PONTIFICIA UNIVERSIDAD CATÓLICA DEL ECUADOR

FACULTAD DE CIENCIAS EXACTAS Y NATURALES

Tesis previa a la obtención del título de Magister en Biología,
con mención en Ecología y Evolución

Diversity of *Anthurium* Schott along an altitudinal gradient in a Montane Forest of Northwestern Ecuador

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Quito, 2025

RESUMEN

Los bosques montanos de los Andes tropicales presentan una alta biodiversidad y endemismo, aunque los patrones altitudinales de diversidad vegetal siguen estando insuficientemente caracterizados para muchos grupos clave, incluido *Anthurium* (Araceae). Para evaluar cómo varía la diversidad alfa y beta de *Anthurium* a lo largo de un gradiente altitudinal de 800 metros en la Reserva Mashpi Lodge, se establecieron treinta transectos de 100 × 3 m distribuidos en tres zonas altitudinales (500–1.300 m). Todos los individuos de *Anthurium* fueron identificados y registrados con el fin de analizar los cambios en los patrones de diversidad. Se documentaron 2.276 individuos correspondientes a 55 especies, 16 de ellas endémicas de Ecuador. La diversidad alfa alcanzó su máximo en las elevaciones intermedias, mientras que la diversidad beta evidenció un alto recambio de especies entre zonas. La zona media presentó la mayor superposición con las zonas adyacentes, lo que sugiere un papel transicional, mientras que las zonas baja y alta albergaron ensamblajes florísticos diferenciados. La elevación, la estructura del bosque, la historia evolutiva del paisaje y las limitaciones de dispersión influyen en la distribución de *Anthurium* a lo largo del gradiente. La coexistencia de especies de amplia distribución con especies de distribución restringida subraya la importancia ecológica de los corredores altitudinales y resalta el valor de conservación de los paisajes montanos heterogéneos.

Palabras clave: Araceae, Composición de especies, Diversidad alfa, Diversidad beta, Patrones de distribución, Recambio de especies.

ABSTRACT

Montane forests in the tropical Andes exhibit high biodiversity and endemism, yet the elevational patterns of plant diversity remain insufficiently characterized for many key groups, including *Anthurium* (Araceae). To evaluate how alpha and beta diversity of *Anthurium* vary along an 800-meter elevational gradient in the Mashpi Lodge Reserve, we established thirty 100 × 3 m transects across three elevational zones (500–1,300 m). All *Anthurium* individuals were identified and recorded to assess changes in diversity patterns. We documented 2,276 individuals representing 55 species, 16 of which are endemic to Ecuador. Alpha diversity peaked at mid-elevations, while beta diversity revealed high species turnover between zones. The middle elevation zone exhibited the greatest overlap with adjacent zones, suggesting a transitional role, whereas the low and high zones supported distinct species assemblages. Elevation, forest structure, the evolutionary history of the landscape, and dispersal limitations shape *Anthurium* distribution along the gradient. The coexistence of both broadly distributed and range-restricted species underscores the ecological importance of elevational corridors and highlights the conservation value of heterogeneous montane landscapes.

Keywords: Alpha diversity, Araceae, Beta diversity, Distribution patterns, Species composition, Species turnover.

OBJETIVO GENERAL

Estudiar la diversidad y composición de especies del género *Anthurium* dentro del área de conservación Mashpi.

OBJETIVOS ESPECÍFICOS

- Identificar cambios en la diversidad Alfa de especies del género *Anthurium* en tres franjas altitudinales: baja (500-700 m), media (800-1 000 m) y alta (1 100-1 300 m).
- Comprobar la variación de la diversidad Beta del género *Anthurium*, a lo largo del gradiente altitudinal.

DESCRIPCIÓN DEL MANUSCRITO

El presente manuscrito, titulado “Diversity of *Anthurium* Schott along an altitudinal gradient in a Montane Forest of Northwestern Ecuador”, ha sido presentado para consideración de publicación de la Revista Plant Ecology and Diversity. El manuscrito ha sido escrito siguiendo los lineamientos de la revista que se encuentran disponibles en el siguiente **enlace**.

La revista Plant Ecology and Diversity se encuentra indexada en la base de datos de Scopus, de acuerdo a la información del siguiente **enlace**.

MANUSCRITO

A continuación, a manera de anexo, se incluye en manuscrito enviado a la revista científica Plant Ecology and Diversity.

Diversity of *Anthurium* Schott along an altitudinal gradient in a Montane Forest of Northwestern Ecuador

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Diversity of *Anthurium* Schott along an altitudinal gradient in a Montane Forest of Northwestern Ecuador

Abstract

Background: Montane forests in the tropical Andes exhibit high biodiversity and endemism, but the elevational patterns of plant diversity for groups like *Anthurium* (Araceae) remain insufficiently characterized.
Aims: To assess how alpha and beta diversity of *Anthurium* vary along an 800-meter elevational gradient in the Mashpi Lodge Reserve, a montane forest of northwestern Ecuador.
Methods: We established thirty 100 × 3 m transects across three elevational zones (500–1,300 m) in the Mashpi Lodge Reserve. All *Anthurium* individuals were identified and recorded to evaluate changes in alpha diversity and beta diversity.
Results: We documented 2,276 individuals representing 55 species, 16 of them endemic to Ecuador. Alpha diversity peaked at mid-elevations, while beta diversity revealed high species turnover across zones. Middle elevations showed the highest overlap with adjacent zones, suggesting a transitional role, whereas low and high zones supported distinct assemblages.
Conclusion: Elevation, forest structure, evolutionary history of the landscape and dispersal limitation influence *Anthurium* distribution along the gradient. The coexistence of broadly distributed and range-restricted species highlights the ecological significance of elevational corridors and supports the conservation value of heterogeneous montane landscapes.

