Environment and Ecology Research 13(4): 521-534, 2025 http://www.hrpub.org
DOI: 10.13189/eer.2025.130406

# The Coastal Greenbelt of Basilan, Philippines: An Initial Record of the Floristic Diversity and Conservation Status of the Beach Forests in Malamawi Island

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*Received March 11, 2025; Revised July 22, 2025; Accepted August 19, 2025*

***Cite This Paper in the Following Citation Styles***

***(a):*** *[1] Ashikeen S. Tampipi, Frandel Louis S. Dagoc, Ivane R. Pedrosa-Gerasmio, Chris Rey Lituanas, Wella A. Tiu-Tatil , "The Coastal Greenbelt of Basilan, Philippines: An Initial Record of the Floristic Diversity and Conservation Status of the Beach Forests in Malamawi Island," Environment and Ecology Research, Vol. 13, No. 4, pp. 521 - 534, 2025. DOI: 10.13189/eer.2025.130406.*

***(b):*** *Ashikeen S. Tampipi, Frandel Louis S. Dagoc, Ivane R. Pedrosa-Gerasmio, Chris Rey Lituanas, Wella A. Tiu-Tatil (2025). The Coastal Greenbelt of Basilan, Philippines: An Initial Record of the Floristic Diversity and Conservation Status of the Beach Forests in Malamawi Island. Environment and Ecology Research, 13(4), 521 - 534. DOI: 10.13189/eer.2025.130406.*



**Abstract** Beach forests, along with mangroves, serve as a buffer against natural calamities and provide other relevant ecosystem services. In an island ecosystem, this type of forest plays a significant role, especially in the absence of mangroves as frontlines. However, information regarding species composition and management strategies for this ecosystem is lacking in the island province of Basilan, Philippines. This study therefore assessed the species composition, diversity, and management of the beach forests in Malamawi Island, Basilan. Field sampling was conducted in July-August 2024, using the standard methods for beach forest assessment but with modifications. Three 100-meter transect lines were established along the beach forest areas. The transect lines were laid five meters above the highest tide mark with five 10x10m quadrats. Twenty-three species belonging to 18 families were recorded. Species diversity in Panigayan is low (H' = 2.23), while Marang-Marang and Lukbuton displayed very low diversity (H' values of 1.65 and 1.56, respectively). The evenness value across three sites ranges from 0.51-0.75, showing a semi-balanced species distribution. Among the species present, *Cocos nucifera* had the highest relative abundance value (30.303), indicating its dominance in the ecosystem and its significant ecological role in the area. Additionally, the management status of the ecosystem revealed that the beach forest is given the least attention compared to the other ecosystems, underscoring the lesser familiarity of this ecosystem. Hence, this study serves as a baseline in developing appropriate resource management strategies to conserve the integrity of the beach forest ecosystem of the island.

**Keywords** *Cocos nucifera*, Coastal Forest, *Terminalia catappa*, Coastal Barrier

## 1. Introduction

Coastal zones are the world's most diverse and productive environment, which includes complex ecosystems such as mangroves, seagrass, and beach forest [1]. Coastal greenbelts are vegetated buffer zones along coastal areas, mainly composed of mangroves and other salt-tolerant species [2]. This vegetation community acts as a natural barrier against flooding and typhoons and has a vital role in climate change mitigation by serving as important carbon storage [3] and reducing the rate at which seawater penetrates the land [4]. However, coastal ecosystems are already among the most threatened, housing about a third of the world's population and facing the impacts of climate change [5]. The vegetation landscape in coastal zones is developed as part of the tourism destination's experience, enhancing the well-being of the tourist, and boasting the local community's economic benefits [6]. Island communities, especially in the Philippines, also heavily rely on the marine and coastal resources that greenbelts support.

Beach forest, in particular, is a unique type of ecosystem, composed of a mixed group of littoral creepers, shrubs, and trees situated above the high tide level mark of the shore [7]. These plant species are suited to thrive in challenging environments such as fluctuating temperatures, salinity, and humidity, thereby influencing the makeup of plant communities [8]. Beach forests are essential for reducing the impact of disasters and climate change; shielding coastal communities and protecting their local properties against natural calamities [9], [10]. Although beach forests offer vital ecological services, environmental stresses like coastal development and climate change pose a growing danger to this ecosystem. Coastal threats like erosion, garbage dumping or those washed by the waves into the forest areas, establishment of infrastructures like beach houses or resorts, and cutting of trees in the beach forest pose an immediate problem to this ecosystem, which may negatively affect the biodiversity of the flora species, and impose potential extinction of some species [11]. In the Philippines, there is a limited number of studies on beach forests. At present, there are no scientific records available about the beach's floristic diversity and conservation status in Malamawi Island. Consequently, this ecosystem has not been incorporated into their integrated coastal management. Thus, this study aimed to assess the forest floristic diversity, its conservation status, and the local management practices in Malamawi Island, Basilan Province, Philippines.

# 2. Materials and Methods

### 2.1. Description of the Study Sites

The study was carried out in Malamawi Island, Basilan province. The island lies within the Sulu Sea, with an approximate land area of 1,754 ha and an estimated coastline length of 18.33 km. Field sampling was conducted from July to August 2024. Three barangays of the island served as the sampling sites, namely, Marang-Marang (6°44'40"N 121°59'26"E), Panigayan (6°42'49"N 121°56'25"E), and Lukbuton (6°44'05"N 121°56'41"E) (Figure 1).

Barangay Marang-Marang (Figure 2A) has a land area of 217.38 ha. The beach forest features a mix of low to medium-height trees, comprising salt-tolerant plant species which are well-adapted to sandy and saline conditions. The beach forest area of Marang-Marang is composed of small communities of the Sama-Banguingui tribe. Barangay Panigayan (Figure 2B) encompasses a land area of approximately 144.39 ha. This area features the longest beach forest of the three sites, with a notable distance from the communities. The beach forest in Barangay Panigayan features a variety of salt-tolerant trees and shrubs, these plants thrive in coastal environments, and some of them have distinctive shapes that are influenced by wind and salt exposure. The substrate is predominantly sandy, which is a common characteristic of coastal areas. Meanwhile, the barangay Lukbuton (Figure 2C) beach forests consist of various salt-tolerant tree and shrub species that stabilized the shoreline. They are low to medium-height trees, often twisted due to exposure to strong coastal winds, salt spray, and shifting sands. The soil is sandy or sandy loam, sometimes mixed with coral debris and shells. However, the majority of the shoreline within Lukbuton is privately owned.

