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Article

Influence of Floating Aquatic Macrophytes on the Structure and Diversity of the Ichthyofauna in the Tropical Lagoon of the La María Campus (Ecuador)

Gerald Amador Saldarreaga Chichande [1], Ángel Virgilio Cedeño Moreira [2,*], Odalis Celine Vilela Sabando [3] and Carlos Antonio Galarza Romero [4]

[1] Universidad Técnica Estatal de Quevedo, Facultad de ciencias pecuarias y biológicas Ecuador, Quevedo; https://orcid.org/0009-0004-0029-9185; gsaldarreagac@uteq.edu.ec

[2] Universidad Técnica Estatal de Quevedo, Facultad de ciencias pecuarias y biológicas Ecuador, Quevedo; https://orcid.org/0000-0002-6564-5569; acedenom@uteq.edu.ec

[3] Universidad Técnica Estatal de Quevedo, Facultad de ciencias pecuarias y biológicas Ecuador, Quevedo; https://orcid.org/0009-0004-0949-3646; ovilelas@uteq.edu.ec

[4] Universidad Técnica Estatal de Quevedo, Facultad de ciencias pecuarias y biológicas, Ecuador, Quevedo; https://orcid.org/0009-0005-7684-9494; cgalarzar@uteq.edu.ec

* Correspondence: acedenom@uteq.edu.ec

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Abstract: Aquatic macrophytes play a fundamental role in the ecological dynamics of tropical lentic ecosystems, acting as modulators of habitat structure. Therefore, this study evaluated the influence of aquatic macrophytes on the structure and diversity of ichthyofauna in the lagoon of the La María campus, Mocache canton, Ecuador. Systematic sampling and morphological characterization were applied to identify six species of macrophytes and five species of freshwater fish, using specialized taxonomic keys. *Eichhornia crassipes* was the most prevalent macrophyte (34.98%), while *Hyphessobrycon sp*. showed the highest representation within the ichthyofauna (68.96%). The ecological diversity analysis revealed a structurally balanced plant community (H′ = 1.61; J = 0.90; 1 − D = 0.77), in contrast to a fish community dominated by a single species (H′ = 0.92; J = 0.57; 1 − D = 0.48). Macrophytes acted as key elements in providing microhabitats, food, and shelter, supporting the persistence and reproduction of smaller fish species. However, the overpopulation of *E. crassipes* represents a potential ecological risk due to the associated reduction of dissolved oxygen. Ecological management of this species is recommended through biocontrol agents and selective removal, as well as active conservation of vulnerable species such as *Nymphaea amazonum*, to maintain the functionality of the aquatic ecosystem. The findings provide evidence of the dual role of macrophytes as ecological facilitators and, in certain contexts, as agents of environmental imbalance in urban tropical wetlands.

Keywords: Aquatic macrophytes; Ichthyofauna; Diversity; Tropical wetlands; Ecological management

Resumen: Las macrófitas acuáticas cumplen un rol fundamental en la dinámica ecológica de los ecosistemas lénticos tropicales, actuando como moduladores de la estructura del hábitat. Por lo tanto, este estudio evaluó la influencia de las macrófitas acuáticas sobre la estructura y diversidad de la ictiofauna en la laguna del campus La María, cantón Mocache, Ecuador. Se aplicó muestreo sistemático y caracterización morfológica para identificar seis especies de macrófitas y cinco especies de peces de agua dulce, utilizando claves taxonómicas especializadas. *Eichhornia crassipes* fue la macrófita de mayor incidencia (34,98%), mientras que *Hyphessobrycon sp*. presentó la mayor representatividad dentro de la ictiofauna (68,96%). El análisis de diversidad ecológica mostró una comunidad vegetal estructuralmente equilibrada (H′ = 1,61; J = 0,90; 1 − D = 0,77), en contraste con una comunidad íctica dominada por una sola especie (H′ = 0,92; J = 0,57; 1 − D = 0,48). Las macrófitas actuaron como elementos clave en la provisión de microhábitats, alimento y refugio, favoreciendo la permanencia y reproducción de especies ícticas menores. Sin embargo, la sobrepoblación de *E. crassipes* representa un riesgo ecológico potencial, asociado a la reducción de oxígeno disuelto. Se recomienda el manejo ecológico de esta especie mediante biocontroladores y remoción selectiva, así como la conservación activa de especies vulnerables como *Nymphaea amazonum*, para mantener funcionalidad del ecosistema acuático. Los hallazgos aportan evidencia sobre el papel dual de las macrófitas como facilitadoras ecológicas y, en ciertos contextos, como agentes de desequilibrio ambiental en humedales tropicales urbanos.
Palabas clave: Macrófitas acuáticas, Ictiofauna, Diversidad, Humedales tropicales, Manejo ecológico

1. Introduction

Aquatic macrophytes, particularly floating and emergent species, are fundamental components of tropical lentic ecosystems, where they perform multiple ecological functions that support system productivity, stability, and biodiversity (Lind et al., 2022). These plants actively contribute to processes such as nutrient regulation, improvement of water quality, substrate stabilization, and the provision of structurally complex microhabitats (Lim & Do, 2023). The heterogeneity they create within the water column directly influences the distribution of light, dissolved oxygen, and temperature, thereby shaping the distribution and abundance of associated biological communities, including the ichthyofauna (Ren et al., 2023).

