ECOLOGICAL INSIGHTS INTO MUD LOBSTERS: MORPHOLOGICAL CHARACTERISTICS AND POPULATION DYNAMICS OF *THALASSINA* SPECIES

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Abstract

This study investigated the morphological characteristics, abundance, density, and frequency of Thalassina anomala and Thalassina spinosa (locally referred to as "Manla") in the mangrove ecosystems of Dipolog City, Zamboanga del Norte. Employing a mixed-methods approach, the research utilized a line-plot sampling technique (plots measuring 3 m × 5 m) to collect both quantitative and qualitative data on these mud lobster species. Key morphological characteristics—including color, length, and weight—were documented, revealing distinct traits for each species. The findings indicated an abundance of 140 individuals, a density of 0.93 individuals per square meter, and occurrence in all sampling plots (frequency = 10), underscoring the stable presence of these species in the study area. The study emphasizes the ecological significance of mud lobsters and highlights the need for further research across diverse mangrove ecosystems to enhance understanding and inform conservation strategies. Moreover, strict enforcement of regulations pertaining to the protection and conservation of aquatic species is essential to support biodiversity within these habitats.

Keywords: *Mud lobsters; Thalassina; Thalassina anomala; Thalassina spinosa; Mangrove ecosystems; Morphological characteristics; Population dynamics*

Introduction

The investigation of *Thalassina anomala* and *Thalassina spinosa* directly supports the United Nations Sustainable Development Goals (SDGs), particularly SDG 14 (Life Below Water), which emphasizes the conservation and sustainable use of marine resources. These mud lobster species play vital roles in maintaining ecological balance within mangrove ecosystems, which are critical for biodiversity, carbon sequestration, and coastal protection (United Nations Environment Programme, 2021). The study also aligns with the Philippine Development Plan's goals of ecosystem resilience and marine resource conservation (National Economic and Development Authority, 2017).

Mud lobsters are recognized as significant ecosystem engineers in mangrove habitats. Their burrowing activities enhance soil aeration and nutrient cycling—critical processes that support the health of mangrove ecosystems. Research by Ashton and Macintosh (2002) emphasizes that burrowing fauna, including *Thalassina*, play essential roles in sediment stability and promote biodiversity by creating microhabitats. The physical alterations they cause in the substrate can lead to improved growth conditions for mangrove trees and associated flora (Ngoc-Ho & de Saint Laurent, 2009). Moreover, studies conducted by Moh

et al. (2015) highlight that the distribution of mud lobsters is influenced by environmental parameters such as salinity, substrate type, and tidal patterns. This adaptability underscores the importance of these species in maintaining ecological balance, particularly in areas experiencing environmental stressors.

Research into the population dynamics of *Thalassina* species has shown that their abundance and distribution are key to understanding their ecological roles. Previous studies, including Lebata et al. (2012), indicate that population metrics such as density and frequency of occurrence are essential for assessing the stability of mud lobster populations in intertidal zones. The present study builds on this foundation by documenting an abundance of **140** individuals, a density of 0.93 individuals per square meter, and a frequency of occurrence of 10 (i.e., presence in all sampled plots) for *T. anomala* and *T. spinosa* in the mangrove area of Dipolog City. This baseline information contributes to understanding the status of mud lobster populations in a Philippine mangrove ecosystem and provides insights to inform conservation strategies.

Grounded in ecological theory, this work draws on Liebig's Law of the Minimum and Shelford's Law of Tolerance as conceptual frameworks (Lee et al., 2023). These theories underscore how environmental factors can limit species distribution and performance, emphasizing that organisms thrive only within specific ranges of conditions. By examining *Thalassina* spp. within their habitat, the study evaluates how these mud lobsters meet environmental tolerances (e.g., sediment type, salinity) and how resource availability might constrain their growth and distribution (Brenner, 2021). Through this lens, the research not only catalogues the characteristics and population metrics of *T. anomala* and *T. spinosa* but also situates these findings in the broader context of mangrove ecosystem health and resilience.

Methods

The study was conducted in the mangrove ecosystem of Purok Eco-5, South Curvada, Dipolog City (Zamboanga del Norte, Philippines), where *T. anomala* and *T. spinosa* are locally known as "Manla." These sites are representative of semi-enclosed coastal mangroves with mixed sand and mud substrates and moderate tidal influence.

A mixed-methods approach, combining qualitative observations and quantitative measurements, was employed to achieve the research objectives. For quantitative sampling, a line-plot method was used. Plots measuring 3 m × 5 m (15 m² each) were established in the mangrove area, with a 5 m buffer separating adjacent plots to ensure independent sampling. This design yielded ten plots (denoted A through J) covering a total sampled area of 150 m². Within each plot, all visible mud lobsters were counted and identified to species. This approach allowed for the assessment of abundance (total individuals counted), density (individuals per unit area), and frequency (number of plots in which the species occurred).

