weight or vice versa. A negative allometric growth pattern is exhibited if $b < 3$, while a positive allometric if $b > 3$. Descriptive statistics and analyses of relationships were done using the Microsoft Excel v. 2010 and Statistical Tool for Agricultural Research (STAR) software.

The absolute abundance of the collected samples was calculated using the following formula;

$\bar{x} = \sum x/n$; where: $\bar{x}$ is the mean number of stock; $\sum x$ is the sum of the individuals in the sampling area; n is the sampling unit

$N = (A/a)\ \bar{x}$; where: N is the estimate of the total stock; A is the total area occupied by the stock; a is the area of the sampling unit

s2 = [n∑x2 – (∑x)2 / n(n-1)]; where: s2 is the sample variance; n is the number of sampling unit

s = √ s2; where: s is the standard deviation

se = s/√n; where: se is the standard error of the mean

95% confidence interval = $\bar{x}$ ± (t) (se); where: t is the critical value

RESULTS AND DISCUSSION

Morphometric relationship of *Cerithidea cingulata*

The mean morphometric measurements and relationship between body parts on shell length of *C. cingulata* are presented in Table (2). A total of forty-one (41) samples were gathered from the sampling stations. Results revealed that all body parts exhibit negative allometric growth (*b*<1). However, statistical analysis showed that only the diameter of operculum, length of body whorl, and length of hump on the body whorl have a significant relationship with shell length. Other characteristics such as maximum width, columellar height, length of oral aperture and width of oral aperture did not have significant relationship with shell length of *C. cingulata.*

Table 2. Morphometric characteristics and morphometric relationship between body parts on shell length of *Cerithidea cingulata*

Characters	Mean±SD	n	b	a	r	*P*
Maximum width	1.12±0.16	41	0.0827	0.8758	0.2778	0.0787
Columellar height	2.33±0.78	41	-0.4200	3.5600	-0.1904	0.2330
Length of oral aperture	0.57±0.09	41	0.0397	0.4501	0.1575	0.3255
Width of oral aperture	0.35±0.06	41	0.0244	0.2827	0.1421	0.3756
Diameter of operculum	0.49±0.23	41	0.3454	-0.5203	0.5361	0.0003*
Length of body whorl	0.92±0.12	41	0.1999	0.3307	0.5956	0.0000*
Length of hump on the body whorl	0.61±0.14	41	0.2350	-0.0849	0.6126	0.0000*

Note: n = number of specimens, a & b = constants, r = correlation coefficient, *P* = level of significance, * = denotes a significant relationship (P<0.01)

Morphometric characteristics provide a foundation for understanding the significant traits associated with shell length and their ecological and evolutionary implications within mangrove ecosystems (**Parés-Casanova, 2017**). Findings of this study showed that the diameter of operculum, length of body whorl, and length of hump on the body whorl had a significant relationship with shell length. The operculum is a protective structure that covers the aperture when the snail retracts into its shell. A significant relationship suggests that as the shell length increases, the operculum also grows, which may be necessary for effective protection against predators and environmental stressors **(Simone, 2020)**. The body whorl is the largest part of the shell and contributes significantly to the overall size and shape of the snail. Its significant correlation with shell length indicates that growth in this area is crucial for maintaining structural integrity and buoyancy as the snail matures. The length of hump on the body whorl can be found only in mature snails that may influence hydrodynamics or feeding strategies. Its significance suggests that as snails grow, this part of their morphology plays an essential role in their adaptation to their environment **(Allmon & Hendricks, 2001)**. Several studies state that both abiotic and biotic factors including environmental factors affect growth and morphometry of gastropods **(Gaspar *et al.*, 2002; Degamon *et al.*, 2022; Catalan & de Chavez, 2023)**.

Length-weight relationship of *Cerithidea cingulata*

Table (3) presents the parameters of the LWR of *C. cingulata* found in the mangrove forest of Barangay Ubagan, Sto. Tomas, La Union. A total of forty-one (41) individuals of *C. cingulata* were collected from the sampling sites. The total length of the snail ranged from 2.2 to 4.2cm while the weight ranged from 1.21 to 4.40 grams. The mean total length and mean weight were 29.37±3.56cm and 2.02±0.56 grams, respectively. Results revealed that the *C. cingulata* exhibited a negative allometric growth pattern (b<3) in the mangrove area. Statistical analysis shows a significant positive relationship between length and weight of *C. cingulata* (P<0.01).