Key policy highlights

Elevational gradients in montane forests support both widespread and range-restricted *Anthurium* species, underscoring the importance of preserving vertical habitat connectivity.

Mid-elevation forests function as transitional corridors that link lowland and highland plant communities and should be prioritized in conservation planning.

High species turnover across elevational zones reveals the need to protect the full altitudinal range to maintain overall biodiversity.

Conservation efforts should account for dispersal limitations and microhabitat specificity, especially in endemic-rich groups like *Anthurium*.

Protecting structurally complex montane landscapes can safeguard both ecological processes and long-term evolutionary potential in tropical plant lineages.

Keywords: Alpha diversity; Araceae; Beta diversity; Distribution patterns; Species composition; Species turnover.

Introduction

The montane forests of the northwestern Andes in Pichincha, Ecuador, are characterized by high species richness and endemism (Jørgensen et al. 1999; Jørgensen et al. 2011; Mittermeier et al. 2011; Terán et al. 2019). These ecosystems develop along complex altitudinal gradients, providing an appropriate framework for analyzing species diversity and distribution patterns (Girardin et al. 2013; Asner et al. 2013). The Mashpi Lodge Reserve (MLR), located within this region, extends across an altitudinal range of 500 to 1,300 m., offering a suitable setting to assess changes in plant diversity in response to elevation (Mashpi Lodge 2025).

Altitudinal gradients have been widely used in ecological research to examine species turnover across elevation (Lieberman et al. 1996; Young and Keating 2001; Homeier et al. 2010; Swenson et al. 2011; Jiménez-Paz et al. 2021). Studies in tropical and Andean forests indicate that alpha diversity generally declines with increasing elevation, while beta diversity tends to be higher at higher altitudes, reflecting greater species turnover across elevation zones (Gentry 1988; Lieberman et al. 1996; Homeier et al. 2010; Swenson et al. 2011). However, these trends vary among taxonomic groups, highlighting the need for further studies to determine how specific plant lineages respond to altitudinal variation (Colville et al. 2020; Leahy et al. 2024)

The family Araceae is a key component of Neotropical montane forests, comprising a diverse array of growth forms, including epiphytes, appressed epiphytic climbers, and terrestrial species (Mayo et al. 1997). In Ecuador, this family includes 23 genera and 747 recorded species (Jørgensen et al. 1999; Cabrera et al. 2022; Boyce and Croat 2025), many of which are found in montane environments and are highly endemic (Croat et al. 2011). Among them, the genus *Anthurium* is particularly diverse in terms of morphology and taxonomy (Croat and Sheffer 1983; Carlsen and Croat 2013; Croat et al. 2011; Croat 2015; Croat 2019a).

Anthurium is characterized by sympodial growth with conspicuous cataphylls, coriaceous to membranaceous leaves exhibiting reticulate venation with marginal collecting veins, and a distinctive inflorescence consisting of a solitary spadix bearing minute bisexual flowers arranged in spirals, subtended by a spathe. The infructescence consists of clustered berries, each containing seeds embedded in a mucilaginous endosperm. Berries are primarily dispersed by understory birds, whose limited movement contributes to localized seed dispersal and high levels of endemism in the genus (Gentry 1993; Mayo et al. 1997; Schwerdtfeger et al. 2002; Croat and Ortiz 2020)

Research on *Anthurium* in Ecuador dates back to the late 19th century with the work of Luis Sodiro, an Italian Jesuit and pioneering field botanist based near Quito. Sodiro described over 280 taxa of Ecuadorian Araceae—mostly *Anthurium*—and was among the first to provide detailed descriptions based on live material collected directly in the field (Croat 1998). Despite limitations such as the lack of type designations and restricted access to his collections, his contributions were foundational for Araceae research in the region, particularly in northwestern Pichincha and along the western slopes of the Ecuadorian Andes (Sodiro 1901; Sodiro 1903; Nicolson 1983).

More recent efforts, particularly those led by Thomas B. Croat, have significantly expanded the understanding of *Anthurium* diversity in the region, contributing to substantial taxonomic progress (Croat and Rodríguez de Salvador 1995; Leimbeck et al. 2001; Leimbeck et al. 2004; Vargas et al. 2004; Croat et al. 2005; Croat et al. 2008a; Croat et al. 2008b; Cerón and Reyes 2009; Croat et al. 2019b; Zambrano and Croat 2024; Zambrano et al. 2025; Zambrano and Croat 2025).

Despite these advancements, a large proportion of *Anthurium* species in Ecuador remain undescribed. Although current estimates place the number of recognized species at 392, the total could exceed 600 (Croat 2015; WCSP 2025; Zambrano and Croat 2025). While species richness has been increasingly documented, little is known about the distribution of *Anthurium* along altitudinal gradients or whether its diversity patterns align with those observed in other montane plant groups. Given that *Anthurium* spans a broad range of elevations, assessing species turnover along altitudinal gradients is essential for a deeper understanding of its distribution and diversity.

In this study, we evaluate how species richness and community composition of *Anthurium* vary along an 800–m altitudinal gradient in the Mashpi Lodge Reserve. By integrating measures of alpha and beta diversity across distinct elevational zones, we aim to understand the extent to which elevation shapes floristic structure in this hyperdiverse genus. This approach addresses a critical gap in the ecological characterization of *Anthurium*, and provides a foundation for future work on its diversification and conservation in Andean montane forests.

