cryptogamie
Bryologie
2022 • 43 • 7

# Bryophytes from Martírios-Andorinhas Mountain Ridge, a highly impacted Amazonia-Cerrado transition zone in southeastern Pará, Brazil

Jean Cesar Simão DOS SANTOS & Anna Luiza ILKIU-BORGES

art. 43 (7) — Published on 9 June 2022
www.cryptogamie.com/bryologie

PUBLICATIONS SCIENTIFIQUES
MUSÉUM NAT HIST NATURELLE

Couverture / *Cover*:
Extraits d'éléments de la Figure 2 / Extracts of the Figure 2

*Cryptogamie, Bryologie* est indexé dans / Cryptogamie, Bryologie *is indexed in:*
– Biological Abstracts
– Current Contents
– Science Citation Index
– Publications bibliographiques du CNRS (Pascal).

*Cryptogamie, Bryologie* est distribué en version électronique par / Cryptogamie, Bryologie *is distributed electronically by:*
– BioOne® (http://www.bioone.org)

**Cryptogamie, Bryologie** est une revue en flux continu publiée par les Publications scientifiques du Muséum, Paris
***Cryptogamie, Bryologie** is a fast track journal published by the Museum Science Press, Paris*

Les Publications scientifiques du Muséum publient aussi/ *The Museum Science Press also publish:* ***Adansonia, Geodiversitas, Zoosystema, Anthropozoologica, European Journal of Taxonomy, Naturae, Comptes Rendus Palevol,* Cryptogamie sous-sections *Algologie, Mycologie.***

Diffusion – Publications scientifiques Muséum national d'Histoire naturelle
CP 41 – 57 rue Cuvier F-75231 Paris cedex 05 (France)
Tél.: 33 (0)1 40 79 48 05 / Fax: 33 (0)1 40 79 38 40
diff.pub@mnhn.fr / http://sciencepress.mnhn.fr

ISSN (imprimé / *print*): 1290-0796 / ISSN (électronique / *electronic*): 1776-0992

# Bryophytes from Martírios-Andorinhas Mountain Ridge, a highly impacted Amazonia-Cerrado transition zone in southeastern Pará, Brazil

**Jean Cesar Simão dos SANTOS**
Programa de Pós-graduação em Ciências Biológicas-Botânica Tropical,
Museu Paraense Emílio Goeldi, Coordenação de Botânica,
Av. Perimetral, 1901, Terra Firme, CEP 66.077-830, Belém, Pará (Brazil)
jean.cesarmt@hotmail.com

**Anna Luiza ILKIU-BORGES**
Museu Paraense Emílio Goeldi, Coordenação de Botânica,
Av. Perimetral 1901, Terra Firme, CEP 66077-830, Belém, Pará (Brazil)
ilkiu-borges@museu-goeldi.br (corresponding author)

Submitted on 2 July 2021 | Accepted on 11 April 2022 | Published on 9 June 2022

Santos J. C. S. dos & Ilkiu-Borges A. L. 2022. — Bryophytes from Martírios-Andorinhas Mountain Ridge, a highly impacted Amazonia-Cerrado transition zone in southeastern Pará, Brazil. *Cryptogamie, Bryologie* 43 (7): 123-134. https://doi.org/10.5252/cryptogamie-bryologie2022v43a7. http://cryptogamie.com/bryologie/43/7

ABSTRACT
The Martírios-Andorinhas Mountain Ridge, in southeastern Pará, is located in a transition zone between two important biomes in Tropical America, Amazonia and the Brazilian Cerrado. The aim of this study was to inventory the bryophyte flora in different vegetation formations of the Martírios-Andorinhas Mountain Ridge, as a contribution to the evaluation of the environmental conservation status of the area. A total of 1784 specimens (1093 of mosses, 691 of liverworts) were gathered, with a prevalence of mosses over liverworts. In terms of species richness, however, liverworts (65 spp.) were as diverse as mosses (65). The number of specimens was higher in secondary forest (799), followed by gallery forest (670), riparian forest (208), and savanna (107). In turn, in number of species, gallery forest (88 spp./25 exclusive) surpassed secondary forest (75/17), riparian forest (64/8), and savanna (32/1). Bryophyte composition and richness reflects the environmental conditions in each vegetation type. Six species are new occurrences for the state of Pará, four for the northern region, and one for Brazil. The great majority (95 %) of the species were already recorded from the Amazonian domain, while 76 % were known from the Cerrado domain. The high percentage of species recorded from Amazonia can be explained by the presence of humid lowland forests in the study area, promoting the establishment of Amazonian species including many Lejeuneaceae.

KEY WORDS
Mosses, liverworts, conservation unit, Amazonia, Brazilian Planalto.

**RÉSUMÉ**

*Bryophytes de la crête de la montagne Martírios-Andorinhas, une zone de transition Amazonie-Cerrado fortement impactée dans le sud-est du Pará, Brésil.*

La crête de la montagne Martírios-Andorinhas, dans le sud-est du Pará, est située dans une zone de transition entre deux biomes importants d'Amérique tropicale : l'Amazonie et le Cerrado brésilien. Le but de cette étude était d'étudier la flore des bryophytes dans différentes formations végétales de la crête de Martírios-Andorinhas, afin de contribuer à l'évaluation de l'état de conservation environnementale de la zone. Un total de 1784 spécimens (1093 de mousses, 691 d'hépatiques) ont été collectés, avec une prévalence des mousses sur les hépatiques. En terme de richesse spécifique, cependant, les hépatiques (65 spp.) étaient aussi diverses que les mousses (65). Le nombre de spécimens était plus élevé dans la forêt secondaire (799), suivie de la forêt galerie (670), de la forêt riveraine (208) et de la savane (107). À son tour, en nombre d'espèces, la forêt galerie (88 spp./25 exclusives) a dépassé la forêt secondaire (75/17), la forêt riveraine (64/8) et la savane (32/1). La composition et la richesse des bryophytes reflètent les conditions environnementales de chaque type de végétation. Six espèces sont de nouvelles occurrences pour l'état du Pará, quatre pour la région du nord et une pour le Brésil. La grande majorité (95 %) des espèces étaient déjà répertoriées dans le domaine amazonien, tandis que 76 % étaient connues dans le domaine du Cerrado. Le pourcentage élevé d'espèces enregistrées en Amazonie peut s'expliquer par la présence de forêts humides de plaine dans la zone d'étude, favorisant l'établissement d'espèces amazoniennes dont de nombreuses Lejeuneaceae.

**MOTS CLÉS**
Mousses,
hépatiques,
unité de conservation,
Amazonie,
Planalto brésilien.

## INTRODUCTION

The Martírios-Andorinhas Mountain Ridge, southeastern Pará state, is located in a transition zone between the Amazonian and Brazilian Planalto regions, being two of ten main phytogeographic regions recognized in Tropical America (Gradstein *et al*. 2001). These two regions represent two important neotropical biomes, Amazonia and the Brazilian Cerrado. The Martírios-Andorinhas Mountain Ridge, moreover, is situated within two conservation units, the Martírios-Andorinhas Mountain Ridge State Park (MAMRSP) and the São Geraldo do Araguaia Environmental Protection Area (Araguaia EPA) (Sectam 2006).

The creation of these conservation units was motivated by the location of the Martírios-Andorinhas Mountain Ridge within a highly impacted area of Amazonia, called the "Arc of Deforestation". This area, which extends from Acre to western Maranhão, undergoes a continuous process of deforestation leading fragmentation of vegetation and significant losses of biodiversity (Vieira *et al*. 2008). The most important vegetation formations of the Martírios-Andorinhas Mountain Ridge are humid Amazonian forest and Cerrado, the latter including gallery forests, grasslands and rocky fields (Sectam 2006; Gorayeb *et al*. 2008).

First lists of plant species from the Martírios-Andorinhas Mountain Ridge focused on orchids (Atzingen *et al*. 1996) and vascular plants (Amaral *et al*. 2008), amounting to about 225 species. Most recently, Alves (2020) reported 72 species of Cyperaceae Juss., of which seven were new to Pará. Despite being located in a highly impacted area in an enclave between two important biomes, no other floristic or phytotaxonomic studies have been carried out in the two conservation units and bryophytes remain completely unexplored.

Hitherto, bryophyte studies in southeastern Pará were conducted only in two localities: the Tucuruí hydroelectric dam region (Ilkiu-Borges *et al*. 2004; Garcia *et al*. 2014) and the Carajás Mountain Ridge (Lisboa & Ilkiu-Borges 1996; Moraes & Lisboa 2006; Oliveira-da-Silva & Ilkiu-Borges 2018). In the latter locality, Oliveira-da-Silva & Ilkiu-Borges (2018) reported 89 bryophyte species from canga vegetation (vegetation on iron rocks). Taking into account other vegetation formations of Carajás, the number of bryophyte species is likely to be at least two-fold higher.