In particular, floating macrophytes such as *Eichhornia crassipes* (water hyacinth), Pistia stratiotes (water lettuce), and Salvinia minima form extensive surface mats that can significantly alter the vertical and horizontal structure of aquatic ecosystems (Hamid et al., 2021). While their presence at moderate levels can have positive effects by providing refuge, food resources, and spawning areas for fishes, excessive proliferation can induce hypoxic conditions, reduce light penetration, and alter trophic pathways, thereby negatively affecting ichthyofaunal diversity (Liu et al., 2025).

Ichthyofauna, in turn, responds with high sensitivity to changes in habitat and resource availability, making it a widely used bioindicator group for assessing the ecological status of inland aquatic systems (Da Silveira et al., 2023). Fish species exhibit diverse feeding, behavioral, and reproductive strategies that are directly influenced by the prevailing aquatic vegetation (Li et al., 2022). Previous studies have shown that the density, structure, and composition of macrophytes can shape species richness, relative abundance, and dominance within fish assemblages (Ma et al., 2021).

In urban ecosystems, where anthropogenic pressures such as eutrophication, habitat modification, and the introduction of non-native species are common, the role of aquatic macrophytes can be dual: they may function as buffers against impacts or, in extreme cases, as agents of ecological degradation (Maranho & Gomes, 2024). Nevertheless, substantial gaps remain in the literature regarding how floating macrophytes influence the structure of fish communities in urban tropical water bodies, particularly in South American regions with high biodiversity and limited ecological planning (Gebreselassie et al., 2022).

The La María campus lagoon, located in the tropical region of Ecuador, is a human-impacted lentic ecosystem with persistent surface-floating macrophytes and a diverse fish community, making it an ideal model for studying plant–animal interactions in an urban context (Soomro et al., 2023). Despite its ecological and functional importance, this water body has been scarcely assessed from an integrated limnological perspective (Martini et al., 2020).

In this context, the present study aims to evaluate the influence of floating aquatic macrophytes on the structure and diversity of the ichthyofauna in the La María campus lagoon. We analyze how vegetative cover affects patterns of species richness, relative abundance, and trophic composition of the resident fishes, with the goal of establishing functional relationships that clarify the ecological role of these plants in tropical environments. The findings seek to contribute to the scientific understanding of urban wetland ecology and to inform strategies for conservation and sustainable management (Li et al., 2022).

2. Methodology

Study Area

The morphological and taxonomic characterization of aquatic macrophytes was carried out in the lagoon of the La María campus, located in Mocache canton, Los Ríos province, Ecuador (1°12'45.0"S, 79°28'34.5"W). The lagoon has an approximate surface area of 0.45 ha, a maximum depth of 2.1 m, and is surrounded by secondary vegetation and intervened pasture areas. The local climate corresponds to a tropical monsoon regime, with average annual rainfall exceeding 1800 mm and a mean temperature of 27 °C.

Sampling design and specimen collection

Macrophyte sampling followed a targeted approach covering representative lagoon microhabitats (shallow margins, shaded areas, open water, and edges with accumulated organic matter). Ten 1 m² plots were delineated and systematically distributed along the perimeter and accessible interior zones of the lagoon. Within each plot, all visible aquatic plant species were recorded and manually collected. Specimens were placed in moistened plastic bags, labeled with plot code and collection date, and transported to the UTEQ Biology laboratory for taxonomic analysis.

Morphological processing and taxonomic identification

Once in the laboratory, specimens were carefully washed with distilled water to remove

sediments and detritus. Detailed morphological analysis was then performed using a stereomicroscope (40×) and a millimeter-scale ruler to record diagnostic characters such as stem type, leaf arrangement, leaf shape, presence of stolons or rhizomes, root structure, inflorescence type, and floral coloration. Observations were photographically documented to provide visual support for diagnoses.

Taxonomic identification was carried out using specialized keys for the aquatic flora of Tropical America, including the manuals by Cook (1990), Holm-Nielsen et al. (1994), and the *Flora del Ecuador* (Herbario QCA and QCNE). In cases of morphological ambiguity, characters were cross-checked against reference specimens deposited in the QCA (Pontificia Universidad Católica del Ecuador) and GUAY (Universidad de Guayaquil) herbaria. Nomenclature was validated against The Plant List and Tropicos.org to ensure up-to-date taxonomic consistency.