Materials and methods

Study Area

This study was conducted between June 2023 and January 2025 in the northern area of the Mashpi Lodge Reserve (MLR), located in the western foothills of the Andes, in Pichincha province, Ecuador (0°9′58″N, 78°52′42″W) (Figure1). The reserve spans approximately 3,100 hectares and protects a highly diverse montane forest ecosystem. The specific study area lies along an altitudinal gradient from 500–1,300 m (a vertical range of 800 m). **[Figure 1 below this paragraph]**

Within this gradient, two principal vegetation types are recognized: Western Low Montane Forest (500–900 m) and Western Montane Forest (900–1,300 m) (Ron 2020). The region is characterized by persistent cloud cover, high humidity, annual precipitation exceeding 3,000 mm, and mean temperatures ranging from 18°C–26°C (Mashpi Lodge 2025).

The MLR is situated on a region characterized by active tectonic uplift and complex volcanic history driven by the ongoing subduction of the Nazca Plate beneath the South American Plate (Vallejo 2007). The soils are predominantly andisols, formed from volcanic ash and pyroclastic deposits, with high porosity, organic matter content, and water retention capacity, yet prone to erosion in areas with steep slopes and high rainfall (Tibaldi and Ferrari 1992; McMichael et al. 2021).

Sampling methods

Sampling was conducted across three altitudinal zones: low (L; 500–700 m), middle (M; 800–1,000 m), and high (H; 1,100–1,300 m). Within each zone, at random, 10 transects measuring 100 m × 3 m were established, resulting in a sampling area of 0.30 hectares per zone and a total surveyed area of 0.90 hectares (Figure1 and Figure 2). Binoculars and telescopic pruners were employed to observe and access individuals up to 8 m in height, with an emphasis on the undestory strata where *Anthurium* species are frequently encountered (Gradstein et al. 2003;

Jácome et al. 2004; Arévalo and Betancourt 2006; Krömer et al. 2007; Ortiz et al. 2019).
[Figure 2 below this paragraph]

Data collection and species identification

Within each transect, all *Anthurium* species were identified and quantified. The number of individuals per species (abundance) was recorded. Collected specimens were photographed, preserved in newspaper and 70% ethanol, and subsequently dried for deposit at the Herbarium QCA at Pontificia Universidad Católica del Ecuador, following standard Araceae preservation protocols (Croat 1985). Species identification was validated through comparisons with herbarium specimens and references from floristic studies and databases such as TROPICOS (2025).

Data analysis

Species composition

All individuals of *Anthurium* recorded in the transects were identified to the lowest possible taxonomic level and counted. Each species was assigned to one or more altitudinal zones (low [L], middle [M], high [H]) based on its occurrence in the transects.

> Differences in community composition across zones were statistically tested using an Analysis of Similarities (ANOSIM), based on a Bray-Curtis dissimilarity matrix derived from presence–absence data per transect. The ANOSIM R statistic and associated p-value were used to assess the degree of dissimilarity among zones (Swenson et al. 2011; Myers et al. 2013; Tello et al. 2015).
>
> We used simple species richness to evaluate changes in species diversity across the transects. The most abundant species were determined by total number of individuals recorded across all transects. Species occurring in all three zones, as well as those restricted to only one zone, were also documented.

Alpha Diversity

Alpha diversity was assessed using the exponential form of the Shannon index (exp H′), which provides an estimate of the effective number of species by incorporating both species richness and evenness (Jost 2006). Prior to analysis, assumptions of normality and homogeneity of variances were tested and Wha 2011).

The Shapiro-Wilk test was used to evaluate whether the diversity data followed a normal distribution, while the Levene test assessed the equality of variances among the altitudinal zones. Given that both assumptions were met, a one-way Analysis of Variance (ANOVA) was applied to compare mean alpha diversity across the three elevational zones.

Beta Diversity

Beta diversity was analyzed to assess species turnover between transects within and across altitudinal zones as a measure of general heterogeneity (Tuomisto 2010). The Bray-Curtis Index was used to quantify species composition dissimilarity, which ranges from 0 (identical species composition) to 1 (completely distinct communities).

To evaluate the relationship between beta diversity, geographic distance, and altitudinal variation, a Mantel test was performed. This test measures the correlation between species dissimilarity and spatial separation (Legendre and Fortin 2010).

Floristic, distance, and altitudinal matrices were constructed using data from each transect to compare beta diversity patterns along both spatial and altitudinal gradients.

All statistical analyses were conducted in R 4.4.3.

Results

Species composition

A total of 2,276 *Anthurium* individuals were recorded across 0.90 hectares, representing 55 species distributed among the low (L), middle (M), and high (H) zones. Of these, 47 were identified to species level, while 8 remained as *Anthurium* sp. Sixteen species were determined to be endemic to Ecuador (Appendix 1).

Species composition varied across the altitudinal gradient. The proportion of shared species between zones was 38.2% for L–M, 29.1% for L–H, and 56.4% for M–H.

The ANOSIM test revealed significant differences in species composition among zones ($R = 0.9527$, $p = 0.001$), indicating high dissimilarity between elevational zones.

The most abundant species included *A. versicolor*, *A. cuspidatum*, *A. marmoratum*, and *A. argyrostachium*. Thirteen species occurred across all three zones, including *A. fragrans*, *A. jaramilloi*, and *A. ochreatum*.

