Thailand Natural History Museum Journal 18(2): 97–105 (2024)

Floral assessment of riparian ecosystem along Cambantoc River in Bay, Laguna Philippines

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Article History
Received: 11 October 2024
Accepted: 26 December 2024

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ABSTRACT

Riparians are wetlands along rivers and streams that are ecologically and economically important; however, these ecosystems are in danger of losing vital functions due to developmental activities and natural disturbances like in the case of the Cambantoc River in Bay, Laguna. This study investigated riparian ecosystems through floral assessment that can be useful for future rehabilitation to conserve biodiversity. Belt transects and quadrat sampling were followed to assess vegetation using kilometer transects established along each of upstream, midstream, and downstream. Five quadrants (10x10 m^2 each) were demarcated per transect for trees (>10 cm Diameter at Breast Height [DBH]) with 3x3 m^2 and 1x1 m^2 to cover intermediate and undergrowth, respectively totaling a 3 km transect and 1,500 m^2 sampling area. Plants were identified morphologically across structural layers, and their conservation status was determined. Ecological values, species evenness, and Shannon-Weinner diversity index were analyzed. Results revealed the dominance of agroforestry in the upstream while remnants of woodlands were described midstream and downstream, suggesting young secondary growth vegetation. There were 139 plant species belonging to 21 genera and ten families dominated by *Lansium domesticum* Correa upstream with an abundance of invasive *Broussonitia papyrifera* (L.) Vent., indicating a level of anthropogenic disturbances. There were 2 vulnerable species recorded, eight exotic species, and 13 native species that are possibly considered for rehabilitation. Frequently occurring species like *Ficus ulmifolia* Lamk, *Ficus septica* Burm. F., and *Ficus nota* (Blanco) Merr. are ecologically important in riparian restoration.

Keywords: conservation, rehabilitation, riparian restoration, species diversity

Citation. Peña R.J.C. and N.M. Pampolina. 2024. Floral assessment of riparian ecosystem along Cambantoc River in Bay, Laguna Philippines. *Thailand Natural History Museum Journal* 18(2): 97–105.

INTRODUCTION

Riparian ecosystems are some of the most diverse terrestrial ecosystems found across all continents. Their physical characteristics, along with seasonal and annual flow and sediment patterns, are shaped by geological and ecoregional factors, water and sediment distribution, connectivity, and the local species pool. However, threats to the health of rivers, riparian areas, and the wildlife they support are increasing due to climate change's impact on the Earth's water cycle and land cover. Additionally, ongoing human development around rivers is further disrupting ecological processes globally (Meritt, 2022).

Humans cause considerable harm to riparian plant communities, which are intricate and dynamic systems that support various species. Additionally, changes in land use have affected the diversity of species within these riparian habitats (Ventura, 2024). Anthropogenic activities cause various changes in the riparian ecosystem. It ranges from alterations of hydrological activities, geomorphic structure, and the loss of riparian vegetation. The loss of tree diversity has detrimental effects on the area, such as excessive flooding, its contribution to the downstream, and outlet pollution as being part of the watershed. Ongoing human activities, such as population growth and land conversion, particularly in the upstream watersheds of many Philippine rivers, are putting pressure on riparian ecosystems. These changes are affecting the rate, quantity, and quality of ecosystem services. In the agricultural province of Bukidnon, riparian areas are frequently used for growing crops like corn and rice. Nearly all the rivers in the province face threats from excessive siltation and declining water quality, with varying levels of severity due to the ongoing exploitation of natural resources (Opiso *et al*., 2015).

Thus, this study aimed to investigate the characteristics of flora along Cambantoc River riparian ecosystems, specifically to; (a) characterize the species composition and riparian vegetation along the river, (b) assess the implications of floral diversity for future rehabilitation and conservation of riparian ecosystems.