Species recording and validation

A total of six aquatic macrophyte species were identified. Validation criteria included the consistency of diagnostic morphological characters with accepted taxonomic descriptions and confirmation by specialists in aquatic flora. Species were recorded under their accepted scientific names, together with their botanical families and the principal distinguishing characters observed in the field and laboratory. Final identifications were corroborated through comparison with the scientific literature and specialized dichotomous keys.

Incidence per square meter (m²)

To determine the incidence of each aquatic macrophyte species, we used the number of occurrences per unit area as the base variable. In each of the ten 1 m² plots established in the La María campus lagoon, the presence or absence of each identified species was recorded (presence = 1; absence = 0). We then summed the presences of each species across plots and calculated its relative frequency, expressed as the percentage of occurrence per square meter. Incidence per m² (%) was computed as:

$$Incidence(\%) = \left(\frac{Number\ of\ plots\ in\ which\ the\ species\ was\ present}{Total\ number\ of\ plots}\right) * 100$$

Statistical analysis

Percentage-incidence data by species were analyzed using a one-way analysis of variance (ANOVA) to detect significant differences among macrophyte species in their spatial distribution. Assumptions of normality and homogeneity of variances were assessed with the Shapiro–Wilk and Levene tests, respectively. When significant effects were detected ($p < 0.05$), Tukey's honest significant difference (HSD) post hoc test was applied to group species statistically according to their incidence levels.

All statistical analyses were performed in R v4.3.1 (R Core Team, 2023) using the

agricolae package. Results are reported as means ± standard error. Species were classified into homogeneous incidence groups based on the letters assigned by the Tukey HSD test.

Ecological diversity analysis

The assessment of ecological diversity for aquatic macrophytes and the ichthyofauna in the La María campus lagoon was based on relative-abundance data obtained from the ten 1 m² plots described above. For each species, we determined the total number of individuals and its relative proportion with respect to the total individuals recorded across the entire survey.

From these data, several diversity indices were calculated. Species richness (S) was defined as the total number of species recorded in the study area. Shannon–Wiener diversity (H′) was computed as:

$$H' = -\sum(p_i\, ln(p_i))$$

Where pi is the proportion of individuals of species i relative to the total number of individuals of all species. To estimate evenness in the distribution of individuals among species, we applied Pielou's evenness index (J), defined as:

$$J = \frac{H'}{\ln S'}$$

Where S is species richness and ln S its natural logarithm. We also calculated Simpson's index in its complementary form (1−D), which indicates the probability that two randomly selected individuals belong to different species:

$$1 - D = 1 - \sum\left(p_i^2\right)$$

where pi^2 represents the squared relative proportion of each species. All calculations were performed using PAST v4.13 and validated with the vegan package in R v4.3.1. The resulting values were interpreted as indicators of the ecological structure of the aquatic system, with emphasis on dominance, evenness, and the stability of the macrophyte community.

Morphological characterization of the ichthyofauna

Fish species were identified using a detailed morphological characterization protocol applied to specimens collected from the La María campus lagoon, Mocache Canton, Los Ríos Province, Ecuador. Specimens were captured by hand and with fine-mesh seine nets (0.5 cm) during morning sampling periods (06:00–09:00) in representative sectors across the water body. Each individual was placed in plastic bags containing lagoon water and transported under low-temperature conditions to the laboratory for taxonomic analysis.

Preparation and examination of specimens

Once in the laboratory, specimens were anesthetized with and eugenol solution (clove oil, 0.1%) and fixed in 10% formalin, then preserved in 70% ethanol. Each specimen was labeled and measured with a digital caliper (±0.01 mm) to record standard length (SL), total length (TL), and other relevant morphometric variables.

An external morphological assessment was conducted for each individual, recording diagnostic characters such as body shape, fin length and morphology, coloration pattern, scale type, head structure, and lateral-line configuration. Observations were supported by a stereomicroscope (40×) and documented with high-resolution digital photography.

Taxonomic determination

Taxonomic identification of each specimen was carried out using specialized keys for Neotropical freshwater fishes, such as those published by Reis et al. (2003), Gery (1977), and INABIO guides (Ecuador). Dichotomous keys were applied, and morphological traits were cross-referenced with taxonomic descriptions available in scientific databases including FishBase, Eschmeyer's Catalog of Fishes, and specialized books on Characiformes and Cichlidae.