### 2.2. Entry Protocol

A research permit was secured from the City Mayor's office of Isabela City and the Barangay offices of each site. Subsequently, a gratuitous permit was obtained from the Department of Environment and Natural Resources (DENR) Region 9 Office in Balintawak, Pagadian City, Zamboanga del Sur, in compliance with Republic Act No. 9147 - Wildlife Resources Conservation and Protection Act.

### 2.3. Field Sampling and Collection

Data were collected from July to August 2024, using the standard methods for forest assessment but with modifications. In each site, three 100-meter transect lines were established parallel to the shore and five meters above the highest high tide mark in the beach area [12]. In every transect line, five 10m x 10m quadrats were laid at a 10-m distance from each other. All plants, such as trees, shrubs, and vines found in the quadrats, were documented and identified based on their morphological structure. Each plant species was identified up to its lowest taxonomic level using the field guide on Mangroves & Beach forests in the Philippines [13] and Co's Digital Flora of the Philippines. Further verifications were done by sending voucher specimens to the Central Mindanao University Museum, Bukidnon.

The report on each species' conservation status was based on the IUCN Red List of Threatened Species 2021-1 (www.iucnredlist.org) and the DENR Administrative Order (DAO) 2017-11.

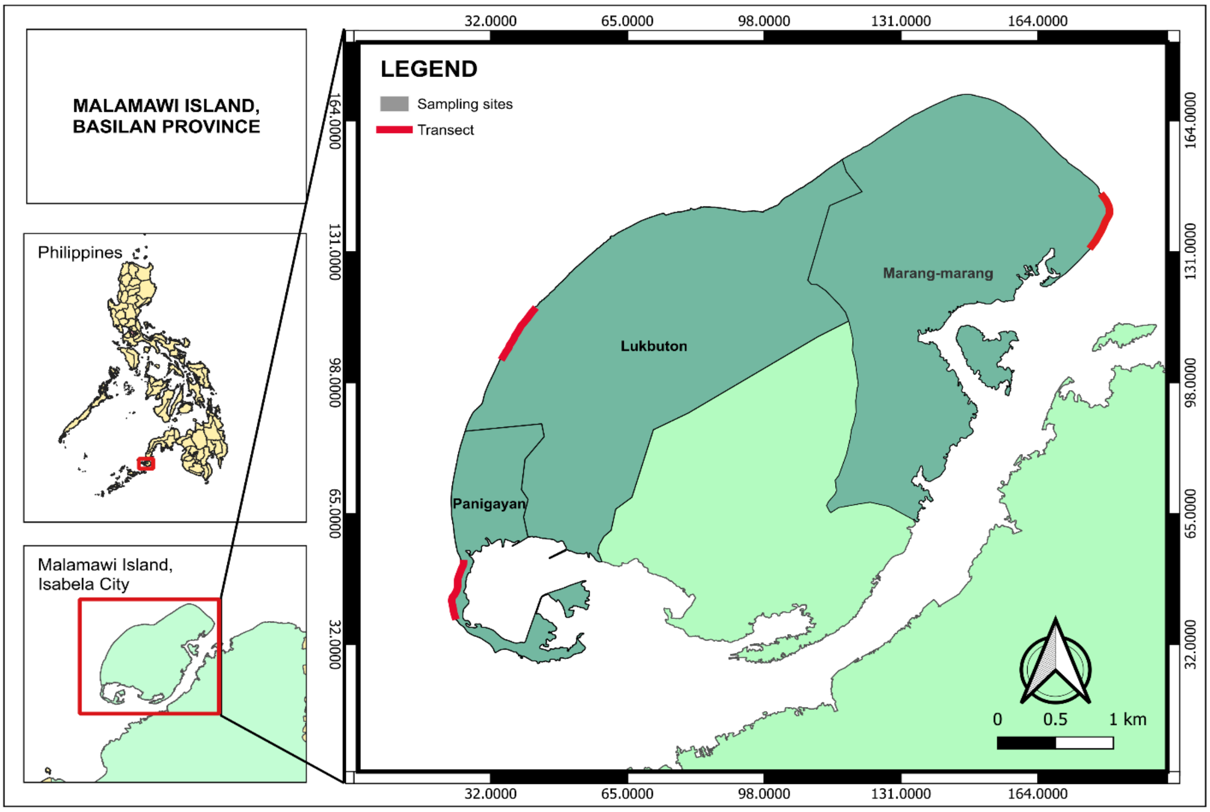



**Figure 1.** The location of the sampling sites in Malamawi Island, Basilan, Philippines (Generated using the QGIS Software Version 3.36.2). Note: Red lines indicate the sampling points where the transect lines were established


**Figure 2.** Photos showing the beach forests of the selected study sites; (A) Marang-Marang, (B) Panigayan, and (C) Lukbuton

### 2.4. Data Analysis

Microsoft Excel was used to compute descriptive statistics such as counts and mean. The species diversity, dominance, and evenness indexes were analyzed using the Shannon-Wiener Diversity index formula. On the other hand, the Paleontological Statistics 4.03v (PAST) [14] was used to evaluate the species diversity indices. The descriptive value is shown in Table 1.

**Table 1.** Descriptive value for species diversity and evenness indices [15]

| Diversity | | Evenness | |
|---|---|---|---|
| Values | Description | Values | Description |
| >3.50 | Very high | 0.96-1.00 | Balanced |
| 3.00-3.49 | High | 0.76-0.95 | Almost balanced |
| 2.50-2.99 | Moderate | 0.51-0.75 | Semi-balanced |
| 2.00-2.49 | Low | 0.26-0.50 | Less balanced |
| <1.99 | Very low | 0.00-0.25 | Unbalanced |

For the Shannon Diversity Index, the following formula was used [16]:

$$H' = \sum_{i=1}^{S} Pi \ \ (lnPi)$$

Where:
H=Species Diversity Index,
s = Number of Species,
Pi = fraction of the entire population made up of species i,
Σ= sum from species 1 to species S
For Simpson's Dominance Index, the following formula was used [17]:

$$D = \sum_{i=1}^{s} Pi^2$$

Where:
D = Value of Simpson's diversity index,
Pi = proportion of individuals in the ith species,
S = number of species
For the Evenness index, this formula was used [18]:

$$e = HlnS$$

Where:
H = species Diversity index,
S = total number of species in the sample

# 3. Results and Discussion

### 3.1. Beach Forest Community Structure

The beach forest of Malamawi Island has a total of 23 species belonging to 18 families (Table 2). Among these species, seven are considered trees, 14 are shrubs, and one is a vine. The families Lamiaceae, Euphorbiaceae, Fabaceae, and Verbenaceae, were each represented by two species, while all other families were represented by a single species. Five beach forest species were common in the three barangays: *Cocos nucifera, Premna serratifolia, Terminalia catappa, Pandanus tectorius,* and *Morinda citrifolia* (Figures 3a & b), of which, *C. nucifera* has the highest abundance value and a total of 149 individuals recorded throughout the three sampling sites. In this floral composition, only eight species are recorded under the “least concern” category in the IUCN Red List. Six species belong to the “Other Wildlife Species” classification in the Philippine DENR List, while the others are not yet evaluated.