MATERIALS AND METHODS

Study Area

The study was conducted in Cambantoc River, which is one of the streams of the Cambantoc subwatershed that serves as a passage of water to the main outlet of the Mt. Makiling Forest Reserve (MMFR) watershed which is Laguna Lake. Upstream, the initial sampling location was identified at 14°07'27.95"N, 121°15'06.40"E. The midstream plot was located at 14°08'57.34"N, 121°16'18.63"E, while the downstream site was at 14°10'58.81"N, 121°16'40.86"E.

Data collection

Samples were gathered from upstream, midstream, and downstream sections of the Cambantoc River as shown in Figure 1. The upstream data were collected in Brgy. Sta Cruz, Bay, Laguna, an area primarily used for agroforestry. The midstream, samples were taken from Brgy. Paciano Rizal, Bay, Laguna, which is now a residential zone undergoing riprap construction. Finally, representative samples for the downstream area were collected in Brgy. Maitim, Bay, Laguna.

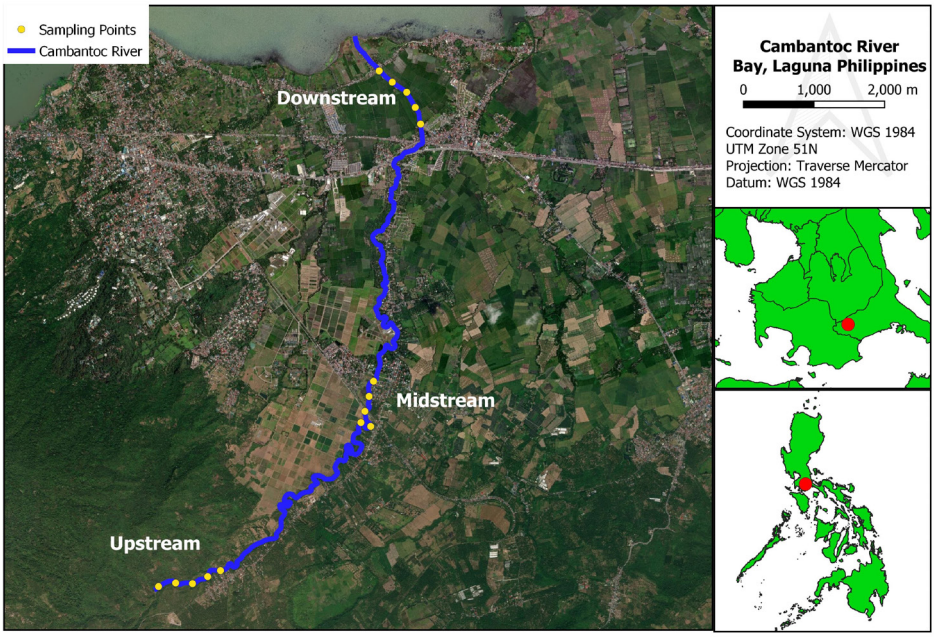

Figure 1. Map of the study site.

Sampling design

A 1-kilometer transect line was established in the upstream, midstream, and downstream areas, with each transect containing five plots set up every 250 meters. The quadrats were oriented in alternating directions to avoid sampling bias. Each area included a sample plot measuring 10 m x 10 m. Within this plot, a 10 m x 10 m quadrat was designated for observing upper canopy trees, along with a 3 m x 3 m quadrat for understory trees and a 1 m x 1 m quadrat to evaluate ground cover.

The nested quadrat for each plot was designed for species diversity assessment. Tree species with a diameter at breast height (DBH) ≥10 cm were measured and the diameter, merchantable height, and total height were recorded for each species. In measuring the understory diversity, small trees with a DBH of <10 cm were included such as the poles, saplings, and shrubs. For the ground cover diversity, an estimation of the percentage cover of grasses and other species was recorded.

The tree composition and diversity in the riparian zone of the Cambantoc River were initially assessed, focusing on their endemic status and conservation levels. This involved examining the total number of species, genera, and families. The reference for determining the endemicity and conservation status of the identified species was DAO 2017-11.