Nine species were exclusive to L: *A. interruptum*, *A. obtusum*, *A. pseudonigrescens*, *A. rodrigueziae*, *A. scandens*, *A.* sp.1, *A.* sp.2, *A.* sp.5, *A.* sp.7; two to M: *A. obscurinervium*, *A.* sp.8; and six to H: *A. incomptum*, *A. latecollectivum*, *A. ovatifolium*, *A. pendulispadix*, *A. subandinum*, *A. tremulum* (Appendix 1).

Alpha Diversity

Alpha diversity, calculated using the exponential Shannon index, did not vary significantly across elevational zones. The Shapiro–Wilk and Levene tests confirmed normality and homogeneity of variances, respectively, and one-way ANOVA revealed no significant differences among zones (Appendix 2).

Diversity values followed a quadratic trend, with higher values in M (800–1,000 m) and lower values in L (500–700 m) and H (1,000–1,300 m) (Figure 3). **[Figure 3 below this paragraph]**

Beta Diversity

Beta diversity, assessed using the Bray-Curtis index, was significantly correlated with both elevation and geographic distance (Figure 4). Pairwise Mantel tests showed increasing dissimilarity between zones as elevational separation increased, with the strongest differences observed between the highest and lowest zones. A similar pattern was found in relation to geographic distance (Appendix 2). These patterns indicate increasing dissimilarity with altitudinal separation. **[Figure 4 below this paragraph]**

Discussion

Our results confirm that the diversity of *Anthurium* along the elevational gradient in the Mashpi Lodge Reserve (MLR) reflects patterns previously documented for Araceae and other plant groups in Neotropical montane systems, including floristic turnover along elevational gradients, higher species richness in intermediate zones, and increased compositional differentiation between low and high zones (Krömer et al. 2007; Acebey and Krömer, 2008; Ortiz et al. 2019). Although alpha diversity did not show statistically significant differences between zones, a clear quadratic pattern was observed (Figure 3), with greater species richness in the middle elevation zone (M). This trend has been widely reported for Andean plant communities (Gentry 1988; Lieberman et al. 1996; Dani et al. 2023) and may be explained by the coexistence of more stable ecological conditions at intermediate altitudes, which allow the overlap of elevational ranges and the simultaneous establishment of species from both low (L) and high (H) zones (Kessler 2000; Ortiz et al. 2019).

The lack of significant differences in alpha diversity may reflect the presence of widely distributed species along the gradient, which homogenize richness values and exhibit high tolerance to multiple environmental factors besides altitude (Gentry 1988; Kessler 2000; Ramos et al. 2020). Nonetheless, the peak observed in M (Figure 3) remains ecologically relevant, as it coincides with conditions of greater structural complexity and microenvironmental heterogeneity. This phenomenon has been linked in other tropical systems to the coexistence of plant species with varying ecological tolerances and niche breadths, as observed in vascular plants in the Bolivian Andes and in vascular epiphytes in montane forests of Venezuela (Kessler 2000; Barthlott et al. 2001).

In contrast, Beta diversity showed significant floristic turnover among zones, positively correlated with both elevation and geographic distance (Figure 4), reinforcing the role of elevation as a structuring axis for *Anthurium* community composition in MLR. Although both variables followed similar patterns of species turnover, the correlation with elevation was stronger, indicating that elevation (Figure 4 A) serves as a more consistent predictor of species composition changes than geographic distance (Figure 4 B).

This pattern, aligns with studies conducted in other tropical montane systems, where even relatively short elevational gradients, such as in the MLR (800 m.), can result in pronounced shifts in community composition (Gentry and Dodson 1987; Küper et al. 2004). In MLR, the stronger correlation with elevation likely reflects the influence of more consistent environmental conditions, such as temperature, humidity, and canopy structure, which exert direct and predictable effects on species distribution (Qian and

Ricklefs 2012; Leimbeck and Balslev 2001). In contrast, geographic distance may encompass more heterogeneous habitats, where specific ecological conditions are less evident, resulting in more variable and potentially random distribution patterns (Arita and Rodriguez 2002).

Consistent with this altitudinal shift, the differences and similarities between zones indicate a compositional segmentation associated with abrupt ecological changes, aligning with the boundaries between the Western Low Montane Forest (500–900 m) and Western Montane Forest (900–1,300 m), as well as other environmental factors present at MLR. In L, exposed conditions such as forest gaps, the presence of the Mashpi River, rocky soils, and higher anthropogenic disturbance limit the presence of species that prefer shaded areas with high humidity (Croat and Ortiz, 2020). Species recorded here, such as *A. scandens*, exhibit greater tolerance to disturbed habitats like forest edges or pastures and may possess more effective dispersal mechanisms.

In M, dominated by mature forests of *Magnolia mashpi*, *Dacryodes cupularis*, *Brosimum utile*, *Ocotea insularis*, and *Cecropia peltata*, we observed an environment favorable to terrestrial, epiphytic, and epiphytic climbers forms of *Anthurium*, due to the availability of humid, shaded, and structurally complex microhabitats. This zone acts as a point of convergence for floristic elements from both high and low elevations, as reflected by species overlap: it shares 38.2% of its species with L and 56.4% with H. This compositional continuity supports the idea of M as an elevational corridor that enable species movement across adjacent ecological zones, as documented in other Andean and Mesoamerican regions (Sierra-Giraldo et al. 2013; Acebey and Krömer 2008).

H, although colder and cloudier, maintains high species richness, likely due to the stability of its humid and shaded conditions. Some species recorded here, such as *A. subandinum* and *A. pendulispadix*, exhibit restricted distributions and a marked preference for such environments. This strict altitudinal specialization suggests evolutionary adaptations to well-defined microhabitats, in this case to higher montane zones.

