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Bryophyte composition, diversity, and biomass across mangrove phorophytes on the Brazilian Amazon coast

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ABSTRACT

Bryophytes are key yet underexplored components of the mangrove ecosystem, contributing to biodiversity, biomass accumulation, and microhabitat complexity. This study investigated the diversity, composition, and vertical distribution of epiphytic bryophytes on three mangrove phorophytes, *Rhizophora mangle* L., *Avicennia germinans* (L.) L., and *Laguncularia racemosa* (L.) C.F.Gaertn., at Ajuruteua Peninsula on the Brazilian Amazon coast. Seven bryophyte species from the Calymperaceae Kindb. and the families Lejeuneaceae N.N.Rostovtsev were identified. Species richness did not vary significantly across vertical zones, and biomass was significantly higher at intermediate canopy levels. Multivariate analysis revealed no significant differences in species composition across vertical phorophyte zones, although differences were observed among phorophyte types. Biomass patterns of *Calymperes palisotii* Schwägr. varied among phorophytes, with *R. mangle* supporting greater bryophyte biomass than *A. germinans*. Our findings, although partial, offer a reference point for future studies that combine physiological, microclimatic, and structural aspects to deepen understanding of how environmental conditions influence bryophyte diversity and productivity in mangrove forests.

KEY WORDS

Bryophytes,
biomass,
mangroves,
phorophyte,
vertical zonation.

RÉSUMÉ

Diversité et biomasse des bryophytes sur les phorophytes de mangrove : groupes de tolérance à la lumière sur la côte amazonienne brésilienne.

Les bryophytes sont des composantes essentielles, mais encore peu étudiées, de l'écosystème de la mangrove. Elles contribuent à la biodiversité, à l'accumulation de biomasse et à la complexité des microhabitats. Cette étude a examiné la diversité, la composition et la distribution verticale des bryophytes épiphytes sur trois phorophytes de mangrove, *Rhizophora mangle* L., *Avicennia germinans* (L.) L. et *Laguncularia racemosa* (L.) C.F.Gaertn., dans la péninsule d'Ajurutéua, sur la côte amazonienne brésilienne. Sept espèces de bryophytes appartenant à la famille des Calymperaceae Kindb. et des Lejeuneaceae N.N.Rostovtsev ont été identifiées. La richesse spécifique ne variait pas significativement selon les zones verticales, tandis que la biomasse était significativement plus élevée aux niveaux intermédiaires de la canopée. L'analyse multivariée n'a révélé aucune différence significative dans la composition spécifique entre les zones verticales de phorophytes, tandis que des différences ont été observées entre les types de phorophytes. Les profils de biomasse de *Calymperes palisotii* Schwägr. variaient selon les phorophytes : *R. mangle* supportait une biomasse de bryophytes plus importante qu'*A. germinans*. Nos résultats, bien que partiels, constituent un point de référence pertinent pour les études futures qui combinent les aspects physiologiques, microclimatiques et structurels afin d'approfondir la compréhension de la manière dont les conditions environnementales influencent la diversité et la productivité des bryophytes dans les forêts de mangroves.

MOTS CLÉS

Bryophytes,
biomasse,
mangroves,
phorophyte,
zonation verticale.

INTRODUCTION

Mangrove forests are coastal ecosystems of great ecological importance, acting as transition zones between marine and terrestrial environments (Alongi 2014, 2020). These ecosystems play fundamental roles in protecting coastlines from erosion, maintaining biodiversity, sequestering carbon, and filtering pollutants (Alongi 2020). In addition, mangrove forests serve as habitat for several species of fauna and flora, including bryophytes, which often develop as epiphytes on the trunks and branches of phorophyte trees (Toivonen *et al.* 2017; Hu *et al.* 2021; Gomes *et al.* 2023). As poikilohydric plants, bryophytes are highly sensitive to microclimatic conditions, making them excellent bioindicators of environmental change that reflect ecosystem changes quickly and effectively (Hu *et al.* 2021).

Epiphytes, which include both bryophytes and other plants (including vascular), represent a significant portion of global biodiversity, with estimates indicating that they constitute between 8% and 10% of all known vascular plant species and 25% to 50% of species richness in tropical forests (Visnadi 2008; Costa & Peralta 2015; Gómez González *et al.* 2017; Sabatini *et al.* 2022; Soto *et al.* 2023). Epiphytes accumulate large amounts of organic detritus, forming a thick layer that can reach up to 44 t/ha in high-montane forests (Hofstede *et al.* 1993; Gómez González *et al.* 2017). Epiphytic bryophytes can account for up to 81.3% of canopy biomass, excluding woody tissues (Díaz *et al.* 2010). The composition and biomass of vascular epiphytes play an important role in the vertical distribution of bryophytes along phorophytes (host trees), but information remains limited, especially in specific regions such as mangrove forests in the Amazon (Sousa & Colpo 2017; Glime 2024).