Data Analysis

Diversity indices offer deeper insights into community composition beyond just species richness (the number of species present); they also consider the relative abundances of various species. These indices provide crucial information about the rarity and commonness of species within a community. Quantifying diversity in this manner is a valuable tool for biologists studying community structure. The Shannon-Weinner diversity index (*H'*) is another widely used metric that assesses species diversity by factoring in both the abundance and evenness of the species present (Beals *et al*., 2000). In the computation of *H'*, the formula used was:

$$H = -\sum_{j=1}^{S} p_i \ln p_i$$

In addition to the total number of species in a community, how their abundances are distributed plays a crucial role in determining diversity. Species evenness (*E*) is a significant factor in maintaining the functional stability of ecosystems and boosting productivity by promoting the representation of each species' functional traits. Conversely, communities with uneven distributions tend to be more vulnerable to invasions and less resilient to stress and disturbances (Daly *et al*.,2018). In the computation of *E*, the formula used was:

$$E_H = H / H_{max} = H / \ln S$$

RESULTS AND DISCUSSION

Species Composition

The relative abundance of various species has long been a crucial indicator for assessing the condition of biological ecosystems. Understanding and analyzing the species composition of the Cambantoc River may provide insights in the assessment of the riparian area.

A total of 139 species belonging to 21 genera and ten families were found present in the different plots in the upstream, midstream, and downstream of the Cambantoc River. Figure 2 shows the recorded number of individuals and species per transect or streams. Among the sampled streams, downstream had the highest number of individuals (56), followed by upstream with 46 recorded individuals, and 36 for the midstream. In terms of tree species count, upstream and downstream areas had 13 recorded species while midstream had 11 different tree species. Across all streams, *Ficus* species were frequently found, namely *Ficus ulmifolia* Lamk, *Ficus septica* Burm F., and *Ficus nota* (Blanco) Merr. According to Pothasin *et al*. (2014), fig trees were frequently found in moderate to moist environments, particularly near rivers and streams. Their research indicated that *Ficus* species were abundant in the riparian zones of Northern Thailand and showed resilience to significant disturbances like heavy rainfall and flooding. This aligns with the findings that *Ficus* species were the most dominant in the Cambantoc River riparian area.

The diversity of species in the upstream areas was noticeably lower than in the downstream areas, primarily due to the conversion of riparian banks into agroforestry and banana plantations. Although the downstream area only had one to two meters of riparian banks, the species there remained relatively undisturbed compared to those in the upstream and midstream areas. The midstream zones had more residential settlements than the upstream, which contributed to a decrease in species diversity. Along the streams, human activities were prevalent, with various residential settlements and livestock enclosures found upstream. This area also served as an alternative route for residents of Barangay (Brgy.). Bagong Silang to transport their goods to the market, with horses carrying fruits and vegetables crossing the riverbanks. Multiple pathways have been cleared for this purpose. Additionally, the upstream region has been transformed into agroforestry and banana plantations, leading to the dominance of *Lansium domesticum* Correa, which the community primarily cultivates. In the midstream area, construction of riprap has been ongoing since 2019, initiated by the local government to address hazards posed to houses along the riparian zone, beginning in parts of Brgy. Masaya and Brgy. Paciano Rizal. No fifth plots were recorded in this stream due to insufficient data collection; one side was already a banana plantation stretching nearly 250 meters, while

the other side featured steep, inaccessible slopes. Various activities were also noted in this stream, including laundry, livestock enclosures, and residential settlements. Lastly, while the downstream area exhibited minimal human activity, it suffered from high pollution levels. The stream runs through residential areas and more recently agricultural land, where waste from homes is disposed of directly into the river. Due to its narrow banks, no additional settlements or activities were observed along the river.

