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# Abundance and diversity of gastropods in replanted and natural mangrove sites in Guang-guang, Dahican, Mati City, Philippines

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## ABSTRACT

This study compared gastropod abundance and biodiversity in naturally grown and replanted mangroves in Guang-guang, Dahican, Mati, Philippines. To do this, a total of 12 transects (50 m) were laid perpendicular to the shore, and vertical quadrats were used for mangrove trees assessed every 5 m along the line transects. Gastropods were identified and counted on the mangrove tree leaves, trunks, and roots found in the natural and replanted sites. A total of 16 gastropod species from four families (Littorinidae, Neritidae, Trochidae, and Siphonariidae) were found. All 16 species were found in the natural sites, whereas four species—*Nerita albicilla* Linnaeus, 1758, *Nerita histrio* Linnaeus, 1758, *Siphonaria sirius* Pilsbry, 1894, and *Siphonaria atra* Quoy & Gaimard, 1833—were absent from the replanted sites. Overall, more gastropods found in the replanted sites compared with the naturally grown sites ( $t$ -tests,  $df = 166$ , mean difference =  $-0.463$ ,  $t$ -value =  $-7.42$ ,  $P = 0.000$ ) although the natural sites hosted more diverse species ( $H' = 2.41$  vs  $2.39$ ). The results suggest the need to improve mangrove conservation, including planting more mangrove species suitable for these habitats as they act as refugia for gastropods, other invertebrates and marine organisms.

**Keywords:** arboreal gastropods, diversity, Guang-guang, mangrove fauna, Mati City

The mangrove ecosystem is highly valuable both for conservation and for providing ecological services (Bindiya et al. 2023; Galon et al. 2021). Mangroves can protect shorelines from tsunamis and tidal flooding, support the juveniles of invertebrates and finfish by providing habitat space and facilitate nutrient absorption and sediment filtration (Macusi and Tipudan 2021; Nallos and Macusi 2023). Moreover, the mangrove forest in Pujada Bay has been a site for human activities such as exploitation, trampling, fishing, educational field trips, seaside strolling, photographing, and field studies, which can

disturb the habitat and reduce the population of finfish and gastropods of commercial importance (Deepananda and Macusi 2012; Onyena and Sam 2020). Mangrove-associated fauna are highly diverse and include gastropods, bivalves, crabs, finfish, reptiles and birds including seagrasses and various seaweed species (Albarico et al. 2020; Macusi et al. 2023; Seniel et al. 2024). In addition, gastropods play a vital ecological and economic role, providing essential ecosystem services and contributing to tourism and trade (Dewi et al. 2023). They serve as food for fish, birds, and humans and are valued in



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export and domestic markets for products like crafts, pearls, and dyes (Alves et al. 2018). In India, they are used for ornamentation, medicine, and lime production (Ramachandra et al. 2012). Ecologically, gastropods act as filter feeders, helping to purify marine water and they also serve as biological indicators, detecting environmental stress and assessing habitat quality (El-Gendy et al. 2021). Their presence or absence can signal changes in aquatic ecosystems.