The Martírios-Andorinhas Mountain Ridge includes a high range of vegetation formations and landscapes across different elevations (to maximally 600 m), favoring bryophyte richness (Santos & Costa 2010). It is therefore an area with potentially high bryophyte diversity.

The aim of this study was to investigate the bryophyte flora in different vegetation formations of the Martírios-Andorinhas Mountain Ridge, as a contribution to the evaluation of the conservation status of the area.

## MATERIAL AND METHODS

The Martírios-Andorinhas Mountain Ridge, encompassing the MAMRASP and the Araguaia EPA conservation units, is located in the municipality of São Geraldo do Araguaia, southeastern Pará, 6°12'48.2"S, 48°31'19.8"W (Fig. 1). MAMRASP is an integral protection conservation unit of about 25 000 hectares created with the aim of safeguarding natural ecosystems, permitting scientific, cultural, educational and entertainment activities (Pará 1996). Araguaia EPA, in turn, is a sustainable use conservation unit of 26 702 hectares aimed at reconciling the preservation of biodiversity with human activities and land occupation (Pará 1996; Sectam

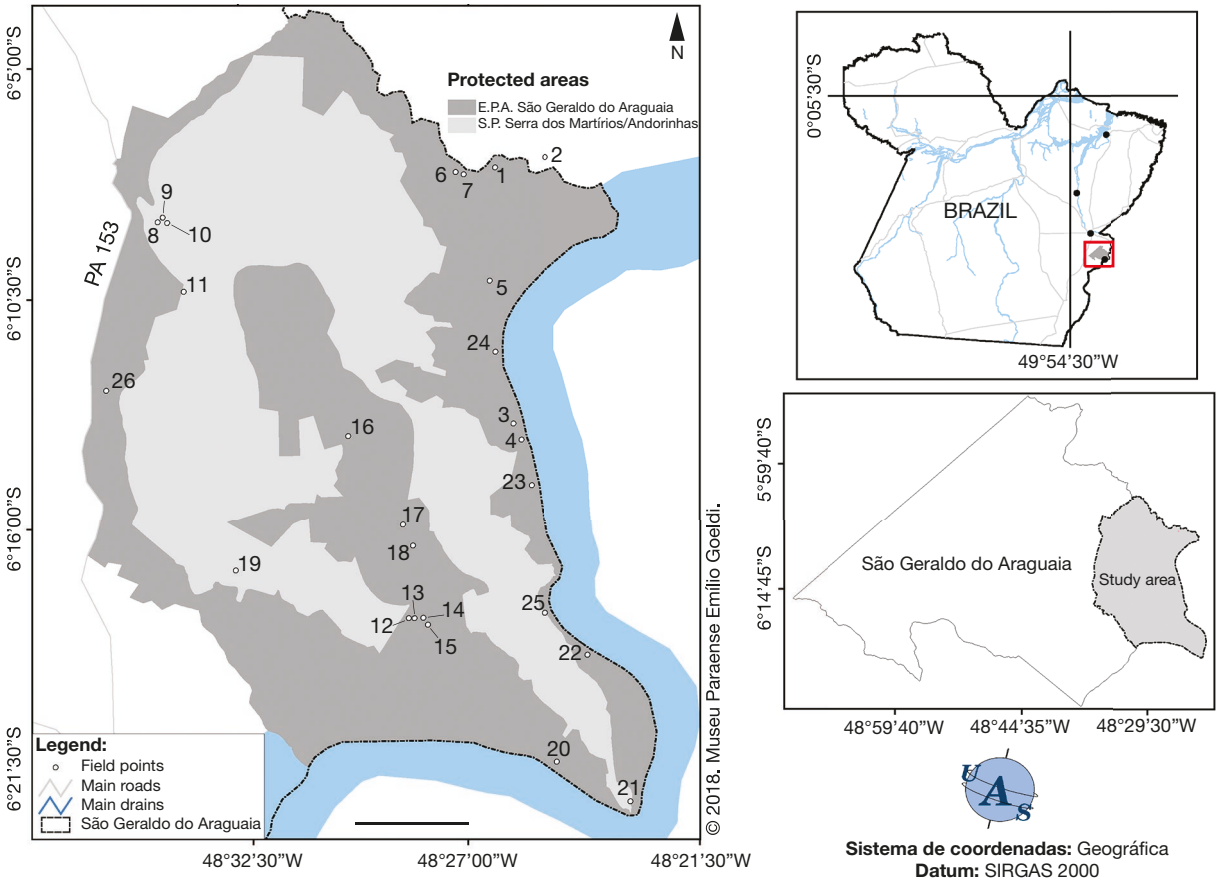


Fig. 1. — Maps showing the location of the Martírios-Andorinhas Mountain Ridge. Source: Museu Paraense Emílio Goeldi – UAS.

2006). It acts as a buffer zone mitigating environmental impacts affecting MAMRASP.

The Martírios-Andorinhas Mountain Ridge is part of the Amazon region but exhibits environments typical of the transition zone between Amazonia and the Brazilian Cerrado including forests, areas of ecological tension, Cerrado vegetation, fields and secondary vegetation (Sectam 2006; Gorayeb *et al.* 2008).

The climate is tropical with a prolonged dry season (Aw type; Köppen classification), an average temperature of 28°C and annual precipitation of 1639 mm (Sectam 2006). The relief is characterized by a very rugged topography with a maximum altitude of 600 meters. The soils are classified as Argisols, Oxisols and Neossols, the latter being the dominant (Sectam 2006; Gorayeb *et al.* 2008).

The vegetation of the Martírios-Andorinhas Mountain Ridge is composed of five main types, of which four were explored in this study: gallery forest, riparian forest, secondary forest and savanna (Fig. 2A-F). In addition, semi-deciduous (dry) forest occurs in the area. Savanna predominates and is characterized by the presence of rocky outcrops and herbaceous, shrub and tree-like layers, the latter consisting of small trees with tortuous branches, exhibiting fire-adapted traits (Ribeiro & Walter 1998; Gorayeb *et al.* 2008). Gallery forests occur on the banks of small streams and rivers, forming a canopy cover across the entire watercourse. They are composed of evergreen species (which do not drop their leaves during the dry season) surrounded by savanna and grass formations (Ribeiro & Walter 1998; Gorayeb *et al.* 2008).

Riparian forests border medium-sized and large rivers do not form a canopy over the entire watercourse. They include tree species with different degrees of deciduousness and differ from deciduous forests by being associated with watercourses and higher and denser vegetation. In the study area, riparian forests were observed on the banks of the Araguaia and Sucupira rivers (Ribeiro & Walter 1998; Gorayeb *et al.* 2008). Secondary forests are forests in the process of regeneration after anthropogenic disturbance. Semi-deciduous forests, finally, occur on mountain slopes, not being dependent on watercourses, and develop on fertile soils enriched by forest biomass (Ribeiro & Walter 1998; Gorayeb *et al.* 2008).

Bryophytes were collected during two excursions, from 14 to 18 December 2007 and from 25 to 30 August 2018, through free walks (Filgueiras *et al.* 1994) across all main local vegetation types except semi-deciduous forests. The collecting methodology was based on Yano (1984) with adaptations and included all substrates colonized by bryophytes.

Bryophyte identification was done using Florschütz-De Waard (1996), Buck (1998, 2003), Reiner-Drehwald (1998, 2000), He (1999), Dauphin (2003), Gradstein & Costa (2003), Gradstein & Ilkiu-Borges (2009, 2015), Bordin &


Fig. 2. — Vegetation types and substrates of bryophytes of the Martírios-Andorinhas Mountain Ridge: **A**-**C**, savanna; **D**, secondary forest; **E**, gallery forest; **F**, riparian forest; **G**, soil; **H**, decaying wood; **I**, living tree trunk; **J**-**L**, rock.

Yano (2013), Pócs *et al.* (2014), Bastos & Gradstein (2020a, b), and Oliveira-da-Silva *et al.* (2021). The classification of the Bryophyta follows Goffinet *et al.* (2009) with adaptations for Sematophyllaceae (Carvalho-Silva *et al.* 2017); that of Marchantiophyta follows Crandall-Stotler *et al.* (2009) with adaptations for *Dibrachiella* (Spruce) X.Q.Shi, R.L.Zhu & Gradst. (Shi *et al.* 2015) and *Thysananthus* Lindenb. (Sukkharak & Gradstein 2017). Vouchers were deposited in herbarium MG.

Data on the geographic distribution of the species in Brazil and world range were based on Yano (1992, 2006, 2011), Reese (1993), Gradstein (1994), Churchill (1998), He (1999), Dauphin (2003), Gradstein & Costa (2003), Reiner-Drehwald & Schäfer-Verwimp (2008), Costa *et al.* (2011), Peralta *et al.* (2011), Oliveira & Bastos (2014), Gradstein & Ilkiu-Borges (2015), Bastos & Gradstein (2020a, b), Flora do Brasil (2020), Wynns (2020), and Silva *et al.* (2021). Substrate classification followed Robbins (1952) with adaptations for termite mounds and living leaves.