Microclimatic variations act as an environmental filter as well, shaping the vertical distribution, composition, and biomass of bryophytes along phorophytes (Gomes *et al.* 2023). Studies show that the availability of light, humidity, and temperature varies

along the vertical gradient of trees, limiting the survival of species with different tolerances (Sporn *et al.* 2010; Flores-Argüelles *et al.* 2022). These microclimatic conditions influence bryophytes in the understory and canopy differently: understory bryophytes generally respond to light availability and precipitation trends, whereas canopy bryophytes experience more pronounced variations in environmental conditions, such as relative humidity and light intensity (Sporn *et al.* 2010; Flores-Argüelles *et al.* 2022; Gomes *et al.* 2023). This sensitivity to light and moisture enables bryophytes in mangrove environments to respond plastically to environmental fluctuations, thereby enhancing their growth rates during seasonal variations.

In mangrove areas, bryophyte distribution reflects vertical microclimatic gradients: the upper zones favor light-adapted, desiccation-tolerant species with higher biomass, while the lower zones host moisture-dependent species with lower light requirements (Gehrig-Downie *et al.* 2011). Here, we aim to describe the richness and composition of bryophytes associated with the three main phorophytes in the mangrove forests of the Ajurutéua Peninsula, located in Pará, Brazil. We also estimate bryophyte biomass along the vertical gradient. Thus, we aim to increase knowledge of mangrove bryophyte communities by understanding the relationships between epiphytic bryophytes and their phorophytes, including changes in diversity and biomass. Our findings intend to provide baseline information on bryophyte diversity and distribution in Amazonian mangroves, contributing to a better understanding of their spatial patterns.

MATERIAL AND METHODS

STUDY AREA

The Ajurutéua Peninsula, located between coordinates 46°50' and 46°30'W and 0°45' and 1°07'S, is approximately 200 km southeast of the mouth of the Amazon River, in the municipality

of Bragança, state of Pará, Brazil (Fig. 1). With an area of circa 250 km², the peninsula is part of a vast mangrove region that covers approximately 152 077 km², constituting the largest continuous area of mangrove on the planet (Souza-Filho 2005). Mangrove vegetation is predominant on the peninsula, covering approximately 90% of its extension, and is characterized by three main tree species: *Rhizophora mangle* L. (Rhizophoraceae), *Avicennia germinans* (L.) L. (Acanthaceae), and *Laguncularia racemosa* (L.) C.F.Gaertn. (Combretaceae) (Virgulino-Júnior *et al.* 2020).

These mangroves exhibit considerable phytoecological diversity, characterized by significant variations in environmental conditions throughout the Ajuruteua Peninsula. The region has a hot and humid climate, with an average annual temperature of 26.5°C, an average annual precipitation of 2348.5 mm, and a relative humidity of 85% over the past 40 years (Virgulino-Júnior *et al.* 2020). The region's weather patterns are primarily influenced by the Intertropical Convergence Zone (ITCZ) (Marengo 1995). When the ITCZ moves southward (from January to June), it characterizes the rainy season, while the dry season, defined as months with less than 100 mm of rainfall (Walsh 1996), typically extends from July to December. The mangrove areas of the peninsula are distributed across a range of conditions, ranging from areas with high salinity (>100) and low levels of inundation to estuaries more influenced by freshwater from the Caeté River (Virgulino-Júnior *et al.* 2020). The semidiurnal macrotidal regime has amplitudes ranging from 4 to 6 m (DHN 2024). This environmental heterogeneity significantly contributes to the diversity of plant and animal species inhabiting the mangroves and is crucial to the region's ecological dynamics.

Furthermore, studies of different mangrove ecosystems highlight the importance of mangroves in the Amazon region for protecting the coastline, stabilizing soil, and maintaining local biodiversity (Souza-Filho 2005). These ecosystems, which strongly interact with rivers and tides, serve as refuges for numerous marine species (e.g., West Indian manatee – *Trichechus manatus* Linnaeus, 1758; Gray snapper – *Lutjanus griseus* (Linnaeus, 1758); White shrimp – *Penaeus subtilis* (Pérez Farfante, 1967); and terrestrial species [e.g., Coati – *Nasua nasua* (Linnaeus, 1766); Howler monkey – *Alouatta ululata* Elliot, 1912; Pygmy anteater – *Cyclopes didactylus* (Linnaeus, 1758)], and are therefore relevant to environmental conservation. The Ajuruteua Peninsula, with its extensive mangrove area, is a representative example of mangrove areas in Brazil, which play fundamental ecological and socioeconomic roles for local communities and the preservation of coastal ecosystems.