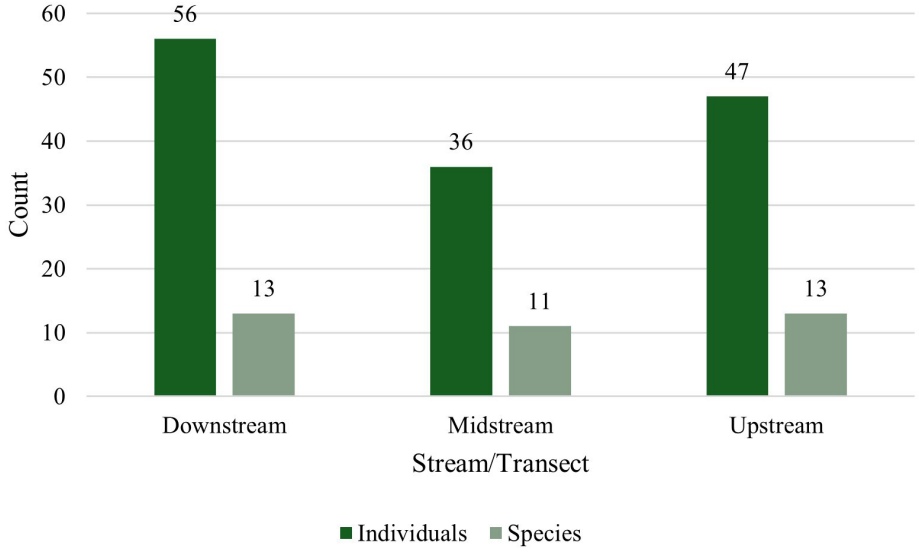

Figure 2. Species composition per stream or transect.

Figure 3 shows that in the upstream area, *Lansium domesticum* was the dominant species with 48.94% (23 individuals) of the total population. It is followed by *Broussonetia papyrifera* and *Ficus septica* with both 8.51% and 4 individuals. Other species recorded were *Persea gratissima* Gaertn., *Macaranga tanarius* (L.) Muell. -Arg., *Acalypha amentacea* Roxb., *Cananga odorata* (Lamk.) Hook. f. & Thoms, *Leucaena leucocephala* (Lam.) de Wit, *Ficus ulmifolia*, *Mangifera indica* L., *Nephelium lappaceum* L., *Citrus reticulata* Blanco., and *Ficus nota*.

The dominant species in the midstream area was *Broussonetia papyrifera* with 38.89% (14 individuals) of the total population. It is followed by *Pterocarpus indicus* Willd. form indicus with 11.11% or 4 recorded individuals. Other species in the area were *Securinega flexuosa* muell.-Arg., *Macaranga tanarius*, *Ficus septica*, *Ficus ulmifolia*, *Gliricidia sepium* (Jacq.) Kunth ex Walp, *Lansium domesticum*, *Swietenia macrophylla* King, *Triplaris cumingiana* Fisch. & Mey., and *Ficus nota*. In the downstream area, the dominant species was *Broussonetia papyrifera* with 26.79% (15 individuals). It is followed by *Ficus ulmifolia* with 14.29% or 8 individuals. Other species found in the area were. *Acalypha amantacea*, *Ficus septica*, *Cananga odorata*, *Leucaena leucocephala*, *Gliricidia sepium*, *Pithecellobium dulce* (Roxb) Benth., *Artocarpus altilis*, *Switenia macrophylla*, *Mangifera indica*, *Artocarpus heterophyllus* Lam., and *Ficus nota*.

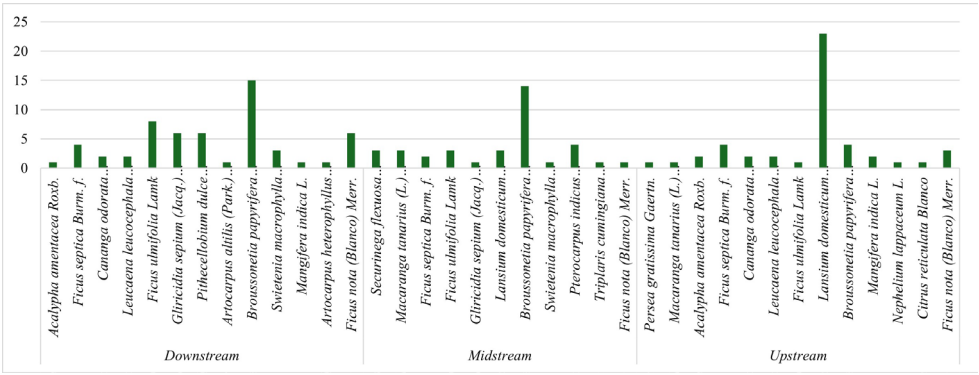

Figure 3. Summary of species composition per stream.