## RESULTS

A total of 1784 bryophyte specimens were collected in the Martírios-Andorinhas Mountain Ridge, including 130 species, 63 genera and 26 families (Table 1). Moss collections (1093 specimens) were more numerous than liverworts (691 specimens) but species richness of the two groups was equal, and include 65 species of mosses (in 34 genera and 17 families) and 65 of liverworts (in 29 genera and nine families).

The largest number of collections was made in secondary forest (799 specimens), followed by gallery forest (670), riparian forest (208) and savanna (107). However, the highest number of bryophyte species was found in gallery forest (88 spp. of which 25 exclusive), followed by secondary forest (75/17), riparian forest (64/8) and savanna (32/1). The number of shared and exclusive species in the vegetation types is presented in a Venn diagram (Fig. 3).

Secondary forest harboured more mosses (524 specimens/39 spp.) than liverworts (275/36); the same trend was observed in riparian forest (mosses: 118/33; liverworts: 90/31), and savanna (mosses: 76/23; liverworts: 31/9). In gallery forest, however, liverworts (45 spp.) were more diverse than mosses (43) even though the number of collections of liverworts (295 specimens) from gallery forest was lower than that of mosses (375) (Fig. 4).

The most speciose families of mosses were Calymperaceae Kindb. (13 spp.), Fissidentaceae Schimp. (10 spp.) and Sematophyllaceae Broth. (9 spp.). Among liverworts, they were Lejeuneaceae Rostovzev (46 spp.), Frullaniaceae Lorch (4 spp.) and Plagiochilaceae (Jörg.) Müll.Frib. & Herzog (4 spp.).

Six families (Aneuraceae H.Klinggr., Cephaloziellaceae Douin, Bartramiaceae Schwägr., Brachytheciaceae Schimp., Dicranaceae Schimp., Pterigynandraceae Schimp.) were represented by only one species, each with more than one occurrence. Only two families (Cephaloziaceae Mig. and Pottiaceae Hampe) were represented by a single species, each found only once in the study area.

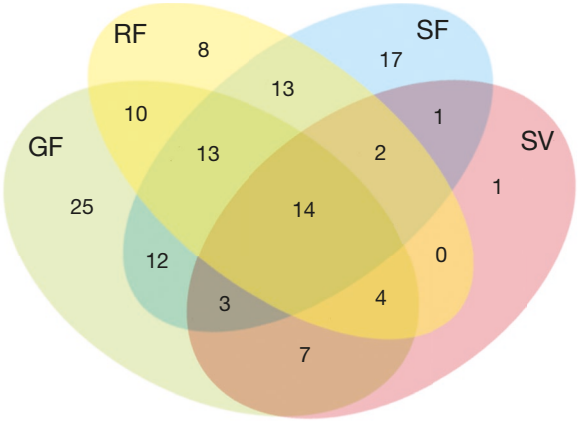


Fig. 3. — Exclusive and shared species in the vegetation types of the Martírios-Andorinhas Mountain Ridge. Abbreviations: **GF**, gallery forest; **RF**, riparian forest; **SF**, secondary forest; **SV**, savanna.

Aneuraceae (1 sp.), Cephaloziaceae (1 sp.), Cephaloziellaceae (1 sp.), Lepidoziaceae Limpr. (4 spp.), and Pterigynandraceae (1 sp.) were exclusive to gallery forest. Radulaceae Müll.Frib. (3 spp.) and Pottiaceae (1 sp.) were exclusive to secondary forests. No family was found to occur exclusively in the riparian forest or in savanna.

*Taxithelium planum* (Brid.) Mitt. was the most abundant moss species in the Martírios-Andorinhas Mountain Ridge, with 105 occurrences, followed by *Microcalpe subsimplex* (Hedw.) W.R.Buck (98 occurrences) and *Octoblepharum albidum* Hedw. (72 occurrences). Among liverworts, *Ceratolejeunea cubensis* (Mont.) Schiffn. and *Acrolejeunea emergens* (Mitt.) Steph. were the most frequently found, with 58 and 56 occurrences, respectively.

Six species were new occurrences for the state of Pará: *Calymperes tenerum* Müll.Hal., *Cylindrocolea planifolia* (Steph.) R.M.Schust., *Eulacophyllum cultelliforme* (Sull.) W.R.Buck & Ireland, *Taxiphyllum laevifolium* (Mitt.) W.R.Buck, *Syrrhopodon flexifolius* Mitt. and *Trichosteleum vincentinum* (Mitt.) A.Jaeger. *Bryum limbatum* Müll. Hal., *Lejeunea cancellata* Nees & Mont., *Lophocolea platensis* C.Massal. and *Trachyphyllum dusenii* (Broth.) Broth. are being recorded for the first time in the northern region of Brazil and *Trichosteleum cyparissoides* (Hornsch.) H.Rob. is new to the country of Brazil.

Regarding substrates, 52.0 % (928) of the specimens were corticolous, 29.3 % (523) rupicolous, 14.4 % (257) epixylous, 3.9 % (70) terrestrial, 0.2 % (4) occurred on termite mounds, and only 0.1 % (2) were epiphyllous (Fig. 2G, H). The predominant pattern of geographic distribution was Neotropical (78 spp.), followed by Pantropical (31), widely distributed (7), South American (6), Afro-American (5) and endemic to Brazil (2). The latter two species included *Cheilolejeunea savannae* L.P.C.Macedo, Ilk.-Borg. & C.J.Bastos and *Lejeunea oligoclada* Spruce. *Schusterolejeunea inundata* (Spruce) Grolle has peri-Amazonian distribution, being restricted to the edges of Amazonia and the Guianas.

TABLE 1. — Bryophytes of the Martírios-Andorinhas Mountain Ridge. Abbreviations: **LT**, living trunks; **DT**, decaying trunks; **R**, rock; **S**, soil; **TM**; termite mounds; **LL**, living leaves; **GF**, gallery forest; **RF**, riparian forest; **SV**, savanna; **SF**, secondary forest; *, new to Pará state; **, new to the northern region of Brazil; ***, new to Brazil.