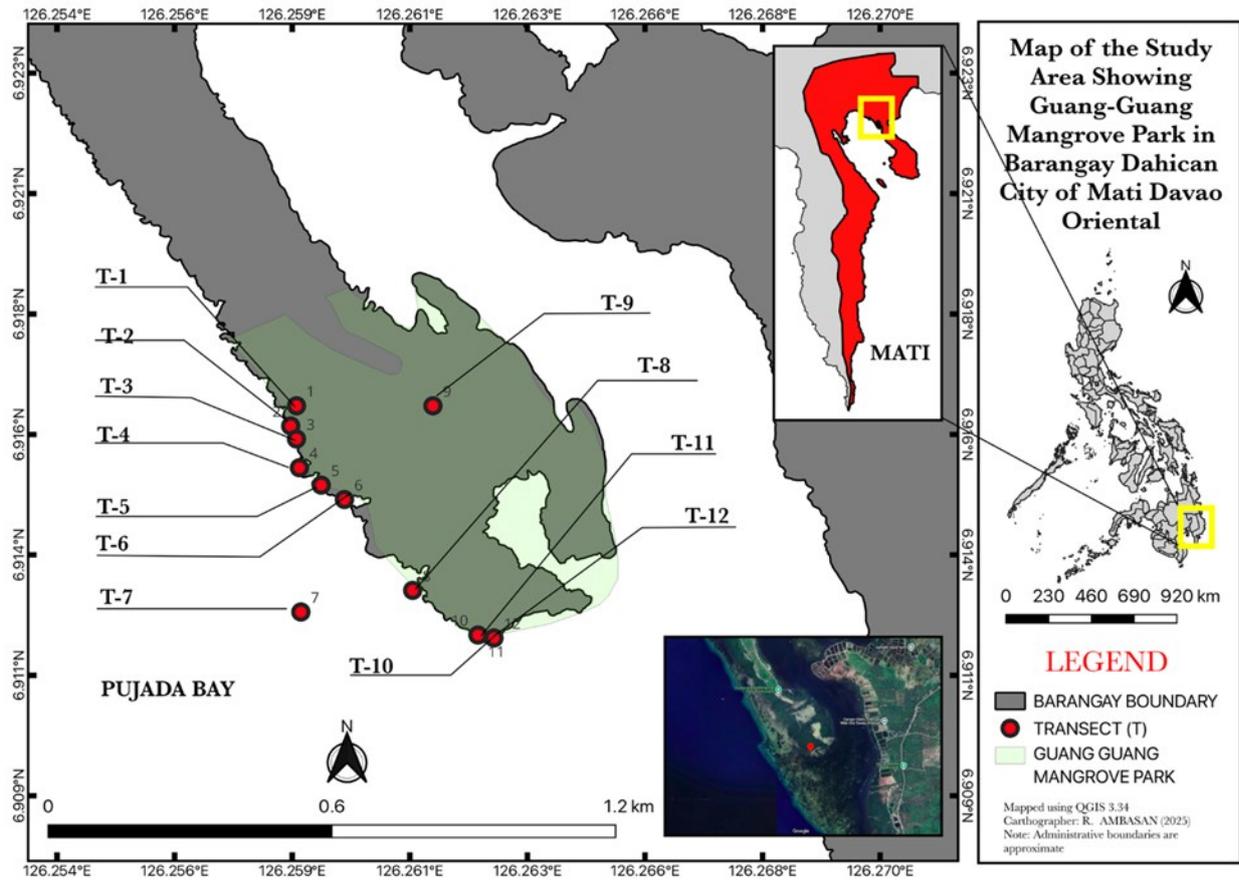
Gastropods can be abundant due to their high fecundity, reproductive capacities, and planktonic larvae, but they can also be affected by high gleaning pressure, especially among commercially harvested species (Maynawang et al. 2024). In a previous paper (Maynawang et al. 2024), the low diversity index (0.99) of gastropods in Guangguang indicated a possible overexploitation of gastropods in the area. Despite these estimates, accurately determining species richness remains a challenge due to factors such as habitat variability, sampling limitations, and taxonomic identification uncertainties. This study, therefore, aimed to identify, compare, and record the abundance of arboreal gastropods found in the roots, trunks and leaves of mangrove trees found in natural and replanted sites. The natural sites are composed of a mix of various Rhizophoraceae species (*Bruguiera cylindrica* (L.) Blume, *Rhizophora apiculata* Blume, *Rhizophora mucronata* Poir, *Rhizophora stylosa* Griff.) and Lythraceae (*Sonneratia alba* Sm.), with both young and older trees and lower density, while the replanted sites are mostly composed of Rhizophoraceae (*B. cylindrica*, *R. apiculata*, *R. mucronata*, *R. stylosa*), younger trees, and higher density. To do this, six transects were laid in the naturally grown sites, and another six transects were laid in the replanted sites, for a total of 12 transects measuring 50 m each, laid perpendicular to the coastline in Guang-guang, Barangay Dahican, Mati, Davao Oriental (see Figure 1). There were 30 m intervals between each transect, and individual trees found within 5 m intervals along the transect were included in the survey; once the tree was identified and measured, a vertical quadrat (2 m × 1 m) was used to sample gastropod species found in the roots, trunks, and leaves of the tree. The Guang-guang mangrove area is considered part of the National Integrated Protected Areas System (NIPAS), part of the Pujada Bay Protected Landscape/Seascape under Proclamation No. 451 dated 31 July 1994, issued by the Philippine government with an approximate area of 168 km<sup>2</sup> (Abreo et al. 2020).

In this study, only arboreal gastropods were counted and handpicked from leaves, trunks, and roots of mangrove trees in naturally grown and replanted mangrove sites during low tide. Representatives of different gastropods were preserved and placed in sample jars for later identification. We used the