DATA COLLECTION

Data collection was carried out in May, June, and December 2015, during the rainy season, in a mangrove forest located near Furo do Taíci (0°58'05.27"S, 46°44'14.98"W) (Fig. 1C). This forest is located in the portion of the Ajuruteua Peninsula closest to the continent, where the influence of freshwater is more pronounced, resulting in low salinity concentrations.

The samples were collected from phorophytes selected for the biomass study in the Ajuruteua Peninsula mangroves, under

License MMA/ICMBIO/SISBIO nº 42900-4. Three mangrove species were chosen: *R. mangle* (red mangrove), *A. germinans* (black mangrove), and *L. racemosa* (white mangrove) – with an average height of 20 m – and three phorophytes were chosen per species (Ag1, Ag2, Ag3, Rm1, Rm2, Rm3, Lr1, Lr2, Lr3), totaling nine phorophytes. Each tree (phorophyte) was divided into three vertical zones according to height (in Portuguese: Altura, in meters): Z1 (the phorophyte base A0 m; A2 m; A4 m; A6 m); Z2 (A8 m; A10 m; A12 m); and Z3 (A14 m; A16 m; A18 m), with three samples collected from each zone. A total of 82 samples were collected from the phorophytes.

The taxonomic identification of the collected material was performed at the Environmental Monitoring and Conservation Laboratory of the State University of Pará (UEPA) using specialized literature, dichotomous keys, descriptions, and taxonomic illustrations. The classifications of Crandall-Stotler *et al.* (2009), Goffinet *et al.* (2008) and Brinda & Atwood (2025) were used for Bryophyta and Marchantiophyta. The identified material was incorporated into the Marlene Freitas da Silva (MFS) Herbarium at the UEPA. The species were classified into guilds based on their tolerance to light, with a focus on generalist species and sun specialists. For this, the following literature was adopted: (Richards 1954; Gradstein 1992; Gradstein *et al.* 2001; Fagundes *et al.* 2016; Gomes *et al.* 2023).

The species *Calymperes palisotii* Schwägr was selected for the biomass analysis. It presented the highest occurrence and abundance among the epiphytic species collected. The collected material was hydrated and cleaned in the laboratory, and the species *C. palisotii* was separated from the others for weighing after oven drying. The biomass was calculated by the formula: where P_s represents the dry weight of each species and A is the total area of each compartment of the phorophyte from which the samples were taken. The total area of each compartment was calculated using the formula for the area of a cylinder: where C is the average circumference of the compartment and h is its total length.

DATA ANALYSES

Species richness estimation was performed using EstimateS 8.2 – Statistical Estimation of Species Richness and Shared Species from Samples (Colwell *et al.* 2004; Colwell 2009). A species accumulation curve was generated to verify sampling sufficiency in each phorophyte based on a species presence and absence matrix. The first-order nonparametric Jackknife estimator was used, accounting for unique sampling units (species occurring in only one sample) and singletons (species represented by a single individual in the sample), a typical pattern in the vegetation physiognomies of tropical regions. Data were randomized 100 times to remove the effect of sample order, and the mean of the randomizations was used to generate the species accumulation curve, enabling comparison between estimators.

The raw data met the assumptions of normality (Shapiro–Wilk test) and homoscedasticity (Levene's test) (Ayres *et al.* 2007). Therefore, one-way analysis of variance (ANOVA) was applied to compare species richness among the three vertical