Each species was identified to the specific or generic level, depending on the clarity of diagnostic characters. In cases of uncertainty or juvenile morphologies, the designation *sp.* was used to indicate a confirmed genus but undetermined species. Alphabetic codes (A–E) were assigned to link species with reference images, facilitating their graphical representation in the results.

3. Results

3.1. Morphological Characterization

The morphological and taxonomic characterization identified six aquatic macrophyte species present in the La María campus lagoon using specialized botanical keys. Figure 2 presents the identified species together with their principal diagnostic traits: (A) *L. adscendens*, characterized by floating or partially emergent stems, alternate lanceolate to ovate leaves, and solitary axillary white flowers; (B) *Eichhornia crassipes*, with bulbous floating petioles, waxy leaves, violet flowers arranged in a spike, and dense fibrous roots; (C) *C. pteridoides*, a floating aquatic fern with highly dissected fronds and fine fibrous roots.

Continuing with the remaining taxa depicted in Figure 2, (D) *N. amazonum*, recognized by orbicular floating leaves with a deep basal sinus and waxy blades, commonly bearing large emergent white flowers; (E) *L. helminthorrhiza*, with stoloniferous floating stems, reddish adventitious roots at the nodes, rounded leaves, and small axillary white flowers; and (F) *Salvinia minima*, a small free-floating plant with leaves in whorls of three, covered with hydrophobic hairs on the leaf surface.

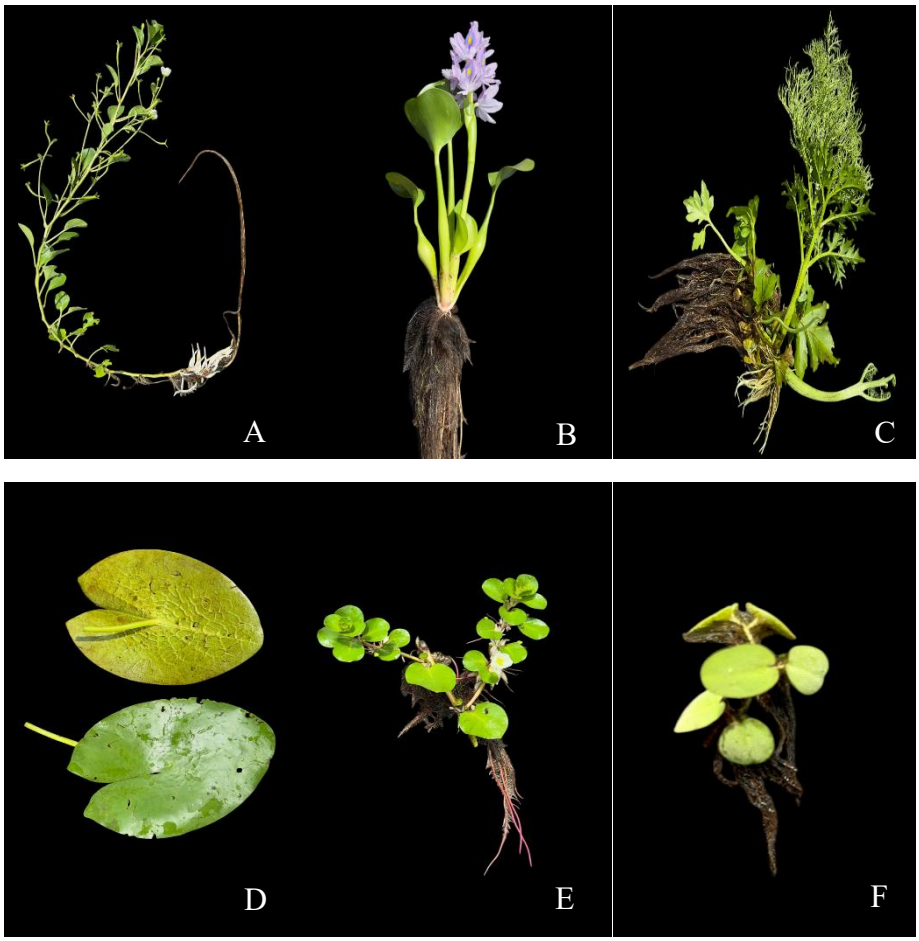

Figure 1. Morphological and taxonomic characterization of aquatic macrophytes identified in the La María campus lagoon (Mocache, Ecuador). (A) *Ludwigia adscendens*; (B) *Eichhornia crassipes*; (C) *Ceratopteris pteridoides*; (D) *Nymphaea. amazonum*; (E) *Ludwigia helminthorrhiza*; (F) *Salvinia minima*. Diagnostic traits used for taxonomic identification based on specialized botanical keys are highlighted.