In each plot, morphological data for each captured mud lobster were recorded following standard protocols for *Thalassina* identification (Ngoc-Ho & de Saint Laurent, 2009). Key morphological characteristics observed included body coloration, total length (cm), and weight (g). These metrics were used to distinguish *T. anomala* and *T. spinosa*, as each species exhibits unique physical traits. Color was noted by visual inspection (e.g.,

yellowish-brown vs. red-orange), length was measured from rostrum to telson using a measuring tape, and weight was measured with a portable scale.

Population counts were conducted by manually excavating burrows within each plot and capturing the mud lobsters. The total abundance of individuals per plot was recorded for both species. From these data, density was calculated as the number of individuals per square meter for each plot (and averaged across plots for an overall density). Frequency of occurrence was determined by counting how many of the ten plots contained at least one mud lobster.

In addition to the quantitative data, researchers made qualitative field observations regarding mud lobster behavior and burrow characteristics (e.g., burrow opening diameters, mound shapes) to complement the numerical findings. Local community members present during sampling were informally consulted about mud lobster sightings and their perceptions of the species, providing anecdotal context to the ecological data. These qualitative insights were used to enrich the discussion of *Thalassina* spp. roles in the ecosystem.

All measurements and counts were conducted during low tide periods for optimal visibility and capture success. Proper species identification was confirmed by morphological keys and descriptions in the literature (Ngoc-Ho & de Saint Laurent, 2009; Moh & Chong, 2009).

Ethical Considerations

This study adhered to ethical principles focused on biodiversity conservation, minimal environmental impact, and community engagement. Researchers implemented sustainable field practices to ensure that populations of *T. anomala* and *T. spinosa* were not unduly harmed or disrupted. Disturbed areas were restored to the extent possible after sampling. All necessary permits for wildlife research and specimen collection were obtained in compliance with Philippine regulations (Department of Science and Technology, 2017).

Collaboration with local communities was undertaken respectfully, acknowledging traditional knowledge and practices, which can enhance conservation efforts (Berkes, 2017). Informal discussions with community members were conducted with transparency and with their consent, aiming to integrate local observations into scientific understanding. The guidance of local experts and community leaders was sought to ensure that research activities were culturally sensitive and mutually beneficial.

Throughout the research process, the team upheld transparency in methodology and reporting. Data and findings have been presented honestly and without fabrication or manipulation. The authors followed recommended best practices for ethical research writing, including proper citation and acknowledgment of all sources and contributions. All analysis, interpretations, and conclusions were derived by the research team, ensuring the integrity of the scientific content (Fowler, 2021). The use of an AI-based tool (OpenAI's ChatGPT) was limited strictly to editorial assistance (e.g., grammar and clarity) and did not influence the research design, data analysis, or scientific outcomes (see Disclosure). The authors remain fully responsible for the accuracy and integrity of the data and findings presented.

Results and Discussion

Morphological Characteristics of *Thalassina anomala* and *Thalassina spinosaspinosa*

Field observations revealed distinct physical differences between *Thalassina anomala* and *Thalassina spinosa* specimens in the study area. *T. anomala* individuals exhibited a yellowish to reddish-brown exoskeleton, with an average total length of 35.6 cm and an average weight of approximately 250 g. In contrast, *T. spinosa* showed a more pronounced red-orange body coloration, with a slightly shorter average length of 31.8 cm and a lighter average weight of about 150 g. These quantitative measures align with known species descriptions, confirming the identity of the two mud lobster species (Ngoc-Ho & de Saint Laurent, 2009). The coloration and size differences may reflect adaptations to microhabitat conditions or species-specific life history traits. For instance, the larger body size of *T. anomala* could be related to its burrowing depth or dietary differences compared to *T. spinosa*, although both species fulfill similar ecological roles in sediment turnover.

Table 1. Morphological Characteristics of *Thalassina* Species

Species	Color	Average Length (cm)	Average Weight (g)
T. anomala	Yellowish to reddish-brown	35.6	250
T. spinosa	Red-orange	31.8	150

Key distinguishing features of T. anomala *and* T. spinosa *recorded in Purok Eco-5, South Curvada (Dipolog City).*

These morphological differences provide insight into how each species may be adapted to the mangrove environment. The robust size of *T. anomala* might confer competitive advantages in deeper burrowing or territory establishment, whereas the vibrant coloration of *T. spinosa* could relate to species-specific behaviors or mating. Both species' trait profiles are consistent with observations in other regions of Southeast Asia (Hassan et al., 2015), suggesting that the characteristics noted here are not anomalous to the Dipolog population.