The floristic composition of *Anthurium* along the elevational gradient reflects the combined effects of ecological plasticity, limited dispersal, and habitat specialization.

Some widely distributed species, such as *A. versicolor, A. marmoratum*, and *A. argyrostachium*, show high tolerance to various microenvironmental conditions, indicating greater ecological plasticity. In contrast, species like *A. roquesevillae* exhibit extremely restricted geographic ranges, consistent with patterns of microendemism (Zambrano and Croat 2025). This contrast is well documented in Araceae and other Andean families such as Orchidaceae, where topographic fragmentation, ecological specificity, and dispersal constraints significantly limit species distributions (Gentry and Dodson 1987; Kessler 2000; Küper et al. 2004). For example, many *Anthurium* species grow in dense understories, where it is more likely that their berries are consumed by resident forest birds rather than migratory or generalist species that forage in open areas or forest edges (Ortiz et al. 2019), thereby limiting their effective long-distance dispersal.

Beyond these current factors, the evolutionary history of the landscape has played a significant role in MLR. As in other areas of the Andean region, climatic fluctuations generated cycles of connectivity and isolation in montane ecosystems, primarily driven by tectonic activity, volcanic events, pleistocene glacial changes, and the continuous uplift of the Ecuadorian Andes (Vuilleumier 1971; Tibaldi and Ferrari 1992; McMichael et al. 2021).Unlike the paramos, which experienced "intermittent connectivity," lower and upper montane forests remained relatively continuous, allowing the persistence of lineages and promoting diversity accumulation via immigration and local diversification (Flantua et al. 2019). In other cases, isolated ecological refugia during dry periods during the Pleistocene may have driven allopatric speciation events and subsequent population differentiation, as suggested for other Neotropical and Central American mountain systems (Vuilleumier 1971; Simpson 1975; Ortiz et al. 2019).

Therefore, beyond elevation, the interaction between forest structure and complexity, humidity, light and shade, canopy connectivity, water availability, and historical biogeographic isolation has generated a complex ecological mosaic. This mosaic shapes both the richness and geographic distribution of *Anthurium*, and explains why zones like MLR simultaneously host generalist species and others with extremely restricted ranges. Altitude alone does not function as an isolated ecological filter (Hazzi et al. 2018); rather, it operates in combination with historical and biogeographic factors that have profoundly shaped patterns of diversity and endemism in Andean *Anthurium*.

Mashpi Lodge Reserve (MLR) represents a critical area for examining species turnover, endemism, and ecological specialization along elevational gradients in the western Andes of the Ecuadorian Chocó. The reserve's rugged topography and steep altitudinal transitions create diverse habitats that promote both ecological differentiation and isolation. *Anthurium*, with 16 endemic species recorded, exemplifies the region's floristic uniqueness and evolutionary significance. Extending similar analyses to other Araceae genera such as *Philodendron* could further elucidate how patterns of turnover and habitat specialization operate across different taxonomic groups.

Given the ongoing anthropogenic pressure around MLR, conservation efforts should prioritize maintaining ecological corridors that link lower and upper montane forests, preserving critical habitats for narrowly distributed species. Such strategies would mitigate edge effects, safeguard endemic taxa, and support the evolutionary processes underpinning the region's distinctive assemblages.

Acknowledgments

We thank Mgtr. Mateo Roldán, Director of Research and Biology at Mashpi Lodge, for his essential support in coordinating field logistics and enabling the execution of this project within the reserve. We are grateful to Mashpi Lodge for providing lodging, meals, and operational assistance during fieldwork. Erika Caicedo, Camila Sandoval, and Freddy Benavides are especially thanked for their valuable help in the field. We also thank the Jardín Botánico de Quito for providing workspace, materials, and technical support, and for maintaining a living Araceae collection that served as a taxonomic reference. We acknowledge Dr. Renato Valencia for his academic input and guidance during data analysis. Finally, we thank the Ministry of Environment, Water and Ecological Transition of Ecuador (MAATE) for granting the collection permits necessary to carry out this research.

Declaration of interest statement

No potential conflict of interest was reported by the authors.

Funding

This research was financially supported by the projects “TEAM” and “Forest dynamics in two one-hectare plots in the Lalo Loor Reserve in Manabí province and quantification of herbaceous plants on Pasochoa volcano,” both conducted under the auspices of the Pontificia Universidad Católica del Ecuador (PUCE), as well as by the Araceae research program of the Jardín Botánico de Quito (JBQ).

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Figures

Figure 1. (A) Location of Mashpi Lodge Reserve in northwestern Ecuador. (B) Distribution of transects along the elevational gradient within the reserve: low elevation zone, red circles (L: 500–700 m), middle elevation zone, blue squares (M: 800–1,000 m), and high elevation zone, black triangles (H: 1,100–1,300 m).

Figure 2. Sampling sites on Mashpi Lodge Reserve. (A) Low elevation zone (L: 500–700 m). (B) Middle elevation zone (M: 800–1,000 m). (C) High elevation zone (H: 1,100–1,300 m). Photos: Ricardo Zambrano C.