Incidence per square meter (m²) of macrophyte species

The species with the highest incidence was *E. crassipes*, reaching a mean value of 34.98%, significantly higher than all other species. *L. helminthorrhiza*, *L. adscendens*, and *Salvinia minima* showed intermediate incidences of 19.62%, 16.55%, and 15.70%, respectively; these did not differ significantly from one another and were statistically grouped with the highest-incidence species. In contrast, *C. pteridoides* and *N. amazonum* exhibited the lowest incidences, averaging 9.21% and 3.92%, respectively, both significantly lower than the highest-incidence group, indicating a restricted or limited distribution within the study area. The predominance of *E. crassipes* in the lagoon's macrophyte community points to marked differences in the spatial distribution of the evaluated species.

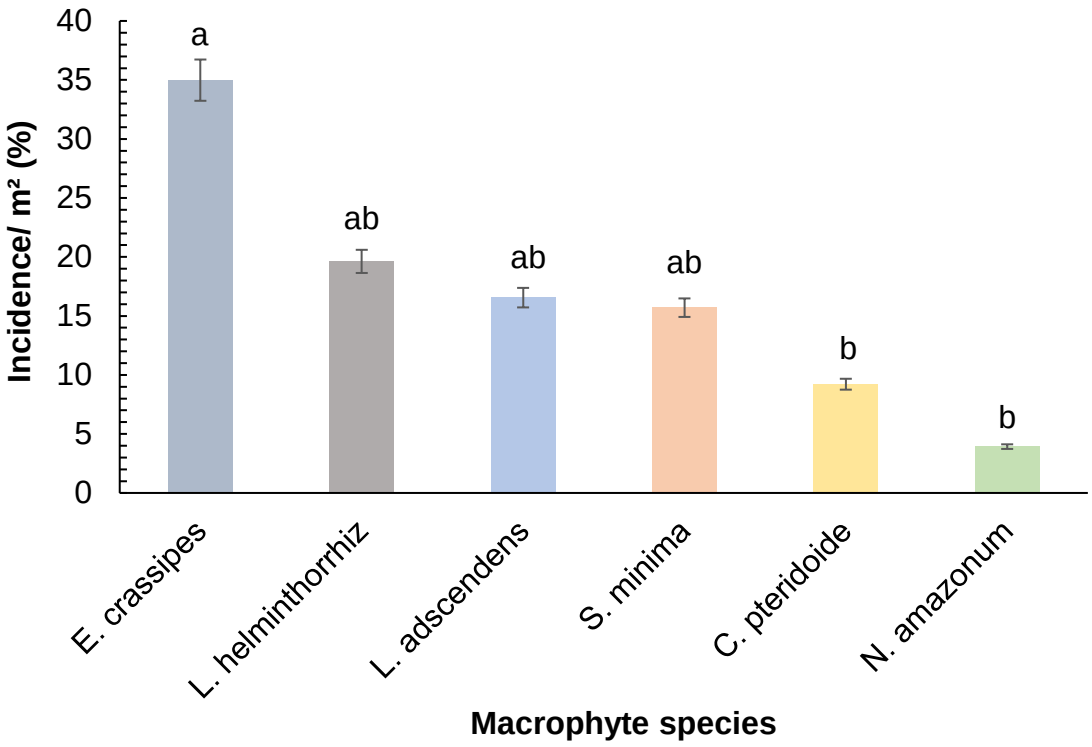

Figure 2. Percentage incidence per square meter (m²) of aquatic macrophytes present in the La María campus lagoon. Bars represent mean ± standard error (n = 3). Different letters above the bars indicate significant differences ($p < 0.05$) according to ANOVA followed by Tukey's HSD test.

Ecological diversity of aquatic macrophytes

cological diversity analyses of the aquatic macrophytes in the La María campus lagoon revealed a community of moderate richness and high evenness. Species richness was six, while Shannon diversity (H′) reached 1.61, indicating relatively high diversity. Pielou's evenness (J) was 0.90, suggesting a fairly uniform distribution of individuals among species. Simpson's index in its complementary form (1−D) was 0.77, confirming low species dominance and, therefore, an ecologically balanced community. Despite this uniformity, one species was dominant *E. crassipes* with a relative abundance of 36.54%, standing out above the remaining species. Overall, these values indicate slight dominance but an adequate level of structural diversity, which is favorable for the ecological stability of the studied aquatic ecosystem.

Table 1.

Ecological indices calculated for the aquatic macrophyte community in the La María campus lagoon (Mocache, Ecuador). Shown are the relative abundance (%) of the dominant species, Shannon diversity (H′), species richness (S), Pielou's evenness (J), and Simpson's diversity (1−D).