Table 3. Parameters of the length–weight relationship of *Cerithidea cingulata* from the mangrove forest of Brgy. Ubagan, Sto. Tomas, La Union

Family/ Species	N	Total Length (cm) (Mean ± SD)	Total Weight (g) (Mean ± SD)	r	r^2	Intercept a	Regression Coefficient (b)	Growth	Growth Pattern
Potamididae *Cerithidea cingulata*	41	2.94±0.36	2.02±0.56	0.8453	0.7145	-0.5413	1.79*	b<3	Negative allometric

* Denotes a significant relationship between length and weight (P<0.01)

Information on LWR can provide insights into how environmental factors influence growth and body shape over time **(Ricker, 1973; Oo & Op, 2018a)**. The negative allometric growth of *C. cingulata* means that as it grows longer, its weight does not increase proportionately, resulting in a more elongated body shape. A slope of 1.79 implies that for every additional unit of length, the weight of *C. cingulata* increases by 1.79 units suggesting that if these snails grow longer, they also gain weight. This can be indicative of ecological adaptations or changes in resource availability **(Suwanjarat & Suwaluk, 2003; Solanki *et al.*, 2017)**. Findings of this study conform to the study of **Degamon *et al.* (2022)** indicating a negative allometric growth of all gastropods collected from mangrove forest of Brgy. Nabago, Surigao City. **Zuschin and Stanton (2001)** state that marine gastropods require strong shell strength to effectively survive in challenging environmental conditions and to adapt to various environmental stresses. Additionally, **Mendoza *et al.* (2019)** noted that the energy allocated for shell growth is greater than that for soft tissues, resulting in a negative allometric growth pattern.

Absolute abundance of *Cerithidea cingulata*

Table (4) presents the absolute abundance of *C. cingulata* in the mangrove forest of Brgy. Ubagan, Sto. Tomas, La Union. A total of 192 individuals of *C. cingulata* were collected from the mangrove area. The mean number of *C. cingulata* observed per square meter was 21. The estimated total stock of *C. cingulata* per square meter was 156,584. These results imply that the species is abundant in the mangrove area. However, the 95% confidence interval ranging from 14,209,786 to 17,661,364 indicates a high degree of uncertainty in the total stock estimate.

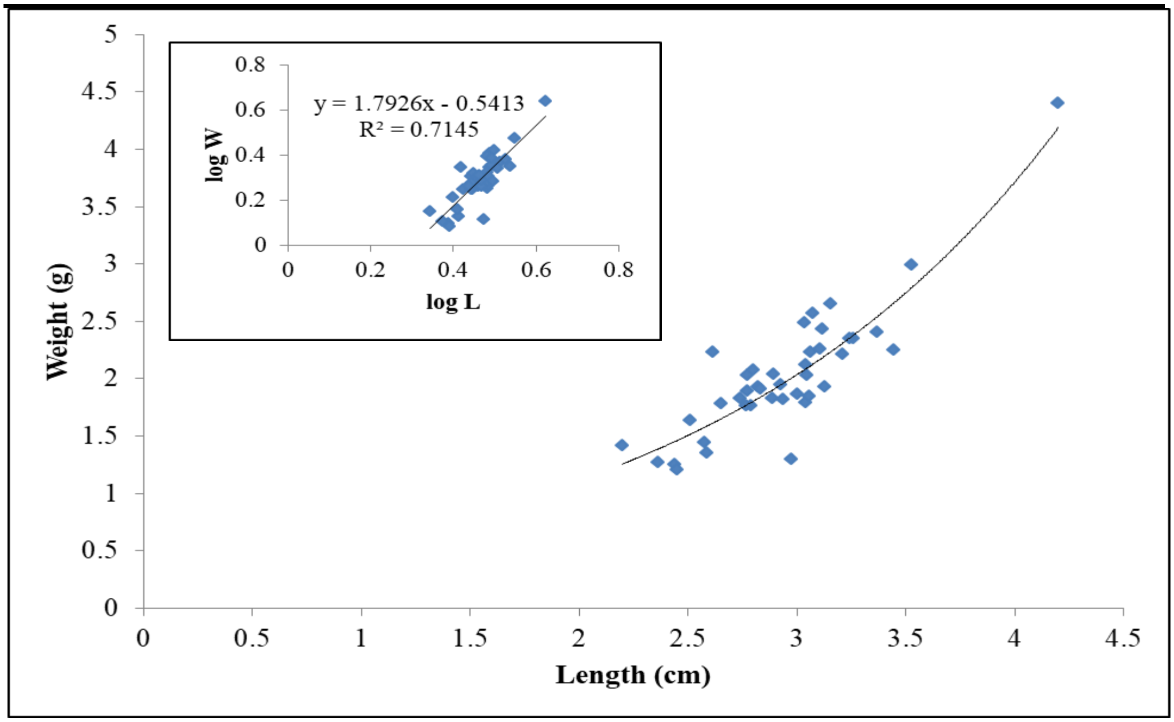

Fig. 2. Length-weight relationship of *Cerithidea cingulata* collected from the mangrove forest of Brgy. Ubagan, Sto. Tomas, La Union