Based on the Shannon diversity index, the beach forest of Panigayan is considered to have low diversity (H’= 2.23), while Marang-Marang (H’=1.65) and Lukbuton (H’=1.56) are regarded as very low diversity (Figure 4). In terms of species distribution, Panigayan and Lukbuton showed semi-balanced distributions with evenness values of 0.71 and 0.59, respectively. In contrast, Marang-Marang had a relatively lower evenness value of 0.40, indicating a less-balanced distribution. The low diversity value in Lukbuton may be attributed to the growing advancement of coastal tourism in the area. Additionally, coastal erosion is one of the concerns in these areas, which occurs when wind, waves, and longshore currents move sand from the shore and deposit it elsewhere. As observed, the large trees in Lukbuton are affected by soil erosion, causing their large roots to be exposed and unable to support against incoming large waves, which could affect their growth.

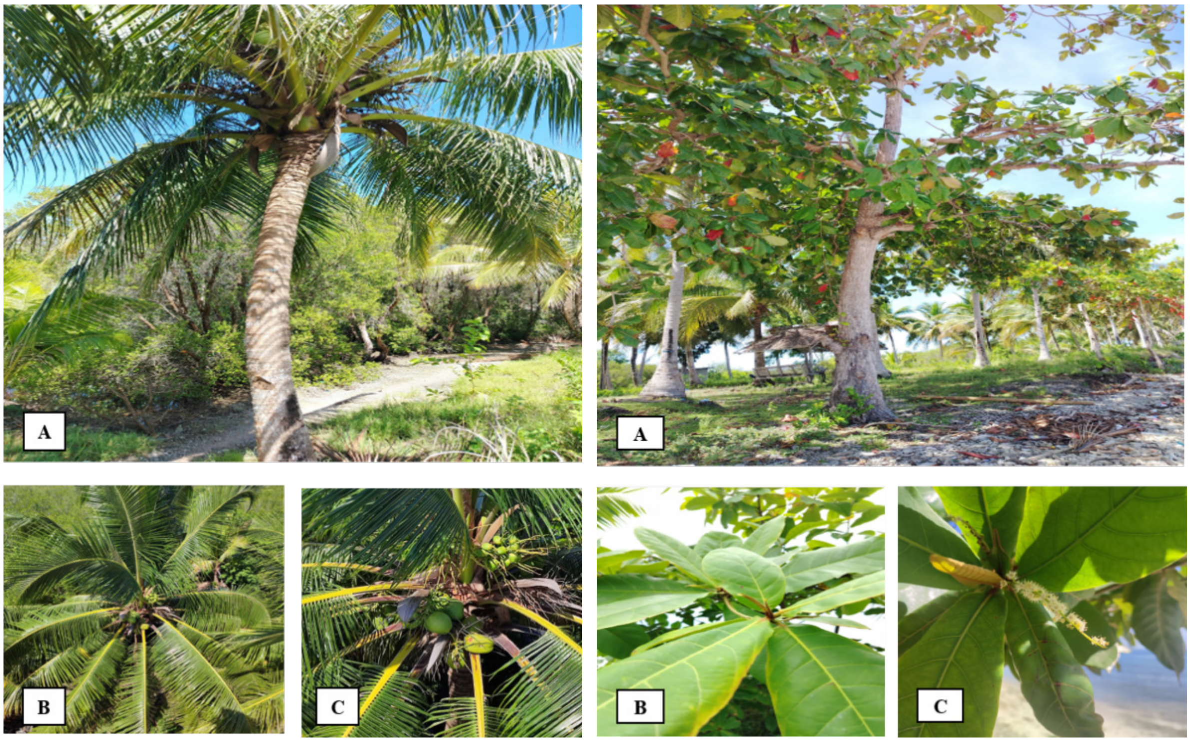
*Scaevola taccada* is only found in one site (Panigayan), and this species is a good regulator of sand erosion. The plant is important for erosion control, beach stabilization, and landscaping, and it is a promising species for the restoration of coastal vegetation [19]. This species, along with *Ipomoea pes-caprae*, thrives closest to the high tide line, and is regularly exposed to salt spray, wind, and sand movement [20].

The diversity values showed a limited number of species across all sites. This may be attributed to rapid land conversion, human settlements, and the recent conversion of beaches to resorts and tourist spots. These anthropogenic pressures impact biodiversity and ecosystem services. The same observation was recorded in the beach forest of San Fernando, San Jose, Antique [7], Southern Philippines [9], and San Agustin, Romblon [11]. Recently, beaches have been converted into recreation spaces in Malamawi, and being an island, the coastal area is vulnerable to natural changes like high-intensity storms and sea-level rise [21] adding pressure to the coastal greenbelt diversity. Unlike coastal forests on the mainland, island forests are often discontinuous due to topography, heterogeneous distribution of resources, [22] and island size [23]. Plant communities on the islands endure the full force of wind, increased wave height and energy, and salt inundation relative to mainland coastal communities due to their geographic position [24].