Species Ecological Distribution and Conservation Status

Understanding the ecological distribution and conservation status of species is crucial for more than just the species themselves. By leveraging this information, we can develop effective biodiversity conservation strategies, informed management plans, and rehabilitation efforts.

Table 1 summarizes the ecological distribution of species across all the sampled streams. Of the 21 species identified, 38.10% or 8 of them were exotic and 61.90% (13) were native tree species. Among the exotic species, *Broussonetia papyrifera* was the most prevalent, while *Lansium domesticum* was the dominant native species. Native species are those that were introduced to an area and have successfully reproduced and persisted over time. They are integral to a balanced ecosystem that has evolved over the years and adapted to the specific environment. Species that are introduced to an area but do not naturally occur there are referred to as exotic species. These can be introduced intentionally or accidentally and may become invasive. Their presence can significantly impact the local ecosystem, often disrupting ecological balance and causing negative effects.

Regarding species conservation status, 19 species (90.48%) were classified as other wildlife species, indicating that while they are not currently threatened, they may be at risk due to habitat destruction or similar issues. Conversely, *Pterocarpus indicus* and *Nephelium lappaceum* were classified as vulnerable species (9.52%), meaning they are neither critically endangered nor endangered, but face threats from negative factors (DAO-2017-11). Understanding the conservation status of tree species is crucial for protecting our natural heritage and maintaining ecosystem resilience for future generations. Additionally, it aids in making informed decisions about suitable tree species for planting initiatives.

Species Diversity Index

The species evenness index indicates how evenly species are distributed in a given area. According to the data collected, as seen in Figure 4, the downstream area had the highest value at 0.87, followed by the midstream at 0.81, while the upstream recorded the lowest value of 0.74. Based on the biodiversity scale for species evenness (Fernando *et al*., 1998), the values for the downstream and midstream areas reflect very high evenness in species distribution, whereas the upstream area demonstrates a high level of evenness. In the upstream area, the land was cultivated with monocultures, including *Lansium domesticum*, *Nephelium lappaceum*, *Cocos nucifera* L., and *Musa* sp. Understanding the species evenness index is essential for successful biodiversity conservation and ecosystem management. It also offers valuable insights for creating sustainable land management practices by illustrating how species distribution influences ecosystem functions and services.

Table 1. Summary of species ecological distribution and conservation status.

Scientific Name	Family	Philippines Common Name	Ecological Distribution	Conservation Status	Stream where it Occur
Securinega flexuosa	Euphorbiaceae	Anislag	Native	OWS	Midstream
Persea gratissima	Lauraceae	Avocado	Exotic	OWS	Upstream
Macaranga tanarius	Euphorbiaceae	Binunga	Native	OWS	Upstream & Midstream
Acalypha amentacea	Euphorbiaceae	Bogus	Native	OWS	Upstream & Downstream
Ficus septica	Moraceae	Hauili	Native	OWS	All streams
Cananga odorata	Annonaceae	Ilang-Ilang	Native	OWS	Upstream & Downstream
Leucaena leucocephala	Fabaceae	Ipil-Ipil	Native	OWS	Upstream & Downstream
Ficus ulmifolia	Moraceae	Is-is	Native	OWS	All streams
Gliricidia sepium	Fabaceae	Kakaute	Exotic	OWS	Midstream & Downstream
Pithecellobium dulce	Fabaceae	Kamachile	Exotic	OWS	Downstream
Artocarpus altilis	Moraceae	Kamansi	Exotic	OWS	Downstream
Lansium domesticum	Meliaceae	Lansones	Native	OWS	Upstream & Midstream
Broussonetia papyrifera	Moraceae	Lapnis	Exotic	OWS	All streams
Swietenia macrophylla	Meliaceae	Mahogany	Exotic	OWS	Midstream & Downstream
Mangifera indica	Anacardiaceae	Mangga	Exotic	OWS	Upstream & Downstream
Artocarpus heterophyllus	Moraceae	Nangka	Native	OWS	Downstream
Pterocarpus indicus	Fabaceae	Narra	Native	Vulnerable	Midstream
Triplaris cumingiana	Polygonaceae	Palosanto	Exotic	OWS	Midstream
Nephelium lappaceum	Sapindaceae	Rambutan	Native	Vulnerable	Upstream
Citrus reticulata	Rutaceae	Sintones	Native	OWS	Upstream
Ficus nota	Moraceae	Tibig	Native	OWS	All streams