Table 4. Absolute abundance of *Cerithidea cingulata* in the mangrove forest of Brgy. Ubagan, Sto. Tomas, La Union

Family/Species	Mean No. of Stock (ind/m^2)	Estimate of the Total Stock (ind)	95% Confidence Interval of Estimate (ind)
Potamididae *Cerithidea cingulata*	21	156,584	14,209,786 to 17,661,364

Abundance serves as a measure of how a population varies over space and time, but it can be quantified in various ways, which can affect the interpretation and communication of spatiotemporal patterns. Measuring absolute abundance is particularly advantageous for biodiversity research, including areas such as monitoring, conservation, and ecology **(Callaghan *et al.*, 2024)**. Results of the study provided a baseline understanding of the population density in the mangrove ecosystem of Brgy. Ubagan, Sto. Tomas, La Union. It indicates that *C. cingulata* is relatively abundant in the area sampled particularly near the inlet canal, which may reflect favorable environmental conditions for its growth and reproduction. During the sampling, the mean values of physico-chemical water parameters such as temperature, dissolved oxygen, pH, salinity, and total dissolved solids were 31.14±0.23°C, 3.50±0.84mg/ L, 6.86, 28mg/ L, and 11.33±1.50ppt, respectively. Likewise, soil analysis revealed that the soil type in the mangrove forest is clay with 22.07±25.92 percent moisture content, 5.87±0.81 pH, 11.26±2.55 percent organic matter, 19.35±6.48ppm available phosphorus (P), and 1940.27±198.65ppm available potassium (K). According to **Räty *et al.* (2021)**, clay soils have a high specific surface area contributing to greater cation exchange capacity (CEC) and nutrient retention compared to sandy soils. This characteristic implies that clay soils are generally rich in nutrients but can also lead to poor drainage and aeration if not managed properly. The moisture content suggests that the soil in the mangrove can hold sufficient water, which is crucial for both plant growth and the survival of *C. cingulata.* Adequate moisture levels enhance nutrient uptake by plants, which in turn supports the snails by providing a rich food source through decaying organic matter and algal growth **(Sharma & Kumar, 2023)**. Generally, the pH level is favorable for nutrient availability although it is slightly below the optimal range (around 6.5) for many plants **(Cornell University, 2010)**. For *C. cingulata* which thrives in slightly alkaline to neutral conditions (pH around 7-8), this acidity might limit the availability of certain nutrients essential for vegetation growth, potentially affecting the food supply for snails **(Kalat-Meimari *et al.*, 2018)**. In addition, the organic matter content indicates that the soil in the area is rich in decaying plant material which enhances soil fertility and structure. High organic matter levels promote microbial activity and nutrient cycling, providing a continuous food source for *C. cingulata* through decomposed organic material. This environment supports not only the snails but also a diverse array of other organisms within the ecosystem **(Nair *et al.*, 2021)**. In terms or nutrient availability, the phosphorus level is adequate for supporting plant growth since phosphorus is crucial for root development and energy transfer in plants **(Malhotra *et al.*, 2018)** contributing to a stable habitat for snails. Similarly, the high potassium levels are beneficial as potassium enhances plant health and resilience against environmental stressors, which can further support snail populations by ensuring robust vegetation **(Johnson *et al.*, 2022)**. However, it can be observed that there is a wide confidence interval observed in the estimate of the total stock of *C. cingulata* which can be attributed to several factors such as population fluctuations due to environmental factors, availability of food resources, and life history traits **(Zuschin & Stanton, 2001; Nurul-Zalizahana *et al.*, 2022)**.

CONCLUSION

The present study provides critical insights about the growth patterns and population dynamics of *Cerithidea cingulata,* with broader implications for mangrove ecosystem management in Brgy. Ubagan, Sto. Tomas, La Union. This study supports the role of *C. cingulata* as an indicator species for mangrove health, urging targeted conservation strategies to preserve both gastropod populations and their habitats. The morphometric traits possibly reflect adaptive growth strategies tied to environmental pressures, such as substrate stability or predation. The negative growth pattern is common in gastropods inhabiting dynamic mangrove zones, where elongated shells may aid in anchoring to substrates during tidal fluctuations. The estimated total stock suggests a stable population however the wide confidence interval underscores variability in distribution which can be attributed to habitat age, canopy cover, and sediment composition. Hence, it is important to conduct long-term monitoring to assess ecological roles of gastropods, such as nutrient cycling and sediment turnover.

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