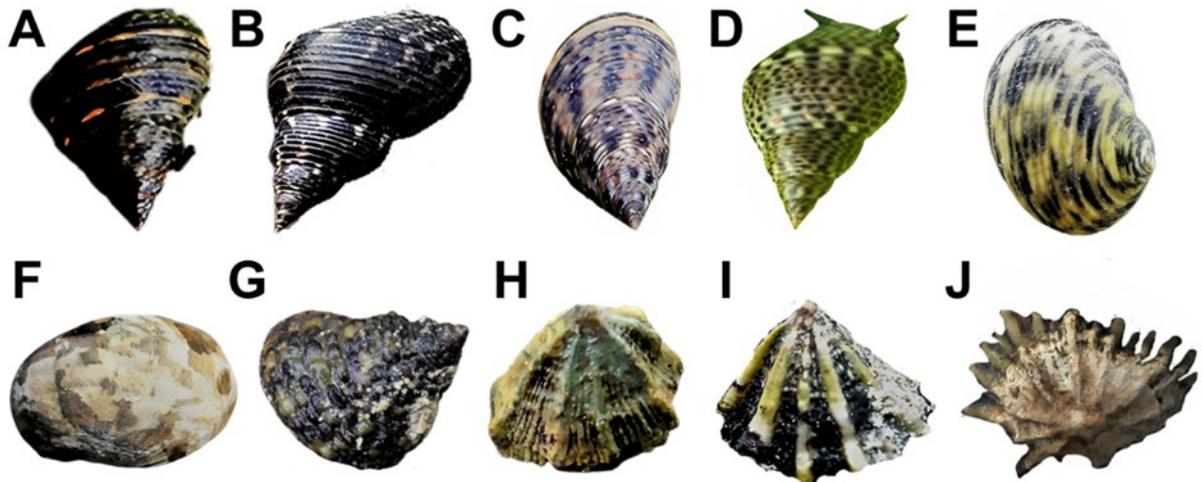
following references for assistance in field identification: Venkatesan et al. (2010); Khade and Mane (2012); Irma and Karina (2012); Picardal and Dolorosa (2014); and MolluscaBase, to guide our decisions in making correct identifications (MolluscaBase 2025). All count data from the field were first checked for their descriptive statistics (mean, median, mode) and graphical analyses of normality and variance before statistical analysis took place. We then used one-way ANOVA and a *t*-test to compare the count data from the two sites. Density was calculated using the common density formula ( $D=n_i/A$ ) where  $n_i$  is the total number of individual species sampled and A is the total area of all transects sampled or area. For diversity calculation, we used the Shannon-Wiener diversity index.

In this study, eight littorinid species were identified in the mangrove forests, for example, on mangrove leaves (Figure 2 A, B, C, D). Littorinidae, a diverse family of intertidal gastropods, comprises small air-breathing snails that graze on algae and bacterial films in mangrove ecosystems (Sanpanich et al. 2004; Cob et al. 2012). Neritidae is another group of herbivorous gastropods that inhabit the intertidal zone and often form dense aggregations. Three *Nerita* species were found and recorded during the study (see Figure 2); they are known to be intertidal. Trochidae was represented by *Monodonta canalifera* Lamarck, 1816 and *Trochus maculatus* Linnaeus, 1758 (see Figure 2). These species are known to be frequently associated with mangrove and estuarine habitats, displaying diverse shell colors and morphological variations (Afsar et al. 2013; Masagca et al. 2010). Lastly, Siphonariidae, a group of air-breathing marine pulmonates, included *Siphonaria javanica* (Lamarck, 1819), *Siphonaria sirius* Pilsbry, 1894, and *Siphonaria atra* Quoy & Gaimard, 1833 (Figure 2). These species ascend mangrove roots at high tide, presumably to avoid submersion and predation by fish or crabs (Maia and Tanaka 2007; Reid 2001).

Table 1 shows the density and relative abundances of gastropods found in the replanted and naturally grown sites. Overall, *Littoraria arduiniana* (Heude, 1885) (14.88%) had the highest relative abundance, followed by *Littoraria bengalensis* D. Reid, 2001 (12.72%) and *Littoraria pallescens* (R. A. Philippi, 1846) (10.57%) in the natural sites. In contrast, in the replanted sites, *Nerita undata* Linnaeus, 1758 (14.94%), *L. pallescens* (13.33%), and *L. bengalensis* (12.74%) were the most abundant. In addition, these three species were also found to have the highest density overall: *N. undata* (59 ind m<sup>2</sup>), *L. pallescens* (52 ind m<sup>2</sup>), and *L. bengalensis* (50 ind m<sup>2</sup>). Their abundances in terms of location on tree leaves, trunks, and roots were also compared but showed no significant differences (df = 2, MS = 0.07987, *F* = 0.30, *P* = 0.745).



**Figure 1.** Map of the study area (T1 to T6 represent natural sites, while T7 to T12 represent the mangrove replanted sites) in Sitio Guangguang, Barangay Dahican, Mati City, Davao Oriental.



**Figure 2.** The various species found in the mangroves: *Littoraria bengalensis* (A), *Littoraria scabra* (B), *Littoraria carinefera* (C), and *Littoraria intermedia* (D), *Nerita undata* (E), *Nerita albicilla* (F), *Monodonta canalifera* (G), *Trochus maculatus* (H), *Siphonaria javanica* (I) and *Siphonaria sirius* (J).