The Shannon-Wiener Index (*H*') provides an estimate of species richness and distribution within a given area. Based on the data collected, the downstream area recorded the highest value at 2.22, followed by the midstream at 2.07, and the upstream with the lowest value of 1.89. According to the biodiversity scale for the H' index (Fernando *et al*., 1998), both the downstream and midstream areas were classified as having low species diversity, while the upstream area was categorized as having very low diversity. The Shannon-Wiener index is an important instrument for evaluating and managing biodiversity, playing a key role in the conservation and sustainability of ecosystems. Monitoring fluctuations in the index over time can reveal how human activities, climate change, or habitat destruction affect biodiversity. Additionally, it helps prioritize conservation efforts by identifying ecosystems with low diversity that may be at greater risk of extinction. In the research by Malabrigo *et al*. (2014) on the Kaliwa River Watershed in the Sierra Madre Mountain Ranges, the Shannon index was calculated to be 1.695 at its lowest and 3.242 at its highest.

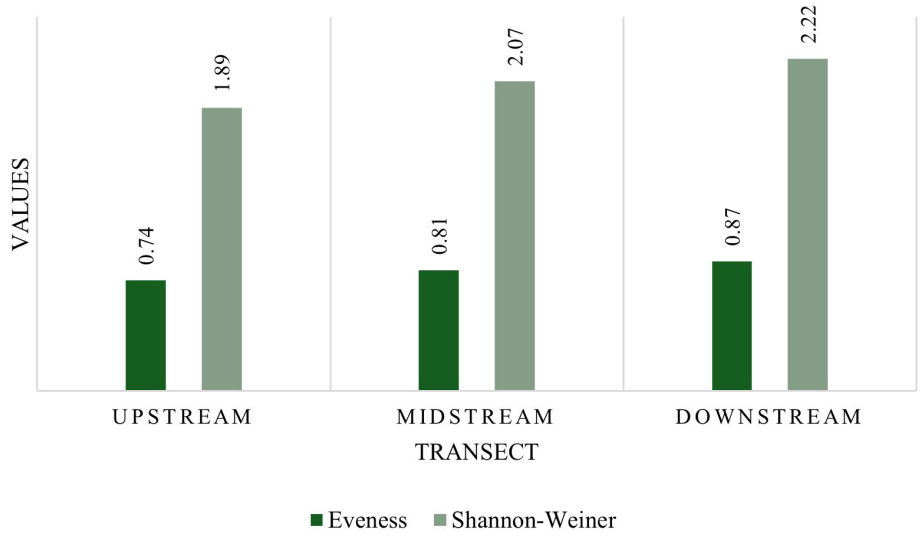

Figure 4. Species diversity index per stream.

CONCLUSION

In conclusion, the study found that the Cambantoc River has low tree species diversity throughout all its streams. This was reflected in the river's physical condition and was caused by various human activities and natural hazards in the area. The findings indicated that the downstream region has a higher population of species compared to the upstream and midstream areas. This variation is linked to land conversion in the upstream region, where the community has developed agroforestry by planting species like *Lansium domesticum* and bananas, resulting in decreased tree species diversity. The study identified two vulnerable species that could support rehabilitation and conservation efforts. All streams contribute and could play a significant role in climate change mitigation if managed effectively.

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