| Family/Species | Occurrence Number | Substrate | | | | | | Vegetation type | | | | World distribution | Voucher |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | LT | DT | R | S | TM | LL | GF | RF | SV | SF | | |
| **MARCHANTIOPHYTA** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **Aneuraceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Riccardia regnellii* (Ångstr.) K.G.Hell | 2 | – | 1 | 1 | – | – | – | 2 | – | – | – | Neotropical | J.C.S. Santos 790 |
| **Cephaloziaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Odontoschisma variabile* (Lindenb. & Gottsche) Trevis. | 1 | – | – | 1 | – | – | – | 1 | – | – | – | Afro-American | J.C.S. Santos 789 |
| **Cephaloziellaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **Cylindrocolea planifolia* (Steph.) R.M.Schust. | 2 | – | – | 2 | – | – | – | 2 | – | – | – | Neotropical | J.C.S. Santos 767 |
| **Frullaniaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Frullania ericoides* (Nees) Mont. | 2 | 2 | – | – | – | – | – | – | – | – | 2 | Pantropical | J.C.S. Santos 873 |
| *F. gibbosa* Nees | 8 | 5 | 2 | 1 | – | – | – | 2 | 2 | 4 | – | Neotropical | J.C.S. Santos 674 |
| *F. intumescens* (Lehm. & Lindenb.) Lehm. & Lindenb. | 4 | 1 | – | 3 | – | – | – | 2 | – | 2 | – | Neotropical | J.C.S. Santos 718 |
| *Frullania* sp. | 6 | 2 | – | 4 | – | – | – | – | – | – | 6 | – | J.C.S. Santos 908 |
| **Lejeuneaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Acrolejeunea emergens* (Mitt.) Steph. | 56 | 42 | 4 | 10 | – | – | – | 27 | 18 | 7 | 4 | Pantropical | J.C.S. Santos 941 |
| *A. torulosa* (Lehm. & Lindenb.) Schiffn. | 15 | 7 | 2 | 6 | – | – | – | 8 | – | 5 | 2 | Neotropical | J.C.S. Santos 915 |
| *Archilejeunea badia* (Spruce) Steph. | 1 | 1 | – | – | – | – | – | – | – | – | 1 | South American | P.L.B. Lisboa 5779 |
| *A. fuscescens* (Lehm.) Fulford | 3 | 3 | – | – | – | – | – | 1 | 2 | – | – | Neotropical | J.C.S. Santos 952 |
| *Ceratolejeunea coarina* (Gottsche) Schiffn. | 12 | 9 | – | 3 | – | – | – | 3 | – | – | 9 | Neotropical | J.C.S. Santos 1027 |
| *C. confusa* R.M. Schust. | 4 | – | – | 3 | 1 | – | – | 4 | – | – | – | Neotropical | J.C.S. Santos 746 |
| *C. cornuta* (Lindenb.) Steph. | 9 | 3 | – | 6 | – | – | – | 7 | – | 1 | 1 | Neotropical | J.C.S. Santos 642 |
| *C. cubensis* (Mont.) Schiffn. | 58 | 27 | 1 | 30 | – | – | – | 35 | – | – | 23 | Neotropical | J.C.S. Santos 636 |
| *C. guianensis* (Nees & Mont.) Steph. | 22 | 7 | – | 15 | – | – | – | 16 | 1 | 1 | 4 | Neotropical | J.C.S. Santos 753 |
| *Cheilolejeunea acutangula* (Nees) Grolle | 5 | 3 | – | 1 | 1 | – | – | 5 | – | – | – | Neotropical | J.C.S. Santos 766 |
| *C. adnata* (Lehm.) Grolle | 26 | 25 | 1 | – | – | – | – | – | 1 | 1 | 24 | Neotropical | P.L.B. Lisboa 5651 |
| *C. aneogyna* (Spruce) A.Evans | 3 | 1 | 1 | 1 | – | – | – | – | 2 | – | 1 | Neotropical | P.L.B. Lisboa 5781 |
| *C. comans* (Spruce) R.M.Schust. | 9 | 8 | 1 | – | – | – | – | 5 | 3 | – | 1 | South American | J.C.S. Santos 837 |
| *C. lobulata* (Lindenb.) Gradst. & C.J.Bastos | 31 | 20 | – | 11 | – | – | – | 22 | 3 | 2 | 4 | Neotropical | J.C.S. Santos 765 |
| *C. rigidula* (Mont.) R.M.Schust. | 15 | 6 | – | 9 | – | – | – | 6 | 1 | 8 | – | Pantropical | P.L.B. Lisboa 5570 |
| *C. savannae* L.P.C.Macedo, Ilk.-Borg. & C.J.Bastos | 10 | 5 | – | 5 | – | – | – | 10 | – | – | – | Endemic | J.C.S. Santos 638 |
| *C. trifaria* var. *clausa* (Nees & Mont.) C.J.Bastos & Gradst. | 3 | 2 | – | 1 | – | – | – | 3 | – | – | – | Neotropical | J.C.S. Santos 841 |
| *Cololejeunea contractiloba* A. Evans | 1 | – | 1 | – | – | – | – | 1 | – | – | – | Neotropical | J.C.S. Santos 868 |
| *C. diaphana* A. Evans | 2 | 2 | – | – | – | – | – | 1 | 1 | – | – | Neotropical | J.C.S. Santos 960 |
| *C. subcardiocarpa* Tixier | 2 | – | 1 | – | – | – | 1 | 1 | 1 | – | – | Neotropical | J.C.S. Santos 1056 |
| *Dibrachiella auberiana* (Mont.) X.Q.Shi, R.L.Zhu & Gradst. | 2 | 2 | – | – | – | – | – | – | – | – | 2 | Neotropical | P.L.B. Lisboa 5850 |
| *D. parviflora* (Nees) X.Q.Shi, R.L.Zhu & Gradst. | 35 | 27 | 3 | 2 | 3 | – | – | – | 26 | – | 9 | Neotropical | J.C.S. Santos 890 |
| *Frullanoides corticalis* (Lehm. & Lindenb.) van Slageren | 1 | 1 | – | – | – | – | – | 1 | – | – | – | Neotropical | J.C.S. Santos 995 |
| *Lejeunea adpressa* Nees | 24 | 19 | 4 | 1 | – | – | – | 4 | 1 | – | 19 | Neotropical | J.C.S. Santos 964 |
| *L. bermudiana* (A.Evans) R.M.Schust. | 8 | 6 | 1 | 1 | – | – | – | 1 | – | – | 7 | Neotropical | J.C.S. Santos 1032 |
| ***L. cancellata* Nees & Mont. | 5 | 1 | 1 | 1 | 1 | 1 | – | 3 | 2 | – | – | Neotropical | J.C.S. Santos 884 |
| *L. cerina* (Lehm. & Lindenb.) Lehm. & Lindenb. | 8 | 6 | – | 2 | – | – | – | 3 | – | – | 5 | Neotropical | J.C.S. Santos 851 |
| *L. controversa* Gottsche | 4 | 1 | – | 3 | – | – | – | 2 | 1 | – | 1 | Neotropical | P.L.B. Lisboa 5653 |
| *L. flava* (Sw.) Nees | 19 | 16 | – | 3 | – | – | – | 19 | – | – | – | Pantropical | J.C.S. Santos 1023 |
| *L. glaucescens* Gottsche | 25 | 13 | 7 | 4 | 1 | – | – | 11 | 5 | – | 9 | Neotropical | J.C.S. Santos 893 |
| *L. oligoclada* Spruce | 19 | 16 | 2 | 1 | – | – | – | 17 | 1 | – | 1 | Endemic | J.C.S. Santos 851 |
| *L. phyllobola* Nees & Mont. | 3 | 2 | 1 | – | – | – | – | 1 | 1 | – | 1 | Neotropical | J.C.S. Santos 899 |
| *L. setiloba* Spruce | 2 | 2 | – | – | – | – | – | – | 2 | – | – | Neotropical | J.C.S. Santos 970 |
| *L. trinitensis* Lindenb. | 3 | 3 | – | – | – | – | – | – | 2 | – | 1 | Neotropical | J.C.S. Santos 939 |
| *Leptolejeunea elliptica* (Lehm. & Lindenb.) Besch. | 1 | – | – | – | – | – | 1 | – | 1 | – | – | Pantropical | P.L.B. Lisboa 5654 |
| *Lopholejeunea subfusca* (Nees) Schiffn. | 5 | 4 | – | 1 | – | – | – | 2 | 1 | – | 2 | Pantropical | J.C.S. Santos 962 |
| *Microlejeunea epiphylla* Bischl. | 7 | 6 | 1 | – | – | – | – | 5 | 1 | – | 1 | Neotropical | J.C.S. Santos 791 |
| *Myriocoleopsis minutissima* subsp. *myriocarpa* (Nees & Mont.) R.L.Zhu, Y.Yu & Pócs | 1 | 1 | – | – | – | – | – | – | 1 | – | – | Pantropical | J.C.S. Santos 962 |
| *Prionolejeunea denticulata* (F. Weber) Schiffn. | 2 | – | – | 2 | – | – | – | 1 | 1 | – | – | Neotropical | J.C.S. Santos 634 |
| *Pycnolejeunea contigua* (Nees) Grolle | 10 | 10 | – | – | – | – | – | 9 | 1 | – | – | Pantropical | J.C.S. Santos 740 |
| *P. papillosa* X.L.He | 1 | 1 | – | – | – | – | – | 1 | – | – | – | Neotropical | J.C.S. Santos 721 |
| *Schusterolejeunea inundata* (Spruce) Grolle | 1 | 1 | – | – | – | – | – | – | 1 | – | – | Amazonia and Guianas | J.C.S. Santos 961 |
| *Stictolejeunea balfourii* (Mitt.) E.W.Jones | 2 | 1 | 1 | – | – | – | – | – | – | – | 2 | Pantropical | P.L.B. Lisboa 5682 |
| *Symbiezidium transversale* (Sw.) Trevis. | 6 | 6 | – | – | – | – | – | – | 1 | – | 5 | Pantropical | J.C.S. Santos 888 |
| *Thysananthus auriculatus* (Wilson & Hook.) Sukkharak & Gradst. | 18 | 13 | 3 | 2 | – | – | – | 7 | 4 | – | 7 | Pantropical | J.C.S. Santos 837 |
| *Xylolejeunea crenata* (Nees & Mont.) X.L.He & Grolle | 3 | – | – | 2 | 1 | – | – | 3 | – | – | – | Neotropical | J.C.S. Santos 1074 |

Table 1. — Continuation.