Index	Value
Maximum relative abundance (%):	36,54
Shannon diversity (H'):	1,61
Species richness:	6,00
Pielou's evenness (J):	0,90
Simpson's index (1-D):	0,77

Morphological characterization of the ichthyofauna

Based on morphological characterization using taxonomic keys and diagnostic reference criteria, five species of freshwater fish were identified in the Mocache region, Ecuador. Species A was identified as *A. rivulatus*, distinguished by its deep, laterally compressed body, extended dorsal and anal fins, and a dark spot in the opercular region. Species B corresponds to *H. malabaricus*, readily recognized by its robust body, prominent lower jaw, and caniniform dentition typical of carnivorous species.

Species C was classified as *Hyphessobrycon* sp., a small characid with an elliptical body, reddish caudal and anal fins, and a characteristic humeral spot for the genus. Species D, identified as *L. bimaculata*, exhibits a cylindrical, elongate body with reddish dorsal and caudal fins and two distinctive lateral black spots on the caudal peduncle. Finally, Species E was recognized as *B. bucay*, characterized by a fusiform body, a complete lateral line, bright silvery coloration, and a slight yellowish hue in the fins

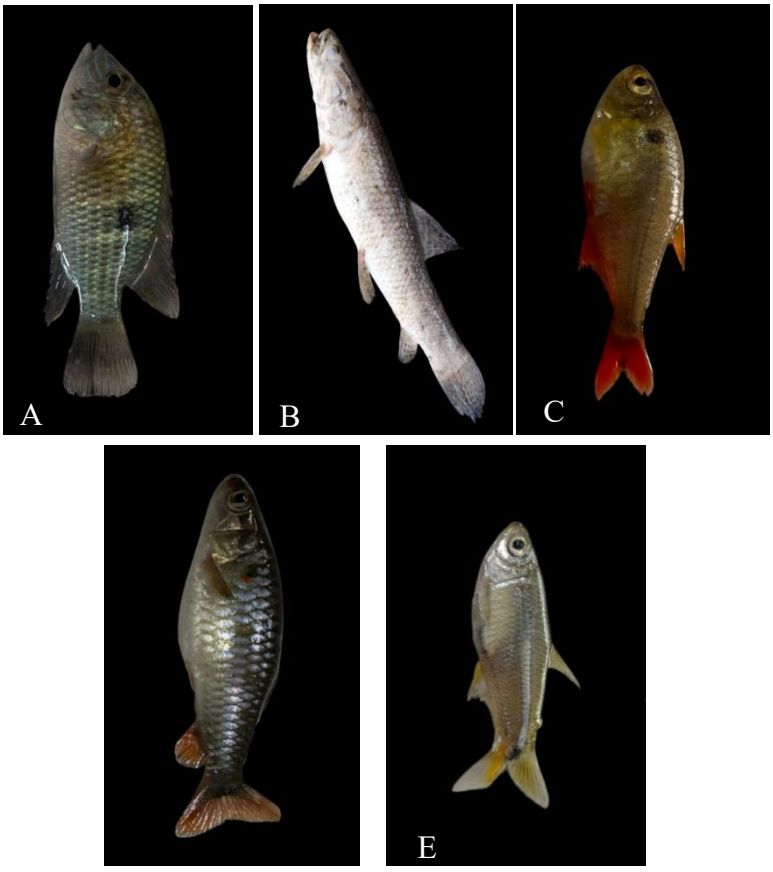

Figure 3. Morphological characterization of freshwater fishes collected from water bodies in Mocache, Ecuador, identified using taxonomic keys. (A) *Andinoacara rivulatus*; (B) *Hoplias malabaricus*; (C) *Hyphessobrycon* sp.; (D) *Lebiasina bimaculata*; (E) *Bryconamericus bucay*.

Ichthyofaunal incidence

The incidence analysis (%) revealed statistically significant differences among the evaluated species ($p < 0.05$), as shown in Figure 3. *Hyphessobrycon* sp. recorded the highest incidence, with a mean value of 68.97 ± 2.1%, significantly exceeding all other species. *B. bucay* showed the second-highest incidence, with a mean of 20.69 ± 0.8%. By contrast, *A. rivulatus* and *L. bimaculata* exhibited significantly lower values, with incidences of 5.17 ± 0.5% and 3.45 ± 0.4%, respectively. The species with the lowest incidence was *H. malabaricus*, at 1.72 ± 0.2%, significantly lower than the rest. Different letters above the bars indicate significant differences according to Tukey's multiple comparison test ($p < 0.05$).