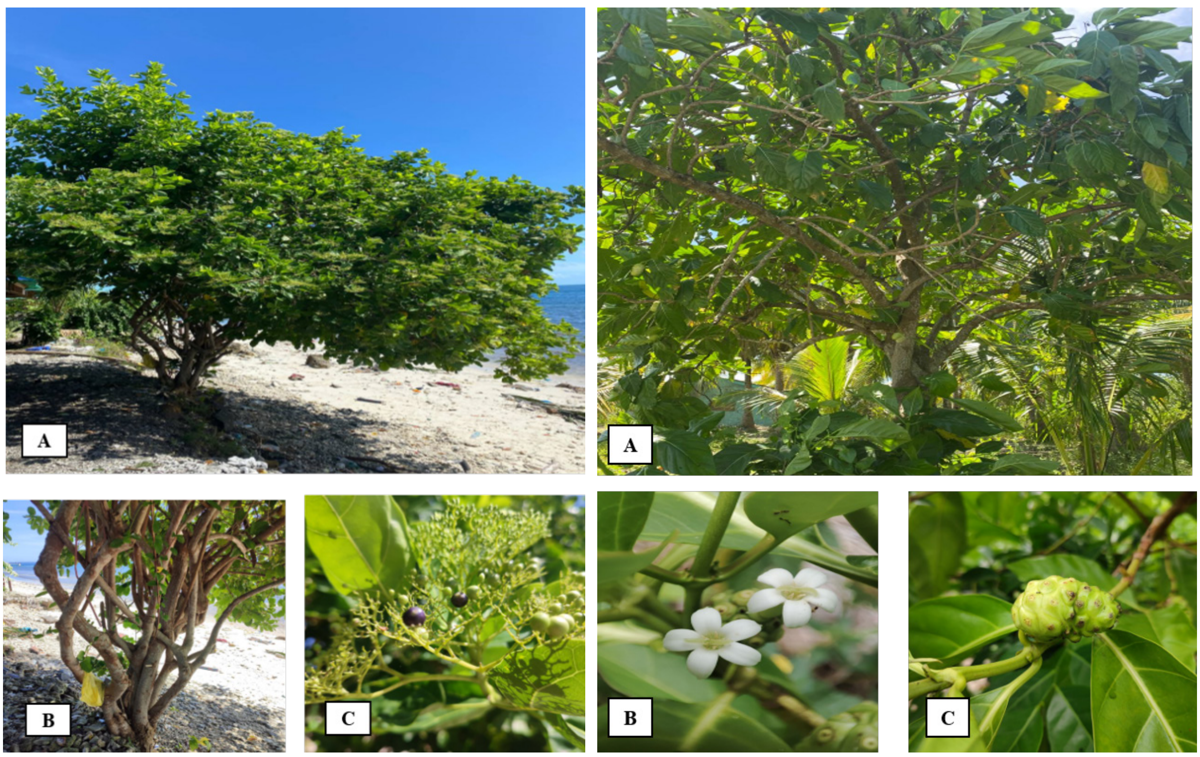
**Table 2.** Checklists of identified beach forest plant species in Malamawi Island

| Family | Species | Common name | Habitus | Distribution per site | | | Conservation status | |
|---|---|---|---|---|---|---|---|---|
| | | | | Marang-Marang | Panigayan | Lukbuton | DAO 2017-11 | IUCN Red list (2024) |
| Apocynaceae | *Tabernaemontana pandacaqui* Lamark, 1885 | Banana bush | shrub | ✓ | ✓ | | | |
| Arecaceae | *Cocos nucifera* Linnaeus, 1753 | Coconut | tree | ✓ | ✓ | ✓ | OWS | LC |
| Combretaceae | *Terminalia catappa* Linnaeus, 1753 | Sea almond tree | tree | ✓ | ✓ | ✓ | OWS | LC |
| Euphorbiaceae | *Euphorbia cyathophora* Murray, 1786 | Dwarf poinsettia | shrub | ✓ | | | | LC |
| Euphorbiaceae | *Euphorbia tirucalli* Linnaeus, 1753 | Pencil cactus | shrub | ✓ | | | | LC |
| Fabaceae | *Prosopis juliflora* (Swartz) De Condolle, 1825 | Mesquite | shrub | ✓ | ✓ | | | LC |
| Goodeniaceae | *Scaevola taccada* (Gaertner) Roxburgh, 1814 | Sea cabbage | shrub | | ✓ | | | |
| Nyctaginaceae | *Bougainvillea glabra* Choisy, 1849 | Paper flower | shrub | ✓ | | | | |
| Lamiaceae | *Premna serratifolia* Linnaeus, 1753 | Headache tree | shrub | ✓ | ✓ | ✓ | | LC |
| Lamiaceae | *Vitex trifolia* Linnaeus, 1753 | Three-leaved chaste tea | shrub | | ✓ | | | |
| Lecythidaceae | *Barringtonia asiatica* (Linnaeus.) Kurz, 1875 | Fish poison tree | tree | | | ✓ | OWS | LC |
| Meliaceae | *Azadirachta indica* Juss, 1830 | Neem tree | tree | | | ✓ | | LC |
| Moraceae | *Artocarpus blancoi* (Elmer) Merril, 1923 | Breadfruit | tree | | | ✓ | | LC |
| Pandanaceae | *Pandanus tectorius* Parkinson ex Du Roi, 1774 | Beach pandan | shrub | ✓ | ✓ | ✓ | OWS | |
| Rubiaceae | *Morinda citrifolia* Linnaeus, 1753 | Indian mulberry | tree | ✓ | ✓ | ✓ | OWS | LC |
| Sapindaceae | *Dodonea viscosa* Jacquin, 1760 | Jamaica dogwood | shrub | | ✓ | | | |
| Taccaceae | *Tacca leontopeloides* (Linnaeus) Kuntze, 1891 | Seashore bat lily | shrub | ✓ | ✓ | | | LC |
| Apocynaceae | *Catharanthus roseus* (Linnaeus) Don, 1837 | Madagascar periwinkle | shrub | | ✓ | | | |
| Fabaceae | *Gliricidia sepium* (Jacquin) Kunth, 1842 | Madre cacao | shrub | | ✓ | | OWS | |
| Moringaceae | *Moringa oliefera* Lamarck, 1785 | Drumstick tree | tree | ✓ | ✓ | | | LC |
| Passifloraceae | *Passiflora foetida* Linnaeus, 1753 | Stinking passion flower | vine | ✓ | | | | |
| Verbenaceae | *Lantana camara* Linnaeus, 1753 | West Indian lantana | shrub | ✓ | ✓ | | | |
| Verbenaceae | *Stachytarpheta jamaicensis* (Linnaeus) Vahl, 1893 | Blue snakewood | shrub | ✓ | | | | LC |

Note: **LC**- least concerned **OWS-** other wildlife species (plant species that are native to the Philippines