| Family/Species | Occurrence Number | Substrate | | | | | | Vegetation type | | | | World distribution | Voucher |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | LT | DT | R | S | TM | LL | GF | RF | SV | SF | | |
| **Lepidoziaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Micropterygium leiophyllum* Spruce | 12 | – | – | 10 | 2 | – | – | 12 | – | – | – | Neotropical | J.C.S. Santos 642 |
| *Monodactylopsis monodactyla* (Spruce) R.M.Schust. | 1 | – | 1 | – | – | – | – | 1 | – | – | – | Neotropical | J.C.S. Santos 643 |
| *Zoopsidella integrifolia* (Spruce) R.M.Schust. | 21 | – | – | 10 | 11 | – | – | 21 | – | – | – | Neotropical | J.C.S. Santos 732 |
| **Lophocoleaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Lophocolea liebmanniana* Gottsche | 1 | – | 1 | – | – | – | – | – | – | – | 1 | Neotropical | P.L.B. Lisboa 5776 |
| ***L. platensis* C.Massal. | 3 | – | – | 3 | – | – | – | 3 | – | – | – | South American | J.C.S. Santos 632 |
| **Plagiochilaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Plagiochila disticha* (Lehm. & Lindenb.) Lehm. & Lindenb. | 40 | 39 | 1 | – | – | – | – | – | 1 | – | 39 | Neotropical | P.L.B. Lisboa 5648 |
| *P. martiana* (Nees) Lindenb. | 12 | 12 | – | – | – | – | – | – | 1 | – | 11 | Neotropical | P.L.B. Lisboa 5652 |
| *P. montagnei* Nees | 17 | 14 | 2 | 1 | – | – | – | 1 | – | – | 16 | Neotropical | J.C.S. Santos 853 |
| *P. raddiana* Lindenb. | 14 | 12 | – | 2 | – | – | – | 3 | – | – | 11 | Neotropical | J.C.S. Santos 866 |
| **Radulaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Radula flaccida* Lindenb. & Gottsche | 3 | 3 | – | – | – | – | – | – | – | – | 3 | Afro-American | P.L.B. Lisboa 5844 |
| *R. javanica* Gottsche | 39 | 39 | – | – | – | – | – | – | – | – | 39 | Pantropical | P.L.B. Lisboa 5717 |
| *R. mammosa* Spruce | 1 | 1 | – | – | – | – | – | – | – | – | 1 | Neotropical | P.L.B. Lisboa 5703 |
| **BRYOPHYTA** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| **Bartramiaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Philonotis hastata* (Duby) Wijk & Margad. | 5 | 1 | – | 4 | – | – | – | 4 | 1 | – | – | Wide | J.C.S. Santos 864 |
| **Brachytheciaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Zelometeorium patulum* (Hedw.) Manuel | 2 | 2 | – | – | – | – | – | – | 1 | – | 1 | Neotropical | P.L.B. Lisboa 5648 |
| **Bryaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Bryum coronatum* Schwägr. | 3 | – | – | 2 | – | 1 | – | 1 | – | 2 | – | Wide | J.C.S. Santos 835 |
| ***B. limbatum* Müll. Hal. | 1 | – | – | 1 | – | – | – | 1 | – | – | – | Neotropical | J.C.S. Santos 1057 |
| *Rhodobryum subverticillatum* Broth. | 1 | – | – | 1 | – | – | – | 1 | – | – | – | South American | P.L.B. Lisboa 5665 |
| **Calymperaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Calymperes afzelii* Sw. | 24 | 21 | 3 | – | – | – | – | – | – | – | 24 | Pantropical | J.C.S. Santos 921 |
| *C. erosum* Müll. Hal. | 25 | 15 | 4 | 6 | – | – | – | 9 | 2 | 1 | 13 | Pantropical | J.C.S. Santos 743 |
| *C. palisotii* Schwägr. | 9 | 6 | 1 | 2 | – | – | – | 5 | – | – | 4 | Wide | J.C.S. Santos 855 |
| **C. tenerum* Müll. Hal. | 1 | – | – | 1 | – | – | – | – | 1 | – | – | Pantropical | J.C.S. Santos 973 |
| *Octoblepharum albidum* Hedw. | 72 | 49 | 8 | 13 | 2 | – | – | 21 | 7 | 8 | 36 | Pantropical | J.C.S. Santos 983 |
| *O. cylindricum* Mont. | 11 | 6 | – | 4 | 1 | – | – | 5 | 4 | 2 | – | Neotropical | J.C.S. Santos 667 |
| *O. pulvinatum* (Dozy & Molk.) Mitt. | 5 | 1 | – | 1 | 3 | – | – | 5 | – | – | – | Neotropical | J.C.S. Santos 726 |
| *Syrrhopodon cryptocarpus* Dozy & Molk. | 16 | 16 | – | – | – | – | – | – | 4 | – | 12 | Pantropical | J.C.S. Santos 882 |
| **S. flexifolius* Mitt. | 1 | – | 1 | – | – | – | – | – | – | – | 1 | Neotropical | P.L.B. Lisboa 5916 |
| *S. gardneri* (Hook.) Schwägr. | 1 | – | – | 1 | – | – | – | – | – | – | 1 | Pantropical | J.C.S. Santos 919 |
| *S. incompletus* Schwägr. | 39 | 33 | 5 | – | – | 1 | – | – | – | 1 | 38 | Afro-American | P.L.B. Lisboa 5560 |
| *S. ligulatus* Mont. | 2 | 2 | – | – | – | – | – | 2 | – | – | – | Neotropical | J.C.S. Santos 999 |
| *S. prolifer* Schwägr. | 48 | 4 | – | 40 | 4 | – | – | 38 | 1 | 9 | – | Pantropical | J.C.S. Santos 703 |
| **Dicranaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Leucoloma tortellum* (Mitt.) A.Jaeger | 6 | – | – | 6 | – | – | – | 5 | – | 1 | – | Neotropical | J.C.S. Santos 644 |
| **Fissidentaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Fissidens angustelimbatus* Mitt. | 1 | – | – | 1 | – | – | – | – | 1 | – | – | Neotropical | J.C.S. Santos 898 |
| *F. angustifolius* Sull. | 2 | 1 | – | – | 1 | – | – | – | 1 | – | 1 | Pantropical | J.C.S. Santos 943 |
| *F. elegans* Brid. | 22 | 4 | 1 | 16 | 1 | – | – | 16 | 2 | – | 4 | Neotropical | J.C.S. Santos 631 |
| *F. guianensis* Mont. | 23 | 12 | 4 | 6 | 1 | – | – | 2 | 1 | 2 | 18 | Neotropical | J.C.S. Santos 651 |
| *F. pallidinervis* Mitt. | 8 | 6 | – | 2 | – | – | – | 2 | – | – | 6 | Neotropical | P.L.B. Lisboa 5594 |
| *F. pellucidus* Hornsch. | 7 | 1 | – | 5 | 1 | – | – | 6 | – | 1 | – | Pantropical | J.C.S. Santos 767 |
| *F. perfalcatus* Broth. | 3 | 2 | – | 1 | – | – | – | 2 | 1 | – | – | Pantropical | J.C.S. Santos 805 |
| *F. radicans* Mont. | 1 | – | 1 | – | – | – | – | – | – | – | 1 | Pantropical | P.L.B. Lisboa 5914 |
| *F. submarginatus* Bruch | 3 | – | – | – | 2 | 1 | – | 1 | – | 2 | – | Pantropical | J.C.S. Santos 1049 |
| *F. zollingeri* Mont. | 7 | 2 | 1 | – | 4 | – | – | – | 2 | 1 | 4 | Pantropical | J.C.S. Santos 885 |
| **Hypnaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Chrysohypnum diminutivum* (Hampe) W.R.Buck | 25 | 11 | 13 | 1 | – | – | – | – | 1 | – | 24 | Wide | J.C.S. Santos 928 |
| *Ectropothecium leptochaeton* (Schwägr.) W.R.Buck | 6 | – | – | 6 | – | – | – | 5 | – | – | 1 | Neotropical | J.C.S. Santos 646 |
| *Phyllodon truncatulus* (Müll. Hal.) W.R.Buck | 1 | – | – | 1 | – | – | – | 1 | – | – | – | Neotropical | P.L.B. Lisboa 5663 |
| **Taxiphyllum laevifolium* (Mitt.) W.R.Buck | 6 | 5 | – | – | 1 | – | – | – | 6 | – | – | Neotropical | J.C.S. Santos 954 |
| *Vesicularia vesicularis* (Schwägr.) Broth. | 9 | – | 5 | 2 | 2 | – | – | – | 3 | – | 6 | Neotropical | J.C.S. Santos 892 |
| **Leucobryaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Campylopus pilifer* Brid. | 1 | – | – | 1 | – | – | – | 1 | – | – | – | Neotropical | J.C.S. Santos 729 |
| *C. surinamensis* Müll. Hal. | 32 | 1 | – | 27 | 4 | – | – | 20 | – | 12 | – | Neotropical | J.C.S. Santos 661 |
| *Leucobryum martianum* (Hornsch.) Müll. Hal. | 31 | 5 | 5 | 15 | 6 | – | – | 26 | 1 | 2 | 2 | Neotropical | J.C.S. Santos 677 |
| *Ochrobryum subulatum* Hampe | 3 | – | 2 | 1 | – | – | – | 3 | – | – | – | South American | J.C.S. Santos 1038 |
| **Neckeraceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Neckeropsis disticha* (Hedw.) Kindb. | 11 | 9 | – | 2 | – | – | – | – | – | – | 11 | Pantropical | P.L.B. Lisboa 5739 |
| *N. undulata* (Hedw.) Reichardt | 32 | 30 | 2 | – | – | – | – | – | 1 | – | 31 | Neotropical | P.L.B. Lisboa 5648 |

Table 1. — Continuation.