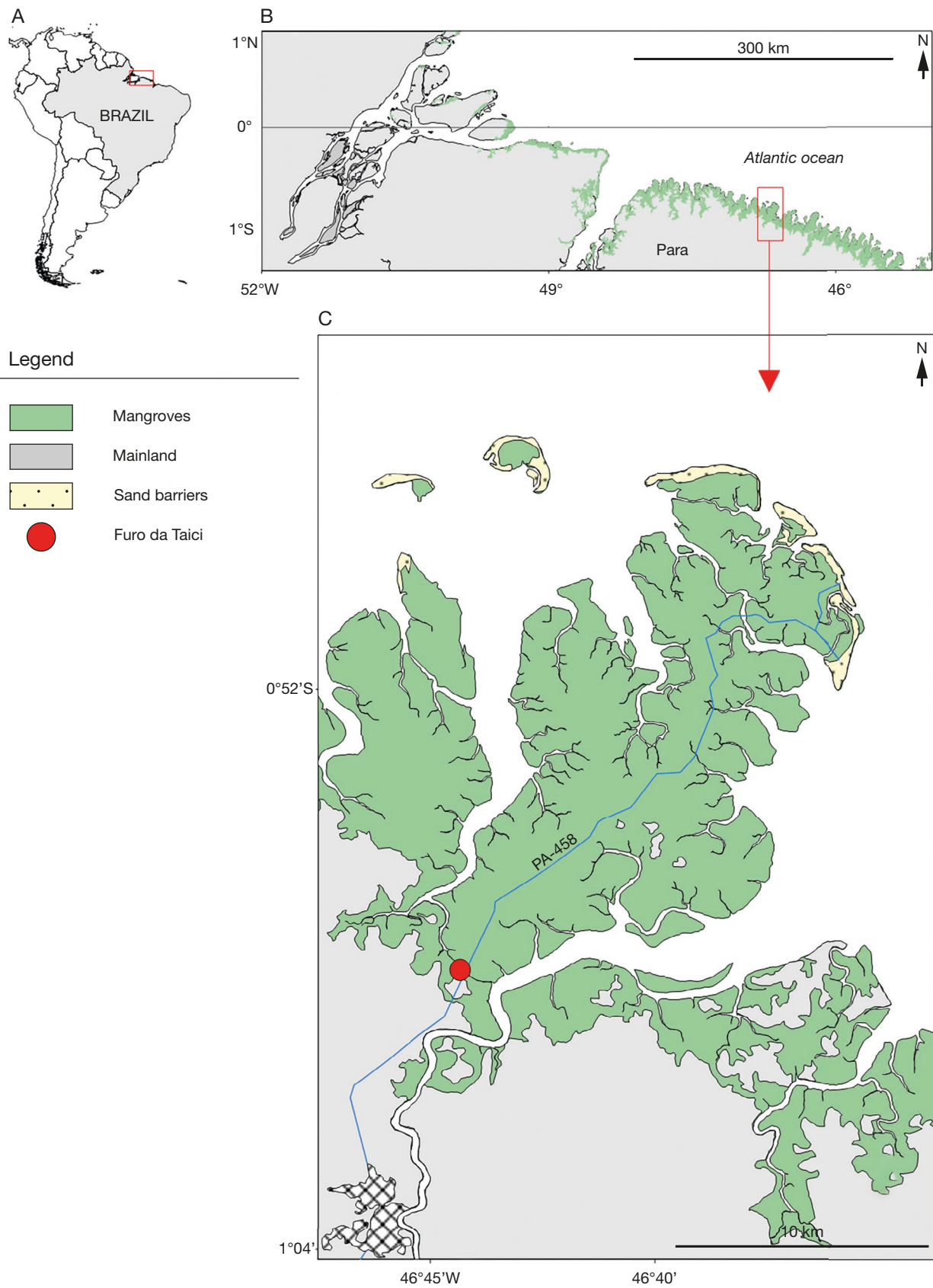


FIG. 1. — Map of the study area: **A**, state of Pará, northern region of Brazil; **B**, Northeast of the state of Pará, on the Brazilian Amazon coast; **C**, Ajuruteua Peninsula, in the municipality of Bragança-Pará.

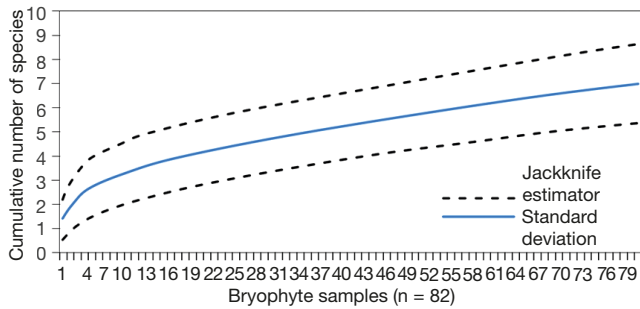


FIG. 2. — Species accumulation curve observed in the phorophytes of the mangroves of the Ajuruteua Peninsula, Bragança, Brazilian Amazon coast, generated based on the Jackknife estimator.

zones of phorophytes. A *t*-test was used to assess differences in the average biomass of the phorophyte species. The community composition was analyzed using multivariate analysis of variance (MANOVA) with the Bray-Curtis similarity index to compare species abundance among the different phorophytes. The Nonmetric Multidimensional Scaling (NMDS) Method was used to order the relationships among the samples, enabling visualization of similarity trends. The initial solution was randomly selected because the algorithm is nonmetric. These analyses were performed using the statistical program Primer v5 (Clarke & Gorley 2001).