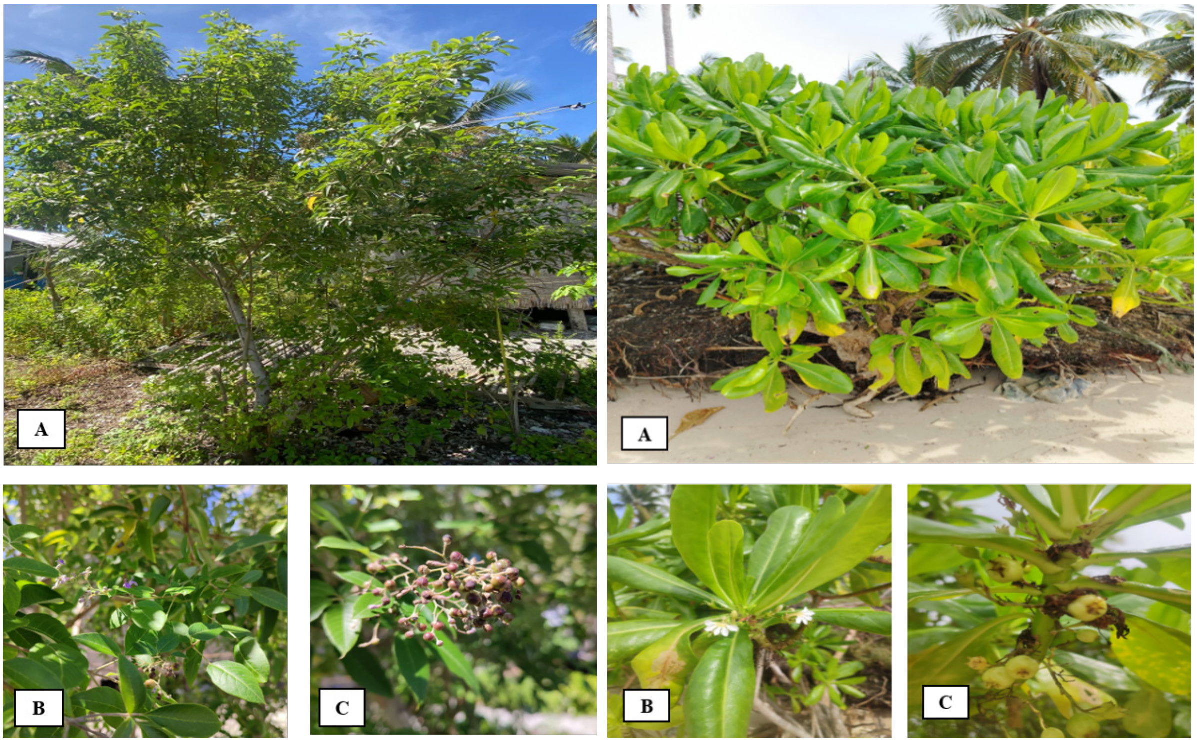



(1) *Cocos nucifera* **(A)** Whole tree, **(B)** Leaves, **(C)** Fruits (2) *Terminalia catappa* **(A)** Whole tree, **(B)** Leaves, **(C)** Flower




(3) *Premna serratifolia* **(A)** Whole tree, **(B)** Trunks, **(C)** Fruits (4) *Morinda citrifolia* **(A)** Tree, **(B)** Flowers, **(C)** Fruit

**Figure 3a.** Photos of common Beach forest plant species across sampling sites; (1) *Cocos nucifera,* (2) *Terminalia catappa,* (3) *Premna serratifolia,* (4) *Morinda citrifolia*




(5) *Vitex trifolia* **(A)** Whole tree, **(B)** Flower, **(C)** Fruits (6) *Scaevola taccada* **(A)** Whole tree, **(B)** Flowers, **(C)** Fruits


(7) *Pandanus tectorius* **(A)** Whole tree, **(B)** Leaves, **(C)** Fruit (8) *Barringtonia asiatica* **(A)** Whole tree, **(B)** Flower, **(C)** Fruits

**Figure 3b.** Photos of common Beach forest plant species across sampling sites; (5) *Vitex trifolia,* (6) *Scaevola taccada,* (7) *Pandanus tectorius,* (8) *Barringtonia asiatica*

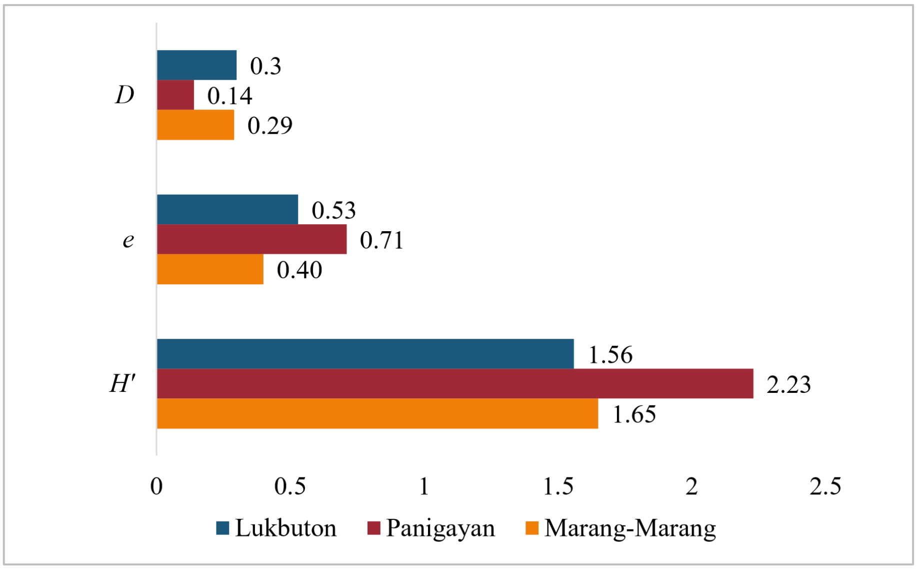



**Figure 4.** Diversity index value of the beach forest plant species in the three sampling sites of Malamawi Island, Basilan, Philippines. Note: *D* - dominance; *e* - evenness; *H'* - Diversity