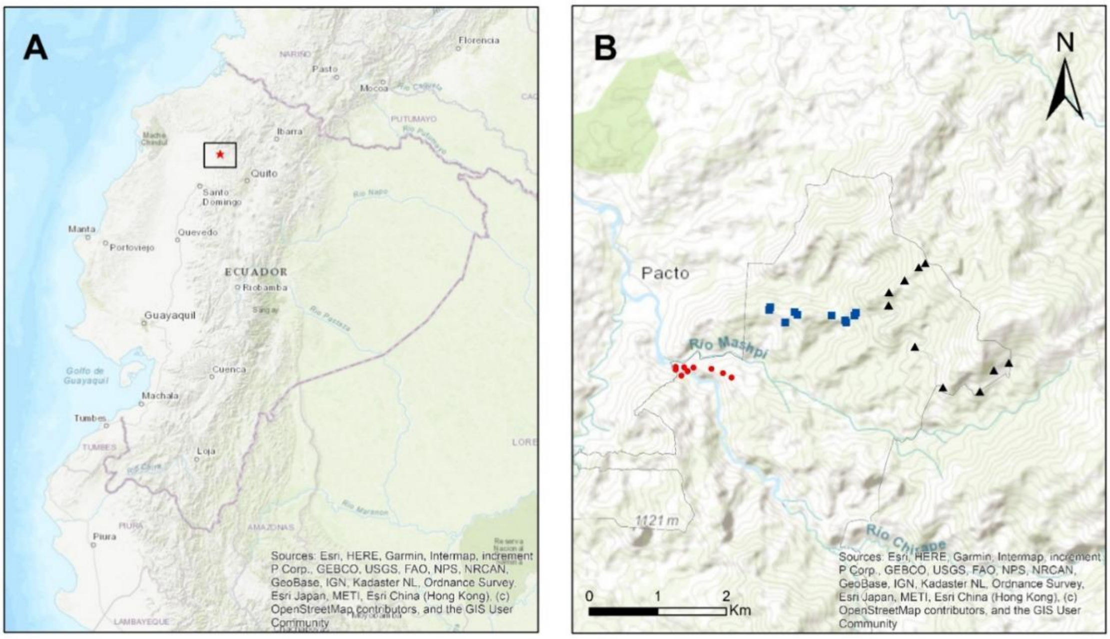
Figure 3. Boxplot of alpha diversity (mean values of the Shannon exponential index) of *Anthurium* across the three elevational zones in Mashpi Lodge Reserve. The x-axis shows the elevational zones: low (L: 500–700 m), middle (M: 800–1,000 m), and high (H: 1,100–1,300 m).

Figure 4. Relationship between beta diversity (Bray–Curtis dissimilarity index) of Anthurium and spatial variables in Mashpi Lodge Reserve. (A) Increasing species turnover with altitudinal distance. (B) Increasing species turnover with geographic distance between transects. The x-axis shows pairwise distance (m) and altitudinal difference (m), respectively, and the y-axis shows Bray–Curtis dissimilarity values. Solid red line shows that similarity between transects declines with increasing altitudinal distance.

Appendices

Appendix 1. Species list and abundance of individuals in the three elevational zones (Low 500–700 m, Middle 800–1,000 m and High 1,100–1,300 m). Data of 2,276 individuals recorded in Mashpi Lodge Reserve by altitude and Endemic (E) or Native (N).

Appendix 2. Summary of statistical results for alpha and beta diversity



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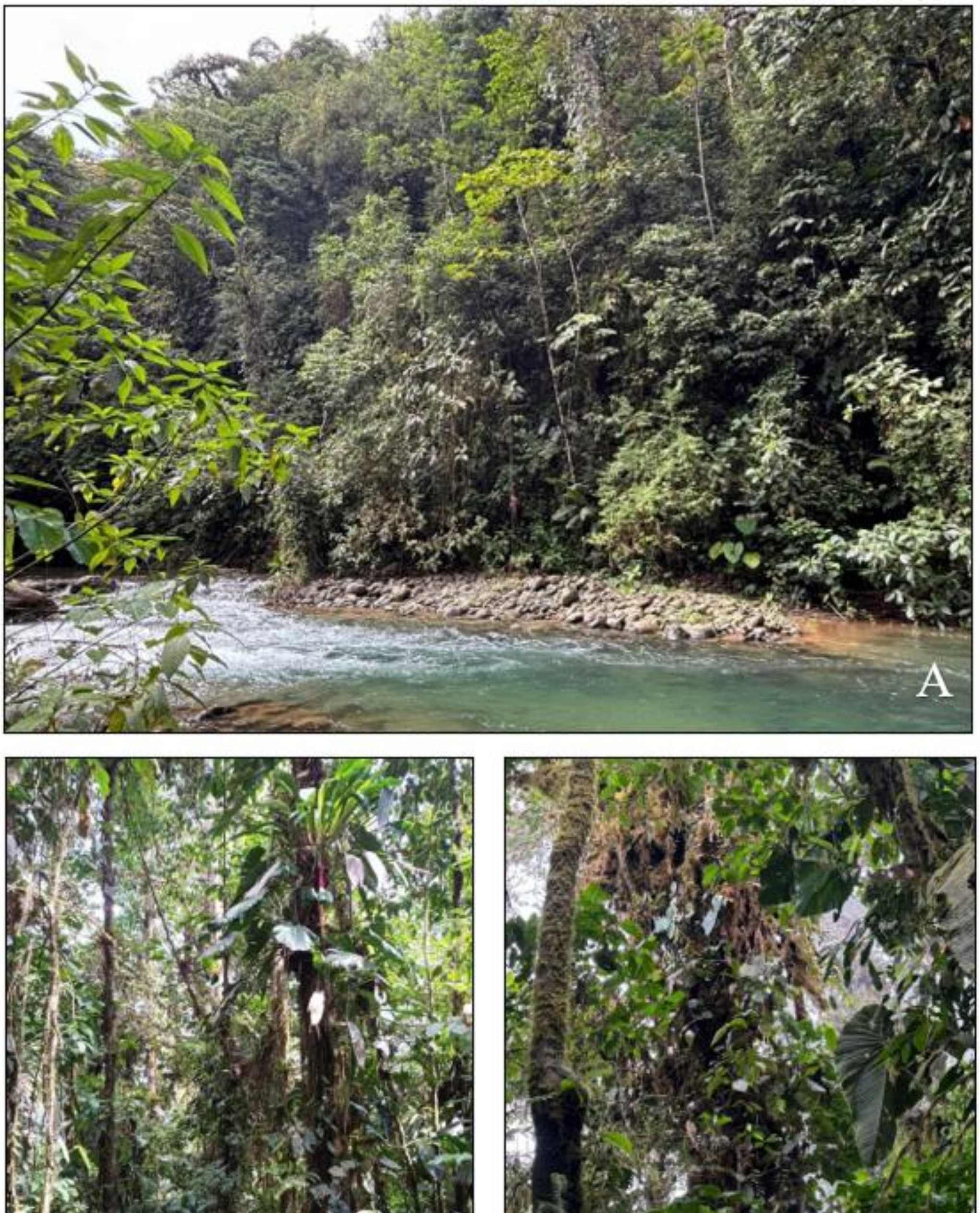