Population Abundance and Distribution

Across the ten sampling plots (150 m² total area), a total of 140 mud lobsters (combined *T. anomala* and *T. spinosa*) were recorded. This overall abundance corresponds to an average density of 0.93 individuals per square meter, indicating a relatively high population density for benthic organisms in a mangrove habitat. Both mud lobster species were found in every plot (100% frequency of occurrence), illustrating their widespread distribution in the study area. Notably, *T. anomala* and *T. spinosa* co-occurred within the same plots, often inhabiting proximate burrows. This sympatric distribution with no plots devoid of mud lobsters underscores a stable and well-established mud lobster community.

Table 2. Population Metrics of *Thalassina* Species in the Study Area

Metric	Value
Total abundance	140 individuals (combined)
Density	0.93 individuals per m²
Frequency	10/10 plots (100% occurrence)

Summary of combined T. anomala *and* T. spinosa *population metrics in Dipolog City mangrove sampling plots.*

The spatial distribution of *T. anomala* and *T. spinosa* by plot is detailed in Table 3. Total mud lobster counts per 15 m² plot ranged from 8 to 22 individuals, with no single plot overwhelmingly dominated by one species. On average, each plot contained 14 individuals (SD ± 4.5), split between the two species. This even distribution pattern suggests that neither *T. anomala* nor *T. spinosa* excludes the other from occupying a given area at the scale of our sampling. Such coexistence may indicate resource partitioning or simply that the habitat has ample resources and space to support both species without intense interspecific competition. Similar patterns of co-occurrence have been reported in Malaysian mangroves, where multiple *Thalassina* species share habitats by utilizing slightly different niche spaces (Moh et al., 2015).

Table 3. Distribution of *Thalassina anomala* and *Thalassina spinosa* by Plot (15 m² each)

Plot ID	*T. anomala* (count)	*T. spinosa* (count)	Total individuals
A	5	8	13
B	11	7	18
C	6	9	15
D	12	10	22
E	10	8	18
F	9	6	15
G	4	6	10
H	5	3	8
I	4	6	10
J	6	5	11
Total	**72**	**68**	**140**

Distribution of mud lobster counts per plot. Each plot is 3 m × 5 m in size. Both species were present in all plots, with varying relative abundances.

From Table 3, it is evident that the two species were often found together in the same plots. While the exact ratio of *T. anomala* to *T. spinosa* varied, neither species was entirely absent from any plot. This indicates that at the spatial scale of these plots, microhabitat conditions were suitable for both species concurrently. The fairly uniform totals (most plots having 10–18 individuals) suggest an absence of any extreme clustering or large voids in population distribution. Such a pattern might be expected if the mud lobsters disperse evenly in search of food (detritus) and burrowing space, or if territorial behaviors limit excessive aggregation.

Ecological Functions and Implications

The burrowing activities of *T. anomala* and *T. spinosa* have significant ecological implications for the mangrove ecosystem. Field observations noted extensive burrow networks in each plot, with some burrow openings interconnected by tunnels beneath the substrate. These burrowing behaviors actively oxygenate the soil by bringing air and tidal water into deeper sediment layers, thereby enhancing nutrient cycling and soil fertility. The churned sediments, visible as mounds at the surface, indicate how mud lobsters transport subsurface materials upward, effectively tilling the mangrove soil. This bioturbation process improves soil structure and creates microhabitats (burrow spaces and aerated soil pockets) that can be utilized by other organisms such as crabs, mollusks, and root-dwelling microbes. By modifying the physical environment in these ways, *Thalassina* spp. serve as ecosystem engineers that increase habitat complexity and promote biodiversity within the mangroves.

The presence of healthy mud lobster populations is generally regarded as an indicator of a well-functioning mangrove ecosystem. Both species feed on detritus within the mud, and their foraging further breaks down organic matter, accelerating decomposition and nutrient release. This nutrient turnover supports the productivity of mangrove trees and associated flora, as essential elements are cycled back into forms available for plant uptake. In our study area, the stable densities of mud lobsters suggest ongoing contributions to these ecological functions. The similar distribution of *T. anomala* and *T. spinosa* implies that collectively they occupy a broad niche and together maximize the area of sediment being processed. In regions where *Thalassina* populations decline, mangrove soils can become more compacted and anoxic, leading to poorer mangrove tree growth (Ashton & Macintosh, 2002). Our findings thus reinforce the notion that conserving mud lobster populations is intertwined with maintaining mangrove ecosystem health.