| Family/Species | Occurrence Number | Substrate | | | | | | Vegetation type | | | | World distribution | Voucher |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | LT | DT | R | S | TM | LL | GF | RF | SV | SF | | |
| **Pilotrichaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Callicostella pallida* (Hornsch.) Ångstr. | 38 | 6 | 9 | 22 | 1 | – | – | 14 | 8 | 4 | 12 | Neotropical | J.C.S. Santos 893 |
| *C. rufescens* (Mitt.) A.Jaeger | 1 | – | – | 1 | – | – | – | – | 1 | – | – | Neotropical | J.C.S. Santos 898 |
| **Pottiaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Hyophila involuta* (Hook.) A.Jaeger | 1 | – | – | 1 | – | – | – | – | – | – | 1 | Wide | J.C.S. Santos 930 |
| **Pterigynandraceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| ***Trachyphyllum dusenii* (Broth.) Broth. | 4 | 1 | – | 3 | – | – | – | 4 | – | – | – | Afro-American | J.C.S. Santos 864 |
| **Pterobryaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Henicodium geniculatum* (Mitt.) W.R.Buck | 2 | 2 | – | – | – | – | – | 1 | – | – | 1 | Pantropical | J.C.S. Santos 878 |
| *Jaegerina scariosa* (Lorentz) Arzeni | 3 | 3 | – | – | – | – | – | 1 | 2 | – | – | Pantropical | J.C.S. Santos 899 |
| **Pylaisiadelphaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Isopterygium subbrevisetum* (Hampe) Broth. | 16 | 9 | 6 | 1 | – | – | – | 1 | – | – | 15 | Neotropical | P.L.B. Lisboa 5670 |
| *I. tenerifolium* Mitt. | 7 | 2 | – | 5 | – | – | – | 6 | 1 | – | – | Neotropical | J.C.S. Santos 612 |
| *I. tenerum* (Sw.) Mitt. | 46 | 17 | 7 | 20 | 2 | – | – | 22 | 7 | 6 | 11 | Wide | J.C.S. Santos 706 |
| *Taxithelium planum* (Brid.) Mitt. | 105 | 52 | 35 | 17 | 1 | – | – | 6 | 24 | 3 | 72 | Pantropical | J.C.S. Santos 984 |
| *T. pluripunctatum* (Renauld & Cardot) W.R.Buck | 2 | – | – | 1 | 1 | – | – | 2 | – | – | – | Neotropical | J.C.S. Santos 1001 |
| **Sematophyllaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Acroporium pungens* (Hedw.) Broth. | 3 | – | 3 | – | – | – | – | – | – | – | 3 | Neotropical | P.L.B. Lisboa 5775 |
| *Brittonodoxa subpinnata* (Brid.) W.R.Buck, P.E.A.S.Câmara & Carv.-Silva | 7 | 2 | 2 | 3 | – | – | – | 4 | 1 | 1 | 1 | Pantropical | J.C.S. Santos 857 |
| *Microcalpe subsimplex* (Hedw.) W.R.Buck | 98 | 33 | 23 | 38 | 4 | – | – | 61 | 4 | 7 | 26 | Neotropical | J.C.S. Santos 760 |
| ****Trichosteleum cyparissoides* (Hornsch.) H.Rob. | 1 | 1 | – | – | – | – | – | – | – | 1 | – | Neotropical | P.L.B. Lisboa 5569 |
| *T. papillosum* (Hornsch.) A.Jaeger | 5 | 3 | 1 | 1 | – | – | – | 1 | – | 1 | 3 | Neotropical | J.C.S. Santos 844 |
| *T. subdemissum* (Besch.) A.Jaeger | 45 | 10 | 9 | 19 | 7 | – | – | 32 | 7 | 2 | 4 | Pantropical | J.C.S. Santos 725 |
| **T. vincentinum* (Mitt.) A. Jaeger | 8 | 1 | 6 | 1 | – | – | – | 1 | 1 | – | 6 | Neotropical | P.L.B. Lisboa 5650 |
| *Vitalia cuspidifera* (Mitt.) P.E.A.S.Câmara, Carv.-Silva & W.R.Buck | 14 | – | 1 | 13 | – | – | – | 12 | – | 2 | – | Neotropical | J.C.S. Santos 630 |
| **Stereophyllaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Entodontopsis leucostega* (Brid.) W.R.Buck & Ireland | 48 | 16 | 3 | 29 | – | – | – | 14 | 18 | 5 | 11 | Wide | J.C.S. Santos 662 |
| **Eulacophyllum cultelliforme* (Sull.) W.R.Buck & Ireland | 8 | – | – | 8 | – | – | – | 3 | 1 | – | 4 | Neotropical | J.C.S. Santos 904 |
| *Pilosium chlorophyllum* (Hornsch.) Broth. | 31 | 11 | 15 | 5 | – | – | – | 6 | 1 | – | 24 | Neotropical | J.C.S. Santos 624 |
| **Thuidiaceae** | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Pelekium involvens* (Hedw.) Touw | 9 | 1 | 8 | – | – | – | – | – | – | – | 9 | Afro-American | P.L.B. Lisboa 5582 |
| *P. scabrosulum* (Mitt.) Touw | 71 | 44 | 27 | – | – | – | – | – | 1 | – | 70 | Neotropical | J.C.S. Santos 921 |
| *P. schistocalyx* (Müll. Hal.) Touw | 14 | 10 | 2 | 2 | – | – | – | 2 | – | – | 12 | Neotropical | J.C.S. Santos 838 |
| Total | 1784 | 928 | 257 | 523 | 70 | 4 | 2 | 670 | 208 | 107 | 799 | – | – |

## DISCUSSION

The results showed a clear prevalence of mosses over liverworts, confirming that mosses are better equipped against desiccation (Goffinet *et al*. 2009) and predominate in dryer and more exposed environments (Lisboa & Ilkiu-Borges 1996; Yano & Peralta 2009, 2011; Luizi-Ponzo *et al*. 2013; Silva *et al*. 2014; Carmo & Peralta 2016; Peñaloza-Bocajá *et al*. 2017; Valente *et al*. 2017; Oliveira-da-Silva & Ilkiu-Borges 2018). However, despite the large difference in abundance, the representation of the two groups in terms of number of species was equal, due possibly to the ample presence of humid, shaded microhabitats in the gallery forests – associated with water courses and shading of trees – favoring the growth of liverworts.

Sixteen species of liverworts occurred exclusively in this environment. A similar correlation between environmental conditions and species richness and composition was observed by Valente *et al*. (2013), suggesting that bryophyte diversity is triggered by availability of moisture and light.

The family composition of mosses and liverworts is similar to that found elsewhere in the region (Brito & Ilkiu-Borges 2013; Pantoja *et al*. 2015; Fagundes *et al*. 2016; Oliveira-da-Silva & Ilkiu-Borges 2018; Ilkiu-Borges *et al*. 2020) and reflects the composition of neotropical lowland forests (Gradstein & Pócs 1989; Gradstein *et al*. 2001).

Families represented by one single species are more or less common in lowland forests and open environments (Gradstein *et al*. 2001), but the species occur at low frequencies. The two families represented by one specimen (Cephaloziaceae: *Odontoschisma variable* (Lindenb. & Gottsche) Trevis.; Pottiaceae: *Hyophila involuta* (Hook.) A.Jaeger.) have already been recorded in other areas of Pará. *Odontoschisma variable* was also recorded in the Cachimbo Mountain Ridge and Carajás Mountain Ridge (Gradstein & Ilkiu-Borges 2015; Ilkiu-Borges & Oliveira-da-Silva 2017), whereas *Hyophila involuta* is a very common species on rock in wet sites and on concrete in ruderal areas, being the most frequent species recorded by Lisboa & Ilkiu-Borges (1995) in the city of Belém, the capital of Pará.