A comparison of the different transects found in the replanted and naturally grown sites showed significant differences in the abundances of gastropods (df = 11, MS = 1.0154,  $F = 6.52$ ,  $P = 0.000$ ). The gastropod counts in the replanted sites were significantly higher compared to those in the other transects. In addition, a two-sample *t-test* of the sampling sites also showed highly significant differences between the replanted and natural sites (df = 166, mean difference = -0.463,  $t$ -value = -7.42,  $P = 0.000$ ). The replanted sites had higher gastropod counts, 40 vs 18 in the natural sites, although the natural sites had higher biodiversity ( $H' = 2.41$  vs 2.39). Our results support the literature showing that mangrove ecosystems support diverse gastropod communities, which play a crucial role in nutrient cycling, organic matter decomposition, and energy transfer (Lopez and Levinton 2011). The abundance of gastropods found in the replanted sites indicates ecological adaptation and is probably attributable to a

more favorable habitat structure for these gastropods, such as habitat complexity and heterogeneity provided by the root systems of *Rhizophora* sp., which protect them from predators. Although the natural stand had a lower number, the higher biodiversity can be attributed to the presence of more mangrove species located in the natural site. These differences may be due to vegetation composition, as Rhizophoraceae species dominate replanted areas and are more suitable for certain gastropod species, but other gastropods may find more favorable microhabitats in other mangrove species (Chen et al. 2021). Statistical analysis showed no significant difference in gastropod abundance among mangrove parts (leaves, trunks, and roots), suggesting uniform resource utilization. Overall, the findings of this study highlight the ecological importance of mangrove-associated gastropods and the need for conservation strategies to mitigate mangrove ecosystem disturbances.

**Table 1.** Density and relative abundance of gastropods found in naturally grown and replanted mangrove trees.

| Species   | Replanted                       |                        | Natural                         |                        |
|---|---------------------------------|------------------------|---------------------------------|------------------------|
|   | Density (ind 10m <sup>2</sup> ) | Relative Abundance (%) | Density (ind 10m <sup>2</sup> ) | Relative Abundance (%) |
| <i>Littoraria arduiniana</i> (Heude, 1885)          | 20                              | 5.20                   | 31                              | 14.88                  |
| <i>Littoraria articulata</i> (R. A. Philippi, 1846) | 30                              | 7.73                   | 11                              | 5.406                  |
| <i>Littoraria bengalensis</i> D. Reid, 2001         | 50                              | 12.74                  | 26                              | 12.72                  |
| <i>Littoraria carinifera</i> (Menke, 1830)          | 30                              | 7.65                   | 8                               | 3.54                   |
| <i>Littoraria intermedia</i> (R. A. Philippi, 1846) | 36                              | 9.18                   | 15                              | 7.24                   |
| <i>Littoraria filosa</i> (G. B. Sowerby I, 1832)    | 34                              | 8.64                   | 9                               | 4.16                   |
| <i>Littoraria pallescens</i> (R. A. Philippi, 1846) | 52                              | 13.33                  | 22                              | 10.57                  |
| <i>Littoraria scabra</i> (Linnaeus, 1758)           | 15                              | 3.82                   | 19                              | 8.89                   |
| <i>Nerita undata</i> Linnaeus, 1758                 | 59                              | 14.94                  | 15                              | 7.27                   |
| <i>Monodonta canalifera</i> Lamarck, 1816           | 33                              | 8.39                   | 14                              | 6.84                   |
| <i>Siphonaria javanica</i> (Lamarck, 1819)          | 13                              | 3.26                   | 7                               | 3.49                   |
| <i>Trochus maculatus</i> Linnaeus, 1758             | 20                              | 5.10                   | 16                              | 7.75                   |
| <i>Nerita histrio</i> Linnaeus, 1758                |                                 |                        | 7                               | 3.40                   |
| <i>Nerita albicilla</i> Linnaeus, 1758              |                                 |                        | 3                               | 1.24                   |
| <i>Siphonaria sirius</i> Pilsbry, 1894              |                                 |                        | 3                               | 1.34                   |
| <i>Siphonaria atra</i> Quoy & Gaimard, 1833         |                                 |                        | 3                               | 1.24                   |

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**GENERATIVE AI STATEMENT**

This study did not use any generative AI for its photos or editing.

**ETHICAL CONSIDERATIONS**

Permission for this research was obtained from the City Environment and Natural Resources Office (CENRO) of Mati City prior to the conduct of the study to ensure compliance with local regulations governing protected areas. The study involved only field observation and limited collection of gastropod

species for taxonomic identification, with no endangered or threatened species harmed.

## DECLARATION OF COMPETING INTEREST

The authors declare that there are no competing interests among the authors.

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**ROLE OF AUTHORS:** EDM- Conceptualization, methodology, software, formal analysis, writing—review and editing, supervision; NU- methodology, validation, investigation, writing—original draft preparation, visualization; IMN- visualization, drafting and revising the manuscript, investigation.

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