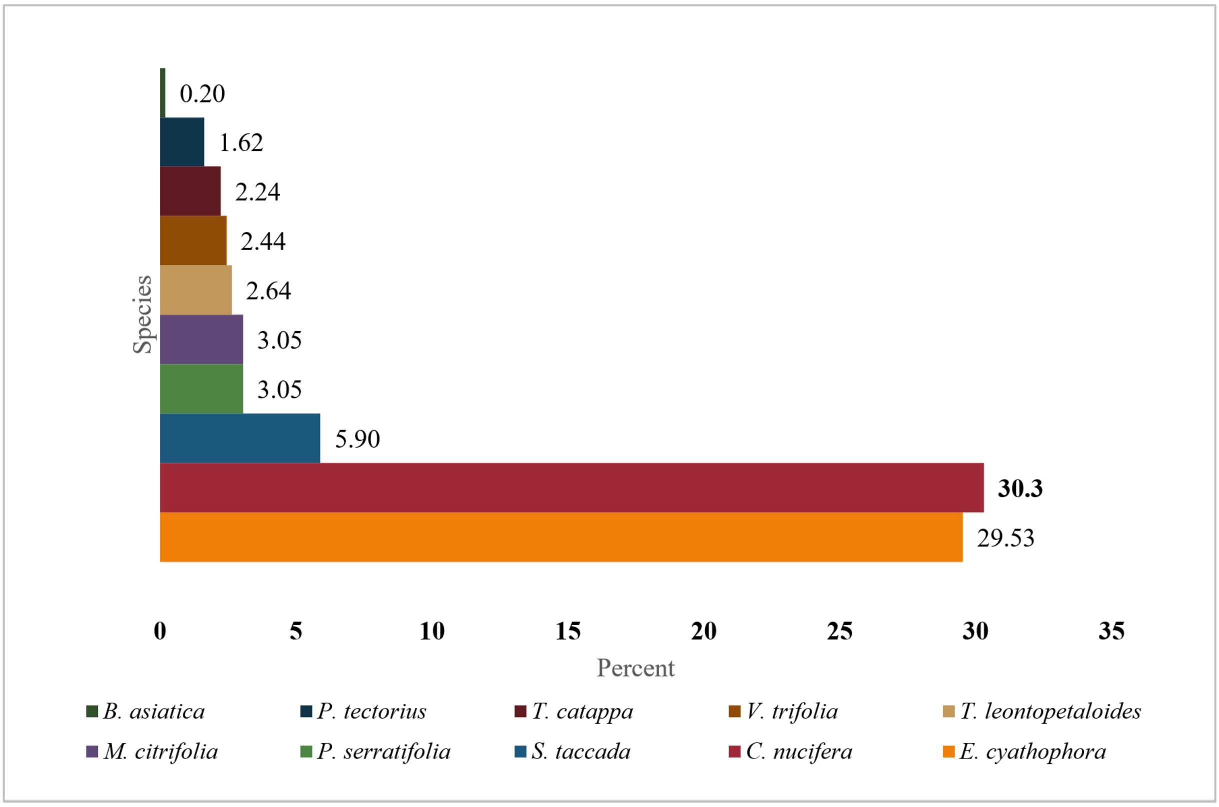



**Figure 5.** Relative abundance of the beach forest plant species in the three sampling sites of Malamawi Island, Basilan, Philippines

Moreover, *C. nucifera* (coconut) recorded the highest abundance among the species across the three sampling sites, with a relative abundance value of 30.30 (Figure 5). As a source of food, water, fuel, and construction materials, the coconut played a fundamental role in human migrations and the development of civilization across the humid tropics [25]. A great deal of study has been done on their pharmacological characteristics, which has shown promise for usage in a variety of industries, including food, cosmetics, biodiesel, pharmaceuticals, etc. [26], [27]. Invasions of palm trees have also been shown to produce new habitats, however, the precise ecological effects are yet unclear. Urbanization and global warming are also predicted to spread palm species further and make it easier for non-native palms to establish themselves in new environments [28].

### 3.2. Beach Forest Plant Species Distribution

The distribution of beach forest plant species varies in every sampling site. Five species were common across the three sampling sites namely; *C. nucifera, M. citrifolia, P. tectorius, T. catappa,* and *P. serratifolia. C. nucifera* has the highest count, with 149 individuals. On the other hand, a few of the coastal forest plants only existed in a single sampling site, indicating limited distribution (Table 2). Among the three sampling sites, Panigayan had the highest species composition which consisted of 15 identified beach forest plants, followed by Marang-Marang (14 species) and Lukbuton (9 species). The species composition of Panigayan can be attributed to the fact that this forest area has fewer nearby houses and no sign of coastal development. The prevalence of *T. catappa, C. nucifera,* and *M. citrifolia* in beach forest areas was also reported in other studies [7], [9], [11].

*C. nucifera* from the family of Arecaceae, or palms, is a well-known botanical family with 2,600 species that are found in tropical and subtropical areas [29]. They are also very important both culturally and economically. In the tropics, the *C. nucifer*a is among the most exquisite and practical trees. It is cultivated in over 90 nations, with Asia and the Pacific accounting for most of the global production. Together, the Philippines, Indonesia, India, Sri Lanka, Thailand, Malaysia, and Papua New Guinea make up almost 80% of the world's coconut plantations [30]. In Malamawi Island, *C. nucifera* served as one of the income sources of the locals through copra and charcoal production.

The high abundance of *C. nucifera* was also evident in the study in the beach forest of Homonhon Island [31] and San Augustin, Romblon [11], Philippines. *C. nucifera* can be tolerant to saline conditions and can grow in sandy, nutrient-poor soils where other trees struggle. The root system of the coconut binds the soil particles and consequently prevents soil erosion due to run-off caused by heavy rain or wind [32].

Euphorbia is one of the most varied Angiosperm genera of flowering plants, with over 1840 species scattered worldwide [33]. Euphorbia species occupy a wide range of habitats and exhibit great diversity growth forms including many kinds of prostrate, ascending, erect and small ephemeral herbaceous annuals or perennial, trees, woody perennials, shrubs and many types of cactus-like succulents. In this study, *E. cyathophora* and *E. tirucalli* were recorded in only one site (Marang-marang), where *E. cyathophora* was the second most abundant beach species next to coconut.

*M. citrifolia*, or Indian mulberry, is a type of coastal tropical evergreen tree that is used for a variety of purposes, including wood, dye, vegetables, animal feed, cosmetics, and herbal medicine. The species is suited for the marginal areas of tropical coastal ecosystems since it is resilient and tolerant of salinity and shade [34]. While *P. tectorius*, a widely known coastal plant belonging to the Pandanaceae family, is a dioecious tree that resembles a palm that grows widely on rock and sandy coastlines. It has a noticeable prop root at the base of the trunk that supports the plant in windy and wet conditions [35].