From a socio-ecological perspective, it is noteworthy that local community interactions with mud lobsters can vary. In some Southeast Asian locales, farmers consider mud lobsters to be pests when the animals encroach into agricultural fields adjacent to mangroves, as their mounding and burrowing can disturb crops (Hassan et al., 2015). In the context of our study, which is confined to protected mangrove forests, such human–mud lobster conflicts were not observed. However, this insight highlights the importance of engaging local communities in mud lobster conservation. By educating residents about the crabs' ecological benefits—such as improving soil quality and supporting fisheries through mangrove health—potential misconceptions can be addressed. Community awareness and involvement are crucial, as local stakeholders are more likely to support conservation measures when they recognize direct or indirect benefits to their livelihoods (PCAARRD, 2019). We discuss specific community engagement strategies in the Recommendations.

Summary of Key Findings

- Distinct Morphological Differences: *T. anomala* and *T. spinosa* exhibit unique physical characteristics in coloration, size, and weight, which may correspond to their ecological roles and habitat adaptations within mangrove ecosystems. These differences aid in species identification and suggest niche differentiation to a minor extent.
- Stable Population Dynamics: The two mud lobster species showed a well-distributed

and abundant presence across all sampling plots. The combined population (140 individuals over 150 m²) and high density indicate a healthy, sustaining population in the study area. Both species coexisted in all plots, reflecting a stable community without competitive exclusion at the observed scale.

- Significant Ecosystem Impact: The burrowing behavior of *T. anomala* and *T. spinosa* contributes substantially to ecosystem services. Their activities enhance soil aeration, nutrient recycling, and habitat complexity, thereby supporting mangrove tree growth and providing microhabitats that boost overall biodiversity. This underscores their role as ecosystem engineers vital for mangrove sustainability.

Conclusions

This study provides essential insights into the morphological traits, population dynamics, and ecological functions of *Thalassina anomala* and *Thalassina spinosa* in a Philippine mangrove ecosystem. The clear distinctions in color and size between the two mud lobster species facilitate field identification and deepen our understanding of their biology. A robust and evenly distributed population (with an overall abundance of about 140 individuals in the sampled area and density ~0.93/m²) points to favorable habitat conditions and effective conservation status in the study site. Such stability in population and distribution is indicative of the species' successful adaptation to local environmental conditions and the absence of immediate large-scale threats.

Importantly, our findings reaffirm that *T. anomala* and *T. spinosa* play vital ecological roles in sustaining mangrove health and productivity. Through their constant burrowing and feeding, these mud lobsters drive processes like soil turnover and nutrient cycling, which are foundational for mangrove ecosystem resilience. In doing so, they indirectly support a myriad of other species (from microbes to fish) that rely on healthy mangrove conditions. As coastal ecosystems face increasing threats from human activities (e.g., coastal development, pollution) and climate change (e.g., sea level rise, altered salinity regimes), the ecological services provided by mud lobsters become even more critical. A decline in these organisms could have cascading negative effects on mangrove forests, underscoring the need to monitor and protect their populations.

The study also highlights the importance of a holistic approach to conservation. Protecting mud lobster populations is not only about preserving a single genus of crustaceans; it is about sustaining the intricate web of life within mangroves. Effective conservation strategies for *Thalassina* spp. will therefore contribute to broader outcomes, including healthier mangrove forests, better coastal protection, and enhanced fisheries productivity in adjacent waters.

Overall, by documenting the characteristics and population status of *T. anomala* and *T. spinosa* in Dipolog City, this research fills a knowledge gap for an under-studied region of the Philippines. These baseline data serve as a reference for future studies and for local management efforts. Continued interdisciplinary research and community engagement are recommended to build on these findings, ensuring that both the species and their habitat are maintained for future generations.

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Disclosure: Use of AI Tools

In compliance with *The Threshold* journal's guidelines for ethical use of artificial intelligence (AI) in academic writing, the authors disclose the use of OpenAI's ChatGPT during the manuscript preparation. The AI tool was utilized only for improving the clarity, coherence, and grammar of the text. All scientific content— including study design, data analysis, interpretation of results, and conclusions—was conceived and developed by the authors without AI assistance. The contributions of ChatGPT were strictly editorial: for example, suggesting alternative phrasing for complex sentences and checking for consistency in terminology. The authors carefully reviewed and edited all AI-suggested changes to ensure accuracy and alignment with the intended meaning. No AI-generated content was accepted without thorough verification against the study's data and established literature. The use of ChatGPT did not influence the integrity or validity of the research findings. This disclosure affirms the authors' commitment to transparency in the writing process and adherence to the journal's ethical standards. All authors take full responsibility for the content of this article, and we confirm that the manuscript, as presented, is an honest and accurate representation of our work.

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