RESULTS

Of the 82 samples collected in mangrove areas on the Ajuruteua Peninsula, covering the three types of phorophytes analyzed, seven species of bryophytes were identified, two belonging to the Calymperaceae family (mosses) and five to the Lejeuneaceae family (liverworts) (Fig. 2; Table 1). Based on the first-order Jackknife estimator, the richness estimate indicated the potential presence of ten species in the nine trees studied, suggesting that approximately 70% of the expected diversity was recorded during the study (Fig. 2).

The analysis of epiphytes of the Calymperaceae and Lejeuneaceae families revealed distinct distribution trends along the vertical gradient of the phorophytes. The heights were grouped into three zones: Zone 1 (base of the tree – A0, A2, A4, A6), Zone 2 (intermediate – A8, A10, A12), and Zone 3 (top – A14, A16, A18) (Table 1).

In the Calymperaceae family, *Calymperes erosum* was recorded only in Zone 3, excluding heights A16 and A18, and was found in the phorophytes Ag1, Ag2, Ag3, Rm1, Rm2, and Rm3, indicating it is a sun specialist. *Calymperes palisotii* exhibited a wide distribution, being recorded in all zones and occurring in all the studied phorophytes (Ag1, Ag2, Ag3, Rm1, Rm2, Rm3, Lr1, Lr2, Lr3), indicating it is a generalist species (Table 1).

In the Lejeuneaceae family, the species presented different distributions. *Cheilolejeunea rigidula* and *Lejeunea laetevirens* were generalists, occurring in all zones and distributed in several phorophytes. On the other hand, two species had distributions restricted to Zone 3 and were classified as sun

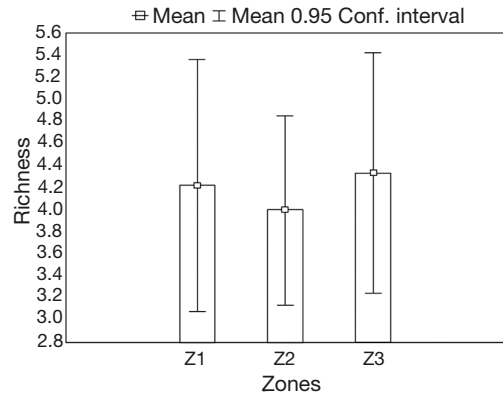


FIG. 3. — Comparison of bryophyte richness among different height zones of phorophytes of mangrove forests in the Ajuruteua Peninsula, Bragança, Brazilian Amazon coast. Z1, base to 6; Z2, 6 to 12; Z3, 12 to 20 (m).

specialists: *Metalejeunea cucullata*, recorded in A14, and *Acrolejeunea torulosa*, present in A16. *Microlejeunea acutifolia* was present exclusively in Zone 2 (at height A10).

The comparative analysis of the species richness of bryophytes between the three vertical zones of the phorophytes revealed no significant differences (ANOVA; $F = 0.14$; p -value = 0.86) (Fig. 3). These results indicate that, despite the variation in the individual distribution of the species, the total diversity did not present a statistically significant trend between the different heights of the tree.

Multivariate analysis of variance (MANOVA) revealed no significant differences in bryophyte species composition among the three vertical zones of phorophytes (MANOVA; $F = 0.91895$; p -value = 0.451), which was corroborated by nonmetric multidimensional ordination (NMDS) analysis (Fig. 4). On the other hand, a significant difference in bryophyte species composition was detected among the three types of phorophytes analyzed (MANOVA; $F = 22.22$; p -value = 0.001) (Fig. 5).

Four of the seven species analyzed were classified as sun specialists in illuminated environments: *C. erosum*, *M. acutifolia*, *M. cucullata*, and *A. torulosa*. The other three species were considered generalists: *C. palisotii*, *C. rigidula*, and *L. laetevirens* (Table 1).

Our findings also showed that bryophyte biomass for *C. palisotii* (Fig. 6) was significantly higher in Zone 2 (Z2) than in the other zones, averaging 1.2 g cm^{-2} .

The comparative analysis of the two average biomass values between the phorophyte species associated with *C. palisotii* revealed no significant difference ($t = 0.34$, p -value = 0.73). Meanwhile, the results indicated that *R. mangle* had an average biomass of 0.8 g cm^{-2} , suggesting that *C. palisotii* biomass accumulation was higher with this species. In contrast, *A. germinans* had an average biomass of *C. palisotii* of 0.4 g cm^{-2} (Fig. 7).