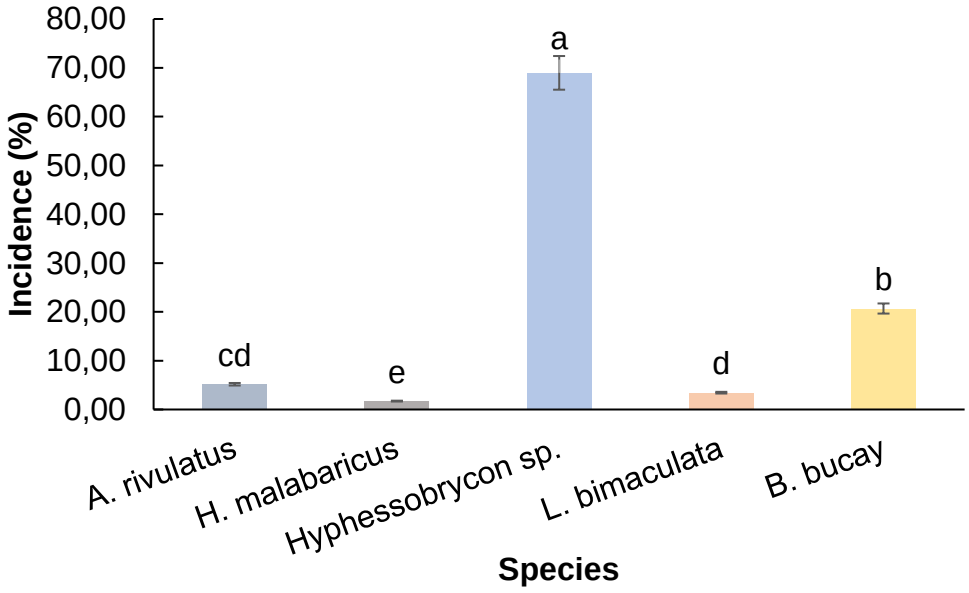

Figure 4. Incidence (%) of the evaluated variable in five fish species collected from the La María campus lagoon, Mocache Canton, Ecuador. Bars represent mean ± standard error. Different letters above the bars indicate significant differences among species according to Tukey's test ($p < 0.05$).

Ecological diversity of the ichthyofauna

The ecological diversity analysis of the ichthyofauna in the La María campus lagoon, Mocache (Ecuador), revealed a community structure dominated by a single species. Maximum relative abundance reached 68.96%, indicating a strong predominance of one species over the others. Shannon diversity (H′) was 0.92, reflecting low-to-moderate diversity within the assemblage.

Species richness was five, suggesting a relatively limited ichthyofaunal community in terms of the number of taxa. Pielou's evenness (J=0.57) indicated an uneven distribution

of individuals among species, corroborating the observed dominance. Finally, Simpson's index in its complementary form (1−D=0.48) showed that the probability that two randomly selected individuals belong to different species is below 50%, reinforcing the interpretation of low evenness and diversity.

Table 2.

Ecological indices of diversity, evenness, and dominance for the ichthyofauna recorded in the La María campus lagoon, Mocache Canton, Ecuador. Reported are maximum relative abundance, Shannon diversity (H′), species richness (total number of species), Pielou's evenness (J), and Simpson's diversity (1 − D) as indicators of the community structure of the fish assemblage.

Index	Value
Maximum relative abundance (%)	68.96
Shannon diversity (H'):	0.92
Species richness:	5.00
Pielou's evenness (J):	0.57
Simpson's index (1 - D):	0.48

4. Discussion

Aquatic macrophyte species exhibit specific ecological adaptations that enable them to colonize and thrive under the particular environmental conditions of aquatic ecosystems, including variation in oxygenation, light penetration, substrate type, and depth (Lürig et al., 2020). These adaptations are expressed through distinctive morphological traits, for example, *E. crassipes* bears inflated, bulbous petioles that confer buoyancy, whereas *S. minima* has leaves covered with hydrophobic trichomes that repel water and facilitate flotation (Doležal et al., 2021). Such functional features not only reflect adaptive capacity but also allow precise taxonomic identification via field and laboratory morpho-anatomical analysis (Szoszkiewicz et al., 2025)

From an ecological standpoint, macrophytes are widely documented across tropical water bodies in Latin America, commonly occurring in lagoons, canals, riparian zones, and wetlands with high organic loads (Rodrigo, 2021). Their importance lies in their role as refuges and habitats for numerous invertebrates, juvenile fishes, and amphibians, as well as in water-purification processes through the uptake of nutrients and heavy metals (Sarkar et al., 2021). Likewise, some species, such as *L. adscendens* and *C. pteridoides*, contribute to micro-ecosystem stability by reducing substrate erosion and enhancing dissolved oxygen via photosynthesis (Ren et al., 2023). The presence and composition of these macrophytes therefore serve as sensitive indicators of a water body's ecological status and the gradients of environmental disturbance to which it is subjected (Vukov et al., 2023).