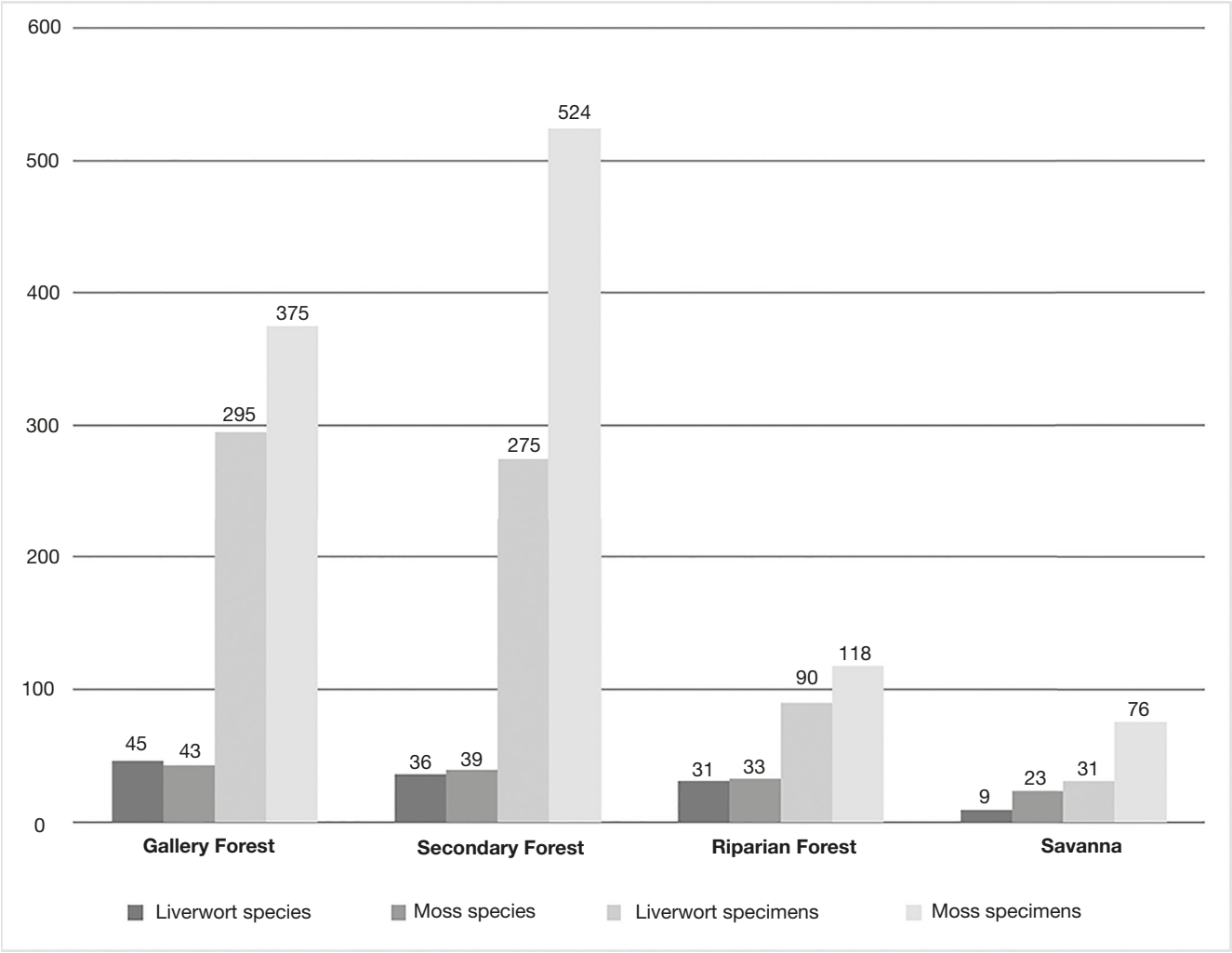


Fig. 4. — Distribution of species and specimens of bryophytes in vegetation types of the Martírios-Andorinhas Mountain Ridge.

The exclusive occurrence of several liverworts to gallery forest (e.g. *Riccardia regnellii* (Ångstr.) K.G.Hell, *Cylindrocolea planifolia*, many species of Lejeuneaceae, all species of Lepidoziaceae, *Lophocolea platensis*) reflects their preference for natural or more humid environments (Gradstein *et al*. 2001). Radulaceae and Pottiaceae were exclusive to secondary forest where they included the most common species, but were usually adapted to moist habitats. Oliveira-da-Silva *et al*. (2021) found that secondary forests harbored a relatively poor flora of *Radula* Dumort. but in our study all species of this genus were gathered in secondary forest and were absent in natural environments.

The mosses most frequently collected in the Martírios-Andorinhas Mountain Ridge (*Taxithelium planum*, *Microcalpe subsimplex*, *Octoblepharum albidum*) are widely distributed in the Neotropics, where they occur in different vegetation types and colonize a wide variety of substrates (Yano 1992; Florschütz-De Waard 1996; Câmara 2011). In Pará, these species have been found to be common in urban areas (Lisboa & Ilkiu-Borges 1995), but also in natural primary or secondary forests (Moraes & Lisboa 2006; Brito & Ilkiu-Borges 2013; Pantoja *et al*. 2015; Fagundes *et al*. 2016; Oliveira-da-Silva & Ilkiu-Borges 2018; Ilkiu-Borges *et al*. 2020).

As to the most common liverworts in the study area, *Ceratolejeunea cubensis* was collected in gallery forest and secondary forest mainly colonizing rocks and living trunks, while *Acrolejeunea emergens* occurred in all vegetation types, colonizing living trunks, rocks and, occasionally, decaying trunks. *Ceratolejeunea cubensis* is a Neotropical species commonly found on rocks, living and decomposing trunks (Gradstein & Costa 2003), in humid forests, seasonal forests, and open places in primary and secondary vegetation (Dauphin 2003). *Acrolejeunea emergens* is usually found on barks in scrubby secondary vegetation, restinga, and on isolated trees in cultivated areas (Gradstein 1994; Gradstein & Costa 2003).

Among the new occurrences for the state of Pará, *Cylindrocolea planifolia*, *Eulacophyllum cultelliforme* and *Taxiphyllum laevifolium* were known in all regions of Brazil (Flora do Brasil 2020), *Calymperes tenerum* was previously registered in the southeastern region and Tocantins (Flora do Brasil 2020), *Syrrhopodon flexifolius* was registered in Amazonas (Flora do

Brasil 2020), and *Trichosteleum vincentinum* was reported for Amazonas and Bahia (Flora do Brasil 2020).

*Bryum limbatum*, *Lejeunea cancellata*, and *Lophocolea platensis* were already registered from the other four regions of Brazil and are being recorded here for the first time in the northern region. Likewise, *Trachyphyllum dusenii* was only known in Maranhão, Distrito Federal, Goiás, Mato Grosso and Minas Gerais. *Trichosteleum cyparissoides* (formerly known as *Trichosteleum bolivarense* H.Rob.), the species found new to the country of Brazil in this study, had been formerly reported as *Trichosteleum bolivarense* from different localities in Brazil, but these records were recently excluded from Brazil (Flora do Brasil 2020).

Regarding substrate preferences of species, the results of this study met the expectations. The high diversity of tropical trees and shrubs coupled with relatively high air humidity and shade (Richards 1984) favored the development of corticolous bryophyte species, which predominated in the study area. As rocky outcrops are also prominent in the area, rocks were the second most frequently colonized substrate, especially along streams and waterfalls.

The scarcity of epiphyllous species, which were only found in forests associated with watercourses, reflects the dryer condition of the environment in the Martírios-Andorinhas Mountain Ridge. The rather open or low forest structure resulted in relatively low atmospheric humidity, despite a relatively high annual precipitation (1639 mm), causing increased temperature and evapo-transpiration, and ultimately negatively affecting the establishment and growth of epiphyllous bryophytes (Olarinmoye 1974). Although the two parks are protected areas, land use – characterized by the conversion of large portions of the area into agricultural lands and pasture – is a major threat to the epiphyllous flora and the whole vegetation (Pócs 1996).

The phytogeographical make-up of the flora of the study area was also similar to that found in other studies conducted in the region (Brito & Ilkiu-Borges 2013; Tavares-Martins *et al*. 2014; Ilkiu-Borges *et al*. 2020). As to the three endemic species recorded in this study, *Cheilolejeunea savannae* was recently described by Macedo *et al*. (2020) from Amazonian savannas in the eastern Amazon (Amapá, Pará, Maranhão), but also occurs in different forest types. *Lejeunea oligoclada* was known from Amazonia and the Brazilian Atlantic coast, where it is widespread and rather common (Reiner-Drehwald & Schäfer-Verwimp 2008; Bastos & Gradstein 2020b). It was found in canga vegetation at the Carajás Mountain Ridge (Ilkiu-Borges & Oliveira-da-Silva 2018), the nearest mountain ridge to the study area. *Schusterolejeunea inundata*, known from Colombia, Venezuela, Peru, Brazil and the Guianas (Gradstein 2021), was previously recorded from the states of Amazonas, Pará, and Maranhão (Lisboa & Ilkiu-Borges 2001; Gradstein & Costa 2003; Peralta *et al*. 2011), where it is uncommon.

Approximately 95 % of the bryophyte species from the Martírios-Andorinhas Mountain Ridge were already registered from Amazonia and 76 % from the Cerrado domain. The higher representation of Amazonian species may be due to the common occurrence of forests in the study area, promoting the establishment of species typical of Amazonian forests including many members of Lejeuneaceae. On the other hand, this may as well reflect the insufficient knowledge of the bryophyte flora of the Cerrado region, being still one of the lesser studied regions of Brazil.

**Acknowledgements**

We would like to thank Dr William Buck for the identification of *Trichosteleum bolivarense* (currently recognized as *Trichosteleum cyparissoide*) and *Trachyphyllum dusenii* during the stay of the second author in the herbarium NY in 2019; Prof Dr S. Robbert Gradstein and an anonymous reviewer for critically commenting and improving the manuscript; the Laboratório de Análise Espaciais (UAS) from Museu Paraense Emílio Goeldi for making the map of the study area; Ideflor-Bio for logistical support during the fieldwork at Serra dos Martírios-Andorinhas; CNPq for the Master's fellowship of the first author. This work was accomplished with support from Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Código de Financiamento 001.

## REFERENCES

Alves K. N. L. 2020. — *Cyperaceae Juss. na Serra dos Martírios--Andorinhas, São Geraldo do Araguaia, Pará, Brasil*. MSc Thesis, Universidade Federal Rural da Amazonia/Museu Paraense Emílio Goeldi, Belém.