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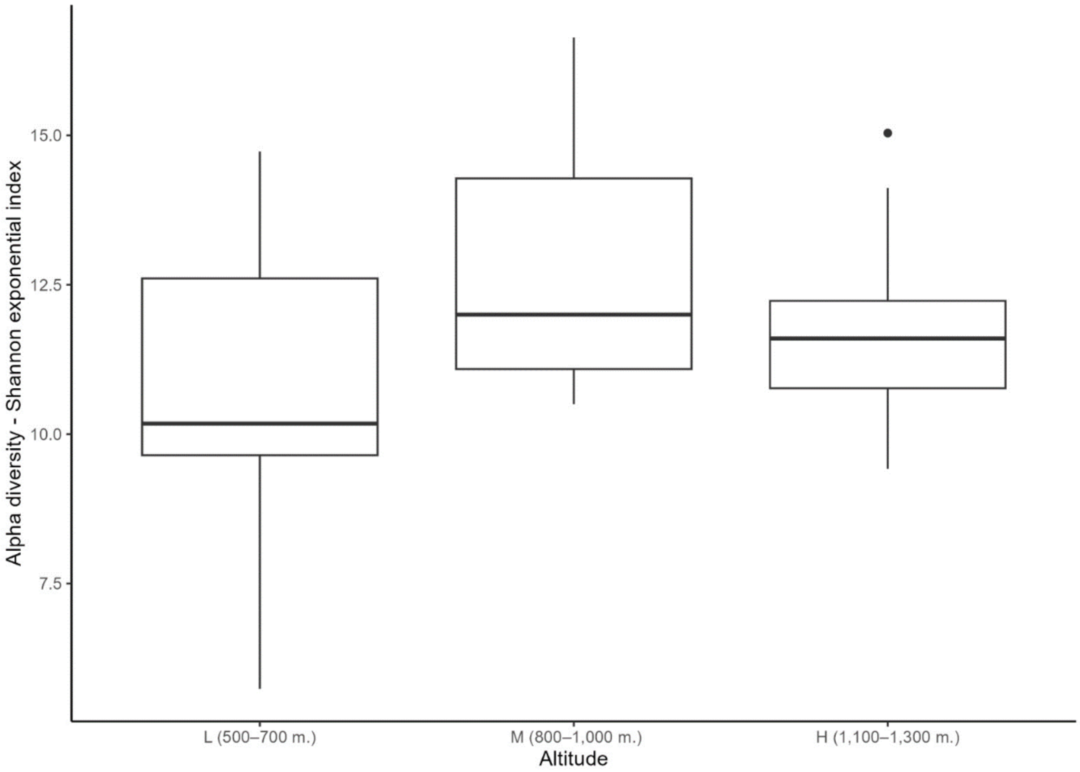

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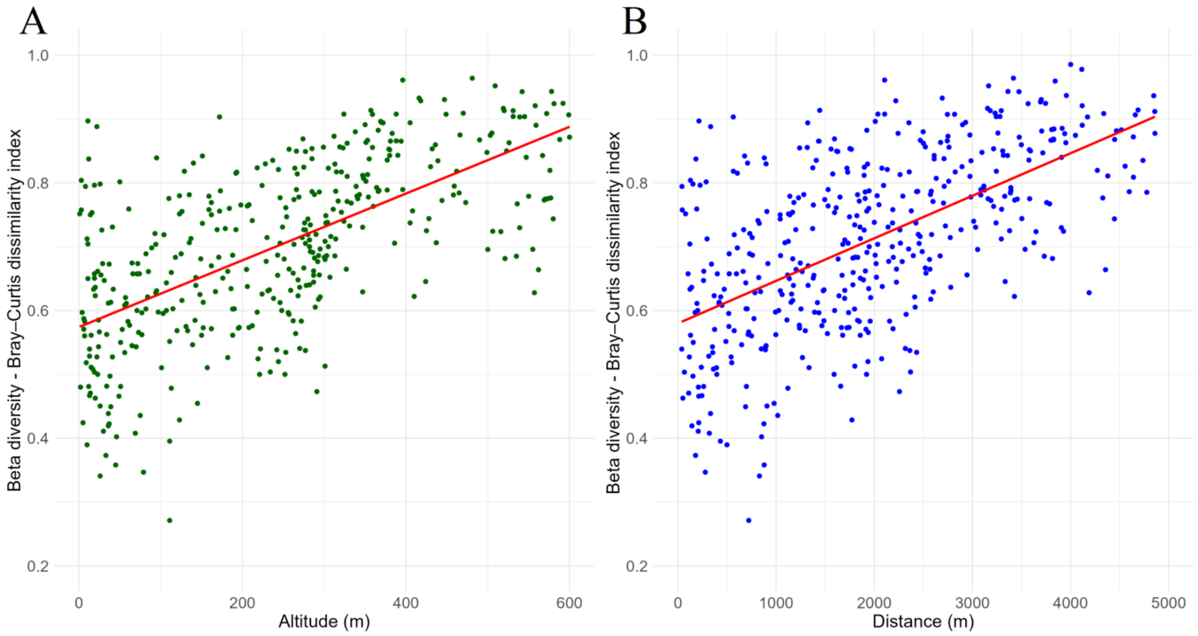