DISCUSSION

The present study investigated the composition, biomass, and vertical distribution of epiphytic bryophytes in mangroves of

TABLE 1. — Bryophytes attached to mangrove phorophytes of the Ajuruteua Peninsula, Pará, Brazilian Amazon coast. Abbreviations: **Ag**, *Avicennia germinans* (L.) L.; **Rm**, *Rhizophora mangle* L.; **Lr**, *Laguncularia racemosa* (L.) C.F.Gaertn. A0, A2, A4, A6, A8, A10, [...], A18; **m**, height.

Taxon	Height (m)											Phorophyte	Ecological Group
	Zone 1				Zone 2				Zone 3				
	A0	A2	A4	A6	A8	A10	A12	A14	A16	A18			
Family Calymperaceae Kindb.													
<i>Calymperes erosum</i> Müll. Hal.									×	X	Ag1, Ag2, Ag3, Rm1, Rm2, Rm3	Sun specialist	
<i>Calymperes palisotii</i> Schwägr	×	×	×	×	×	×	×	×	×	X	Ag1, Ag2, Ag3, Rm1, Rm2, Rm3, Lr1, Lr2, Lr3	Generalist	
Family Lejeuneaceae Cas.-Gil													
<i>Cheilolejeunea rigidula</i> (Nees ex Mont.) R.M.Schust.	×	×	×	×	×	×	×	×	×	X	Ag1, Ag2, Rm1, Rm2, Rm3	Generalist	
<i>Lejeunea laetevirens</i> Nees & Mont	×	×	×	×	×	×			×	X	Ag1, Ag2, Ag3	Generalist	
<i>Microlejeunea acutifolia</i> Steph.						×					Lr3	Sun specialist	
<i>Metalejeunea cucullata</i> (Reinw., Blume & Nees) Grolle								×			Lr3	Sun specialist	
<i>Acrolejeunea torulosa</i> (Lehm. & Lindenb.) Schiffn.									×		Ag1	Sun specialist	

the Ajuruteua Peninsula, expanding the known bryophyte flora of the Amazonian coastal mangroves. A total of seven species belonging to the families Lejeuneaceae and Calymperaceae were recorded on 82 samples collected at different heights from three phorophyte species. This represents approximately 70% of the expected diversity, suggesting that the sampling captured a substantial portion of the local assemblage. The number of species found in this study corresponds to 58% of those recorded in mangroves on the east coast of Marajó Island, Brazil (Gomes *et al.* 2023), indicating that bryophyte diversity in mangroves tends to be lower than that observed in terra firme or upland tropical forests (4.6% of the 150 species) (Sierra *et al.* 2018). Compared with mangrove areas in the state of São Paulo, in southeastern Brazil, the bryophyte diversity of the mangroves on the Ajuruteua Peninsula, in the state of Pará, accounts for only 6% of the species recorded there (Visnadi 2008). However, this author obtained results similar to those here when comparing species richness by phorophyte type, ranging from 4% for *L. racemosa* and 5% for *R. mangle* to 19% for *A. germinans*.

The predominance of the family Lejeuneaceae is consistent with other floristic studies conducted in the Amazon coastal and Neotropical regions (Gradstein *et al.* 2001; Garcia *et al.* 2014; Gomes *et al.* 2023), reflecting the family's wide distribution and success in humid lowland environments. The presence of the family Calymperaceae, although represented by only two species, is also relevant, as both families are now recorded for the first time associated with mangrove forests in the state of Pará, Brazilian Amazon coast. These results help fill the knowledge gap in the bryophyte flora of mangrove ecosystems in the North Brazil Shelf, where few inventories have been conducted to date (Garcia *et al.* 2014; Gomes *et al.*

2023), and in the other Brazilian mangrove regions (Visnadi 2008; Costa & Peralta 2015).