*Premna serratifolia* is a member of the Lamiaceae family and is native in tropical and subtropical. This shrub has a maximum height of 1.5 meters [36], and has various medicinal uses and pharmacological properties such as tumor cell suppression, cytotoxic, anti-inflammatory, and anticancer properties [37], [38].

Notably, several species are known to thrive in the beach forest area. Table 3 displays the list of beach forest flora observed outside the established transect lines, i.e. *Ipomoea pes-caprae, Milletia pinnata* (in Marang-Marang and Lukbuton), and *Cordia subcordata* (Marang-Marang). *Ipomoea pes-caprae* (Convolvulaceae), a pantropical plant with sea-drifted seeds, is found globally in the littoral areas of tropical and subtropical regions [39]. It has a high nutrient-utilization efficiency and plays an important role in sand fixation, wind resistance, landscape greening, and ecological restoration in tropical and subtropical coral islands and coastal zones [40]. *I. pes-caprae* is a conspicuous ground runner, which plays a strong role in preventing erosion of the beach in the islands, therefore is widely used in improving islands' coastal areas. The plant parts of *I. pes-caprae* are used in traditional medicine to treat diseases such as inflammation, gastrointestinal disorders, pain, and hypertension [41].

**Table 3.** Other beach forest species identified outside of the transects are considered

| Family | Species | Conservation status |
|---|---|---|
| Convolvulaceae | *Ipomoea pes-caprae* (L.) R. Br. | Least concern |
| Fabaceae | *Millettia pinnata* (L.) | Least concern |
| Boraginaceae | *Cordia subcordata* Lam. | Least concern |

*Millettia*, belonging to the Fabaceae family, consists of about 200 species thriving in tropical and subtropical regions. The seeds of *Millettia pinnata*, an endemic plant in Asia, are frequently used to produce biodiesel [42], [43]. *Millettia* trees can tolerate harsh environments and have the potential to fix nitrogen. They are frequently employed for dune binding and soil erosion management [44], with their dense network of lateral root systems [45].

Meanwhile, *C. subcordata* (Boraginaceae) is a woody tree that grows in coastal wasteland and mangrove edges. It has a strong resistance to wind because of its developed root systems. The features of *C. subcordata*, such as its large leaf area, high density of leaf epidermal stomata, thick upper epidermis, high vessel diameter and density, low leaf water conductivity, and high xylem density, may adapt to conditions brought by drought, *i.e.,* high temperatures, poor soil, and intense sunlight [46] - a relatively same environmental condition in tropical coastal regions. Its wood is used for woodcraft, and the tree, which is used in landscaping, also has medicinal and ecological value (e.g., coastal protection) [47].

### 3.3. The Influence of Soil Nutrients on the Species Abundance of Beach Forest

Changes in plant diversity and vegetation structure might result from soil's significant involvement in habitat creation and heterogeneity [48]. The availability of nutrients affects almost every element of an ecosystem and plays a crucial role in how such ecosystems react to changes [49]. Recent research on tropical forests has shown a favorable correlation between soil nutrient concentration and plant species richness [50]. The lack of soil nutrients can impact the structure of the forest community [51]. In general, low pH and soil nutrients may be limiting factors for species growth and distribution [52].

In the Canonical Correspondence Analysis (Figure 6), it was revealed that the sampling sites' mean values of organic matter are 12.07% (Marang-Marang), 13.25% (Panigayan), and 14.47% (Lukbuton). The mean potassium level across the sampling sites is high and ideal with a range from 155-355 ppm. Moreover, soil pH significantly affects plant variety, and the spread of many tropical species is restricted by the combination of acidic soil and low temperatures [53]. As observed, Marang-Marang has a pH of 7.84, Lukbuton with 7.71, and Panigayan with 7.35, revealing a slightly alkaline soil conditions thereby a limiting factor in the selection of plant species thriving the area. This indicates that essential micronutrients may become less available for plant uptake.

The Canonical Correspondence Analysis (CCA) ordination plot illustrates the relationship between species composition, environmental variables, and study sites (Figure 6). This analysis provides insights into the main environmental variables influencing the distribution of plant communities in the study area. The direction and length of the vectors demonstrate how important the environmental factors—pH, potassium, phosphorus, and organic matter—are in forming plant communities. The pH and potassium vectors are oriented towards the left, suggesting that species positioned in this direction are associated with more alkaline and potassium-rich soils. Notably, *Euphorbia cyathophora* and *Lantana camara* are closely linked to these variables, indicating their preference for such conditions. *Lantana camara* is considered invasive species and not very selective of its environmental condition, hence the results.

The phosphorus vector, which is pointing slightly upward, indicates that the availability of phosphorus may have a positive effect on species like *Cocos nucifera*. Phosphorus is a crucial macro-nutrient for plant growth, particularly in nutrient-poor tropical soils, and has been shown to affect species richness and productivity [54]. On the other hand, species like *Terminalia catappa* and *Pandanus tectorius* are closely aligned with the organic matter vector, which extends to the right, indicating that these species do well in regions with higher levels of organic matter.

The findings of this study highlight the importance of soil properties in shaping vegetation patterns. The fact that certain species are positioned away from the environmental variables that were measured implies that other elements, like competition, water availability, or human disturbance, might potentially have an impact on species assemblages.