Among the identified species, *N. amazonum* stands out not only for its aesthetic and functional value within the aquatic ecosystem but also for its conservation relevance

(Rasool et al., 2023). This aquatic plant characterized by orbicular floating leaves with a basal sinus and emergent white flowers, is widely distributed across South American freshwater bodies, including Ecuador, Peru, Brazil, Colombia, and Bolivia (Dehgan, 2022). Nevertheless, despite its broad geographic range, multiple populations of *N. amazonum* are currently in decline due to aquatic habitat degradation, water pollution, agricultural expansion, and the introduction of invasive species (Nzei et al., 2024). In some countries it has been categorized regionally as at risk or vulnerable, underscoring the need for monitoring and conservation strategies (Wright et al., 2022). Its presence in the La María campus lagoon constitutes a positive indicator of ecological quality and, at the same time, a key opportunity to promote local protection actions for a species that may be at risk of extinction.

By contrast, *E crassipes* (water hyacinth) showed a high incidence in the study area, indicating a potential condition of overabundance (Djihouessi et al., 2023). Although native to South America, this species has exhibited invasive behavior in numerous tropical and subtropical ecosystems owing to its high rate of vegetative reproduction and its capacity to form dense floating biomasses (Ferreira et al., 2025). Excessive proliferation can severely alter trophic niches by blocking solar radiation, decreasing dissolved oxygen, and displacing sensitive native species both plants and animals (Subramanian et al., 2023). It also limits aquatic fauna's access to food resources and spawning habitats, affecting the structure and functioning of local trophic networks (Borgå et al., 2022). As management alternatives, the use of natural biocontrol agents such as insects of the genus *Neochetina*, together with scheduled mechanical removal and valorization of harvested biomass for compost, biogas, or even paper products, has been proposed, an approach that would enable ecologically responsible and sustained containment (Ramírez et al., 2024).

The presence of aquatic macrophytes not only directly shapes the ecosystem's physical structure but also plays a fundamental role in configuring ichthyofaunal diversity (Brysiewicz et al., 2022). The plant species identified such as *E. crassipes*, *L. helminthorrhiza*, *S. minima*, and *N. amazonum* create complex, heterogeneous habitats that provide refuge, feeding grounds, and spawning areas for a variety of fishes (Machado et al., 2021).

For example, the pendent roots of *E. crassipes* and *S. minima* form three-dimensional microhabitats where nutrients accumulate and aquatic invertebrate communities develop; these, in turn, serve as food resources for species such as *Hyphessobrycon* sp. and *B. bucay* (Chakraborty et al., 2023). Likewise, shaded zones beneath the floating leaves of *N. amazonum* and *C. pteridoides* provide shelter from predators and elevated temperatures, benefiting smaller-bodied or juvenile fishes such as *L. bimaculata* (Zaman et al., 2025).

In addition, these plants help modulate the water's physicochemical conditions by stabilizing surface temperatures, trapping sediments, and reducing turbidity, which favors more sensitive species such as *A. rivulatus* (Chakraborty et al., 2022). Therefore, the diversity and distribution of aquatic macrophytes act as structuring factors that promote the coexistence of multiple fish species, increase environmental heterogeneity, and strengthen the ecosystem's ecological resilience (Sanders & Frago, 2024). Their

conservation and monitoring are thus key to maintaining trophic balance and the functional integrity of the evaluated aquatic system (Ding et al., 2025).

The presence of certain aquatic macrophytes, such as *E. crassipes*, can play a pivotal role in the proliferation of small fish species like *Hyphessobrycon* sp. by generating favorable ecological conditions that directly influence their biological success (Shahbaz et al., 2023). These floating plants form dense, pendent root structures that create complex three-dimensional habitats, providing effective refuge from piscivorous predators especially during juvenile stage and thereby substantially reducing predation pressure (Able et al., 2022). Additionally, the roots and stems of these macrophytes promote the establishment of benthic and planktonic invertebrate communities, including insect larvae, microcrustaceans, and rotifers, which constitute an essential food source for *Hyphessobrycon* sp. (Wink, 2024). The accumulation of organic matter in the immediate vicinity of these plants further enriches the ecosystem's trophic base (Cieśla & Gruca-Rokosz, 2024).

5. Conclusion

The presence and distribution of aquatic macrophytes in the La María campus lagoon significantly influence the structure and diversity of the ichthyofauna. Species such as *E. crassipes*, *S. minima*, and *N. amazonum* create functionally complex habitats that provide refuge, trophic resources, and spawning areas for small-bodied fishes, thereby promoting the coexistence of species such as *Hyphessobrycon* sp. and *B. bucay*.

Although moderate diversity was recorded in both the plant and fish communities, the dominance of *E. crassipes* suggests a potential imbalance in the system's ecological dynamics, with negative implications for the availability of oxygen, light, and space for other species.

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