The classification of species into light-tolerance guilds we used (Fagundes *et al.* 2016; Gomes *et al.* 2023) revealed that light availability is a relevant factor in the species' occurrence along the vertical gradient in the study area. Sun-adapted species such as *M. cucullata* were restricted to the upper zones, while generalist species such as *C. palisotii* and *L. laetevirens* occurred across all vertical levels. These patterns support the interpretation that luminosity acts as a key environmental filter influencing bryophyte zonation in mangrove phorophytes. The absence of significant differences in overall species composition among vertical zones, as shown by MANOVA, suggests that variations in microclimatic conditions (e.g., humidity and temperature) along the trunk are insufficient to cause significant shifts in bryophyte assemblage structure. This could indicate that species with broader tolerance ranges can persist along the entire vertical profile of the phorophytes (Sousa & Colpo 2017). However, only nine trees were compared in this study, which may also explain the lack of statistical significance. Moreover, the significant differences observed among phorophyte types demonstrate that the nature of host trees influences the vertical distribution of bryophyte assemblages in this mangrove system. *Rhizophora mangle*, for example, supported greater bryophyte biomass, particularly of *C. palisotii*, than *A. germinans*.

In mangroves, although phorophyte diversity is low, species such as *R. mangle*, *A. germinans*, and *L. racemosa* provide contrasting substrates that favor distinct epiphytic assemblages adapted to extreme environmental conditions. However, in mangroves, phorophyte specificity is better described as host preference or filtering rather than strict host specificity,

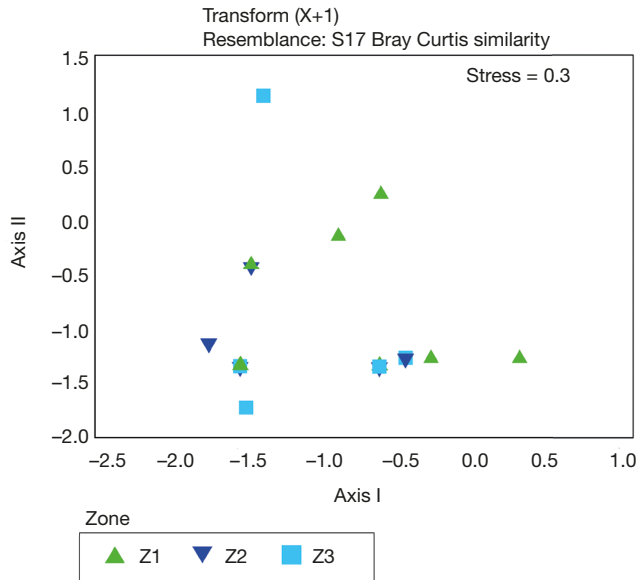


FIG. 4. — Relationship of bryophyte species with the three phorophyte zones.

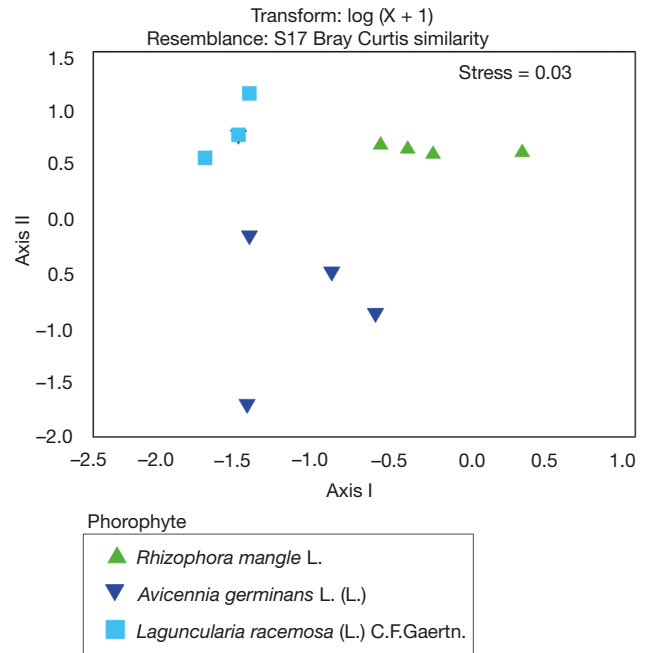


FIG. 5. — Relationship between bryophyte and phorophyte richness.

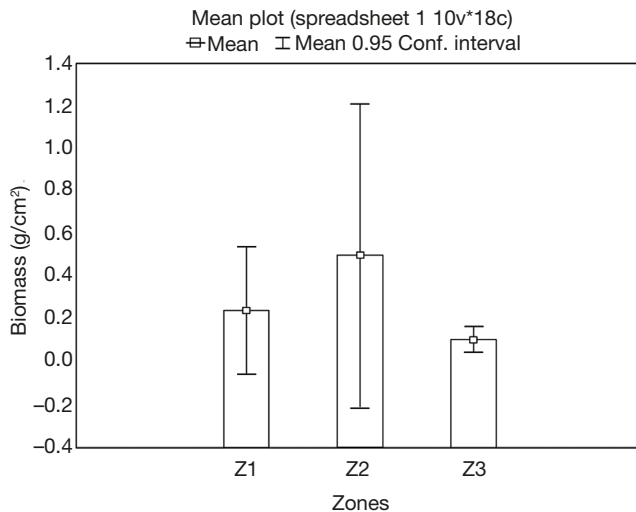


FIG. 6. — Biomass (g cm⁻²) of *Calymperes palisotii* Schwägr by two phorophyte zones.