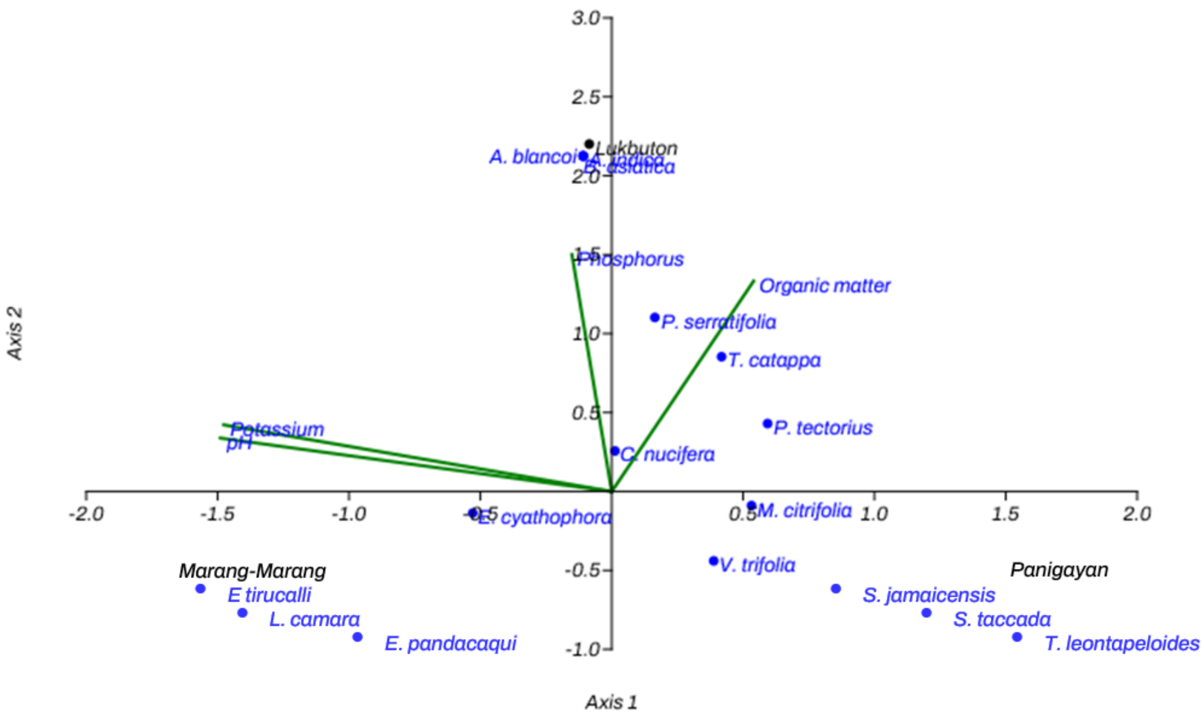



**Figure 6.** Canonical Correspondence Analysis (CCA) influencing soil nutrients and species abundance. Note: Blue font – Soil nutrients; Bulleted blue font – Species; Black font – Sampling sites

### 3.4. Management Assessment

Nature conservation and tourism interests must be balanced as a result of growing environmental policy, demand for nature protection areas, and demand for beach tourism spaces [55]. Extreme weather events, coastal erosion, physical damage to infrastructure, increasing sea levels, floods, water shortages, and water contamination are just a few of the environmental elements that make islands and coastal communities particularly vulnerable [56]. Sandy beaches are extremely vulnerable because they are not effectively maintained or frequently included in conservation efforts since they are not recognized as ecosystems [57]. In Malamawi, there is no comprehensive management plan, particularly in the beach forest ecosystem.

Responses from the key informant's interviews revealed their limited knowledge about beach forest. Most of them are only familiar with *C. nucifera, T. catappa, P. tectorius,* and *M. citrifolia* as the most common plants they observed in the three sites. Accordingly, the local government initiated the planting of *T. catappa* but was not consistent because they observed that the planted trees did not grow well. Likewise, no specific local ordinances regarding the cutting of beach forest trees in Malamawi Island was in place, which could be the underlying factor why cut trunks can be observed in the area. Some portions of beach forests were also cleared for road networks as well as the establishment of cottages for tourism. Beach forests located near sandy shores are mostly privatized and prepared for tourism purposes.

Additionally, some member of the communities gathers dead wood for charcoal making. The coconut trees are used for copra production, which is another source of income for the locals. The coconut shells are used for charcoal making, either for household fuel consumption or sold for additional income. Some areas in the beach forest are open to community activities like picnic, camping, and nature-based activities like photography and sightseeing.

Given the current findings, several important management decisions about the beach forest ecosystems under consideration must be made. To begin, the primary cause of disturbance that results in structural changes to the usual spatial arrangement of coastal plant communities is erosion [58] which is evident in the beach forest sampling sites. The most popular method for preventing erosion is to make the beach semi-stable by stopping sand movement through fencing and planting beach forest plants like *I. pes-caprea*. *I. pes-caprea* is a primary sand stabilizer, being one of the first plants to colonize the dune and enduring salted air [59]. Their elongated root system helps bind the sediment particles and is very effective in controlling erosion [60]. It is one of the most common and most widely distributed salt tolerant plants, which produce water dispersed seeds that float and are unaffected by salt water, remaining viable for up to six months in sea water [61].

Despite the Philippines' island ecosystems' inherent capacity for robust coastal resilience, management assessment shows that their coastal greenbelts are under threat because of absence or lax enforcement of policies, scarce resources, and a lack of adoption of indigenous knowledge. Numerous coastline lengths have degraded as a result of various phenomena, necessitating ongoing management measures. While the natural functioning of beaches provides significant economic benefits to society, particularly in terms of protection, recreation, and aesthetics, the conflict lies in the differentiated interest in these habitats. Coastal areas are frequently overused for temporary recreational and aesthetic purposes, as well as residential and commercial spaces which compromise the ecosystem integrity and continuous delivery of services. This progressive scenario calls for localized and site-specific actions to ensure ecosystem sustainability.

# 4. Conclusions

The coastal greenbelt of Basilan, particularly in Malamawi Island, serves as an important ecological zone characterized by the presence of diverse beach forest species. The beach forest ecosystem of Malamawi Island has a total of 23 species belonging to 18 families; of which *C. nucifera* is the most abundant. The three sampling areas have a low diversity, nonetheless still can sustain biological processes, offer habitat for several species, and enhance the stability and resilience of the coastal ecosystem as a whole. However, with the low species diversity and the growing environmental pressures, this ecosystem may be more vulnerable to disturbances. Based on the management survey, the beach forest does not have any management regulations because the community is engaged more in the management practices of mangroves. There is a lack of focus on beach forests, which should be included in the priority in conservation and management efforts, as they also offer crucial ecosystem services similar to other forest types, beyond their aesthetic significance. Major recommendations include full inventory research on the beach forests on the island, an Information Education Communication (IEC) campaign to educate the locals about this forest type, conduct of coastal resource management planning through Focus Group Discussions (FGDs), and formulation of policies for conservation and management strategies for the beach forests in Malamawi Island, Basilan.

# Acknowledgments

The first author would like to express her gratitude to the Department of Science and Technology - Accelerated Science and Technology Human Resource Development Program (DOST-ASTHRDP), Philippines, for the graduate research grant. To the City Agriculture of Isabela City, Basilan, headed by Sir Albino Orbecido and his office members Sebastian Guerero, Mark Anthony Tisoy, and Gabby, for the logistical support for the entire sampling period. Special thanks are extended to Jill Ruby Parmisana, Nur Inih U. Sahidjan, and Norvie A. Semine for their assistance in field sampling.

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