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Appendices

Species	**Abundance by elevation range**			**Total**	**Endemic/Native**
	Low	**Middle**	**High**		
Anthurium alluriquinense	0	4	38	42	N
Anthurium argyrostachyum	0	43	76	119	N
Anthurium balslevii	14	34	0	48	E
Anthurium boosianum	0	12	22	34	E
Anthurium boylei	0	23	2	25	N
Anthurium citrifolium	0	3	2	5	N
Anthurium cuspidatum	68	20	1	89	N
Anthurium decursivum	35	7	0	42	E
Anthurium dolichostachyum	44	25	14	83	N
Anthurium esmeraldense	13	17	25	55	N
Anthurium fragrans	50	41	3	94	N
Anthurium incomptum	0	0	4	4	N
Anthurium interruptum	11	0	0	11	N
Anthurium jaramilloi	39	8	2	49	E
Anthurium lancea	0	18	84	102	N
Anthurium latecollectivum	0	0	6	6	E
Anthurium longiluteum	0	8	11	19	E
Anthurium maculosum	0	5	14	19	E
Anthurium magnifolium	0	5	8	13	E
Anthurium margaricarpum	0	3	7	10	N
Anthurium marginellum	81	32	0	113	N
Anthurium marleenianum	22	4	32	58	E
Anthurium marmoratum	51	100	32	183	N
Anthurium michelii	37	1	0	38	N
Anthurium microspadix	15	23	28	66	N
Anthurium mindense	0	5	24	29	N
Anthurium nigropunctatum	0	9	46	55	N
Anthurium obscurinervium	0	2	0	2	N
Anthurium obtusilobum	0	62	29	91	N
Anthurium obtusum	5	0	0	5	N
Anthurium ochreatum	35	4	66	105	N
Anthurium ovatifolium	0	0	10	10	N
Anthurium oxyphyllum	13	19	2	34	N
Anthurium panduriforme	20	29	19	68	N
Anthurium pendulispadix	0	0	3	3	N
Anthurium pseudonigrescens	5	0	0	5	E
Anthurium pulverulentum	6	7	7	20	N
Anthurium rodrigueziae	5	0	0	5	E
Anthurium roquesevillae	0	15	1	16	E
Anthurium scandens	18	0	0	18	N
Anthurium striatipes	0	9	54	63	E
Anthurium subandinum	0	0	12	12	E
Anthurium teisherianum	0	4	7	11	E
Anthurium tremulum	0	0	2	2	E

Anthurium trisectum	11	4	0	15	N
Anthurium truncicola	10	18	15	43	N
Anthurium versicolor	67	95	44	206	N
***Anthurium* sp.1**	1	0	0	1	
***Anthurium* sp.2**	6	0	0	6	
***Anthurium* sp.3**	0	7	2	9	
***Anthurium* sp.4**	14	20	0	34	
***Anthurium* sp.5**	16	0	0	16	
***Anthurium* sp.6**	39	0	2	41	
***Anthurium* sp.7**	14	0	0	14	
***Anthurium* sp.8**	0	10	0	10	
Total	765	755	756	2276	E= 16; N=31

Appendix 1. Species list and abundance of individuals in the three elevational zones (Low 500–700 m, Middle 800–1,000 m and High 1,100–1,300 m). Data of 2,276 individuals recorded in Mashpi Lodge Reserve by altitude and Endemic (E) or Native (N).

ANALYSIS	TEST / COMPARISON	STATISTIC	P-VALUE
ALPHA DIVERSITY (EXP H′)	ANOVA	F = 2.13	0.138
NORMALITY ASSUMPTION	Shapiro–Wilk	W = 0.9687	0.5051
HOMOGENEITY OF VARIANCES	Levene	F = 0.5005	0.6117
BETA DIVERSITY (BRAY–CURTIS)	Mantel test (Elevation)	r = 0.6747	0.001
	Mantel test (Geographic dist.)	r = 0.594	0.001
PAIRWISE ELEVATION: L–M	Mantel r	r = 0.4757	0.001
PAIRWISE ELEVATION: L–H	Mantel r	r = 0.6728	0.001
PAIRWISE ELEVATION: M–H	Mantel r	r = 0.6828	0.001
PAIRWISE DISTANCE: L–M	Mantel r	r = 0.416	0.001
PAIRWISE DISTANCE: L–H	Mantel r	r = 0.6567	0.001
PAIRWISE DISTANCE: M–H	Mantel r	r = 0.5042	0.001

Appendix 2. Summary of statistical results for alpha and beta diversity