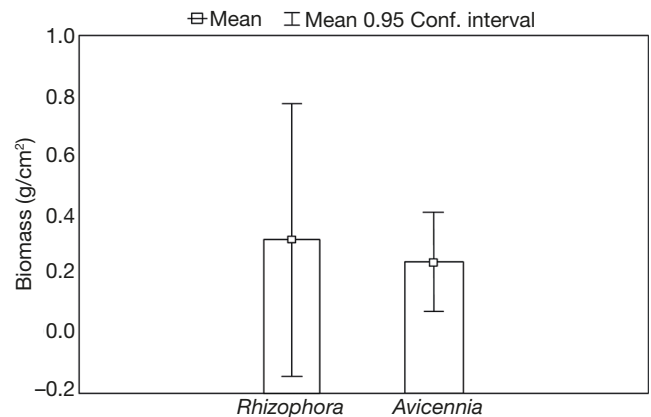


FIG. 7. — Biomass (g cm⁻²) of *Calymperes palisotii* Schwägr per phorophyte.

where mangrove tree diversity is low (c. ten mangrove species, Castillo-Cárdenas & Toro-Perea 2012), limiting strong host specialization and rendering the observed “specificity” more often a functional association rather than a taxonomic species-specific one.

Phorophyte identity also influences the composition of epiphytic bryophytes and lichens, a pattern widely documented across different forest types. In tropical Atlantic Forests, for example, tree species such as *Euterpe edulis* Mart. and *Tapirira guianensis* Aubl., host distinct assemblages of corticolous lichens, particularly from Graphidaceae and Thelotremaaceae, associated with variations in bark pH and texture (Cáceres *et al.* 2007). In subtropical laurel forests, phorophytes such as *Laurus novocanariensis* Rivas Mart., Lousá, Fern. Prieto,

E.Dias, J.C.Costa & C.Aguiar and *Ocotea foetens* (Aiton) Baill. support lichens like *Lobaria pulmonaria* (L.) Hoffm., reflecting higher water retention and microclimatic stability (González-Montelongo *et al.* 2022). In temperate forests, species such as *Fagus sylvatica* L. and *Quercus robur* L. show recurrent associations with epiphytic bryophytes, including *Frullania dilatata* (L.) Dumort. and *Orthotrichum affine* Schrad. ex Brid., as well as lichens such as *Parmelia sulcata* Taylor (Bates 1992; Ódor *et al.* 2013).

Biomass values were significantly higher in Zone 2, the intermediate canopy level (Fig. 6), suggesting that this position provides a more favorable condition for bryophyte growth. This pattern has been observed in other tropical forests, where mid-canopy zones often present optimal microclimatic conditions for epiphyte development (Pereira *et al.* 2021; Gomes *et al.* 2023).

Overall, our findings highlight the complex interplay between environmental conditions and substrate distribution in shaping

bryophyte assemblages within mangrove forests. This study underscores the ecological significance of mangrove canopies as habitats for bryophytes. It provides a valuable baseline for further research integrating physiological, microclimatic, and structural variables to better understand how environmental factors regulate bryophyte diversity and productivity in mangrove ecosystems.

CONCLUSION

Our findings on the epiphytic bryophytes in mangrove areas on the Ajuruteua Peninsula, in Bragança, Pará, Brazil, recorded only seven species, belonging to the Calymperaceae and Lejeuneaceae families, accounting for approximately 70% of the estimated diversity. The distribution of species along the vertical gradient revealed a predominance of generalist species and a restricted occurrence of light specialists in the upper tree zones. Although richness did not vary significantly across heights, the greater biomass in the intermediate zone indicates a direct effect of light on bryophyte growth. Finally, the species composition differed significantly among the phorophytes, with *R. mangle* supporting the highest values of biomass of the bryophyte community in this ecosystem.

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Author's contributions

The research idea was developed by PSC, ACCTM, and MEBF; PSC collected bryophytes; PSC and ACCTM validated the taxonomic identity of all records; PSC performed the statistical analyses; PSC was responsible for preparing and writing the manuscript; DSM, ACCTM, and MEBF revised the manuscript; all authors approved the final version of the text.

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