Amaral D. D., Almeida S. S., Ferreira L. V. F. & Bastos M. N. C. 2008. — Florestas, cerrados e conservação na Serra das Andorinhas, *in* Gorayeb P. S. S. (ed.), *Parque Martírios-Andorinhas: Conhecimento, História e Preservação*. EDUFPA, Belém: 172-193.

Atzingen N. V., Cardoso A. L. R. & Ilkiu-Borges A. L. 1996. — Flora orquidológica da Serra das Andorinhas, São Geraldo do Araguaia-PA. *Boletim do Museu Paraense Emílio Goeldi, série Botânica* 12: 59-74.

Bastos C. J. P. & Gradstein S. R. 2020a. — The genus *Cheilolejeunea* (Marchantiophyta: Lejeuneaceae) in tropical America. *Nova Hedwigia* 111 (3-4): 287-335. https://doi.org/10.1127/nova_hedwigia/2020/0596

Bastos C. J. P. & Gradstein S. R. 2020b. — The genus *Lejeunea* Lib. (Lejeuneaceae, Marchantiophyta) in Brazil. *Phytotaxa* 453 (2): 55-107. https://doi.org/10.11646/phytotaxa.453.2.1

Bordin J. & Yano O. 2013. — Fissidentaceae (Bryophyta) do Brasil. *Boletim do Instituto de Botânica de São Paulo* 22: 1-168.

Brito E. S. & Ilkiu-Borges A. L. 2013. — Bryoflora of the municipalities of Soure and Cachoeira do Arari, on Marajó Island, in the state of Pará, Brazil. *Acta Botanica Brasilica* 27 (1): 124-141. https://doi.org/10.1590/S0102-33062013000100013

Buck W. R. 1998. — Pleurocarpous mosses of the West Indies. *Memoirs of the New York Botanical Garden* 82: 1-400.

Buck W. R. 2003. — Guide to the Plants of Central French Guiana. Part 3. Mosses. *Memoirs of the New York Botanical Garden* 76: 1-167.

Câmara P. E. A. S. 2011. — A review of *Taxithelium* subgenus *Taxithelium* (Bryophyta, Pylaisiadelphaceae). *Systematic Botany* 36 (4): 824-835. https://doi.org/10.1600/036364411X604840

Carmo D. M. & Peralta D. F. 2016. — Survey of bryophytes in Serra da Canastra Nacional Park, Minas Gerais, Brazil. *Acta Botanica Brasilica* 30 (2): 254-265. https://doi.org/10.1590/0102-33062015abb0235

Carvalho-Silva M., Stech M., Wickett N. J., Liu Y. & Câmara P. E. A. S. 2017. — A molecular phylogeny of the Sematophyllaceae s.l. (Hypnales) based on plastid, mitochondrial and nuclear markers, and its taxonomic implications. *Taxon* 66 (4): 811-831. https://doi.org/10.12705/664.2

Churchill S. P. 1998. — Catalogue of Amazonian Mosses. *The Journal of the Hattori Botanical Laboratory* 85: 191-238.

Costa D. P., Pôrto K. C., Luizi-Ponzo A. P., Ilkiu-Borges A. L., Bastos C. J. P., Câmara P. E. A. S., Peralta D. F., Bôas-Bastos S. B. V., Imbassahy C. A. A., Henriques D. K., Gomes H. C. S., Orcha L. M., Santos N. D., Siviero T. S., Vaz-Imbassahy T. F. & Churchill S. P. 2011. — Synopsis of the Brazilian moss flora: checklist, distribution and conservation. *Nova Hedwigia* 93 (3-4): 277-334. https://doi.org/10.1127/0029-5035/2011/0093-0277

Crandall-Stotler B., Stotler R. & Long D. 2009. — Morphology and classification of the Marchantiophyta, *in* Goffinet B. & Shaw A. J. (eds), *Bryophyte Biology*. Cambridge University Press, Cambridge: 1-54.

Dauphin G. 2003. — *Ceratolejeunea*. *Flora Neotropica Monograph* 90: 1-86.

Fagundes D. N., Tavares-Martins A. C. C., Ilkiu-Borges A. L., Moraes E. N. R. & Santos R. C. P. 2016. — Riqueza e aspectos ecológicos das comunidades de briófitas (Bryophyta e Marchantiophyta) de um fragmento de Floresta de Terra Firme no Parque Ecológico de Gunma, Pará, Brasil. *Iheringia, Série Botânica* 71: 72-84.

Filgueiras T. D. S., Nogueira P. E., Brochado A. L. & Guala G. F. 1994. — Caminhamento: um método expedito para levantamentos florísticos qualitativos. *Cadernos de Geociências* 12: 39-43.

Flora do Brasil 2020. — Jardim Botânico do Rio de Janeiro. Available at: http://floradobrasil.jbrj.gov.br/. Accessed on 11 May 2021.

Florschütz-De Waard J. 1996. — Sematophyllaceae, *in* Görts-Van Rijn A. R. A. (ed.), *Flora of the Guianas. Musci III.* Royal Botanical Gardens, Kew: 384-438.

Garcia E. T., Ilkiu-Borges A. L. & Tavares-Martins A. C. C. 2014. — Brioflora de duas florestas de terra firme na Área de Proteção Ambiental do Lago de Tucuruí, PA, Brasil. *Hoehnea* 41 (4): 499-514. https://doi.org/10.1590/2236-8906-10/2013

Goffinet B., Buck W. R. & Shaw J. A. 2009. — Morphology, anatomy, and classification of the Bryophyta, *in* Goffinet B. & Shaw A. J. (eds), *Bryophyte Biology*. Cambridge University Press, Cambridge: 55-138.

Gorayeb P. S. S., Costa F. R. & Souza-Filho P. W. M. 2008. — Geomorfologia da Serra das Andorinhas, *in* Gorayeb P. S. S. (ed.), *Parque Martírios-Andorinhas: Conhecimento, História e Preservação*. EDUFPA, Belém: 78-93.

Gradstein S. R. 1994. — Lejeuneaceae: Ptychantheae, Brachiolejeuneae. *Flora Neotropica Monograph* 62: 1-216.

Gradstein S. R. 2021. — The Liverworts and Hornworts of Colombia and Ecuador. *Memoirs of the New York Botanical Garden* 121: 1-723.

Gradstein S. R., Churchill S. P. & Salazar-Allen N. 2001. — Guide to the bryophytes of tropical America. *Memoirs of the New York Botanical Garden* 86: 1-577.

Gradstein S. R. & Costa D. P. 2003. — The Hepaticae and Anthocerotae of Brazil. *Memoirs of the New York Botanical Garden* 87: 1-301.

Gradstein S. R. & Ilkiu-Borges A. L. 2009. — Guide to the Plants of Central French Guiana. Part 4. Liverworts and Hornworts. *Memoirs of the New York Botanical Garden* 76: 1-140.

Gradstein S. R. & Ilkiu-Borges A. L. 2015. — A taxonomic revision of the genus *Odontoschisma* (Marchantiophyta: Cephaloziaceae). *Nova Hedwigia* 100 (1-2): 15-100. https://doi.org/10.1127/nova_hedwigia/2014/0219

Gradstein S. R. & Pócs T. 1989. — Bryophytes, *in* Lieth H. & Werger M. J. A. (eds), *Tropical Rain Forest Ecosystems*. Elsevier Science Publishers, Amsterdam: 311-325.

He X.-L. 1999. — A taxonomic monograph of the genus *Pycnolejeunea* (Lejeuneaceae, Hepaticae). *Acta Botanica Fennica* 163: 1-77.

Ilkiu-Borges A. L. & Oliveira-da-Silva F. R. 2017. — Flora das cangas da Serra dos Carajás: Cephaloziaceae. *Rodriguésia* 68 (3): 803-805. https://doi.org/10.1590/2175-7860201768302

Ilkiu-Borges A. L. & Oliveira-da-Silva F. R. 2018. — Flora das cangas da Serra dos Carajás, Pará, Brasil: Lejeuneaceae. *Rodriguésia* 69 (3): 989-1012. https://doi.org/10.1590/2175-7860201869305

Ilkiu-Borges A. L., Tavares A. C. C. & Lisboa R. C. L. 2004. — Briófitas da Ilha de Germoplasma, reservatório de Tucuruí, Pará, Brasil. *Acta Botanica Brasilica* 18 (3): 689-692. https://doi.org/10.1590/S0102-33062004000300026

Ilkiu-Borges A. L., Takashima-Oliveira T. T. G. & Brito E. S. 2020. — Bryophytes from Caviana and Mexiana islands, archipelago of Marajó, Brazil. *Cryptogamie, Bryologie* 41 (20): 255-264. https://doi.org/10.5252/cryptogamie-bryologie2020v41a20

Lisboa R. C. L. & Ilkiu-Borges A. L. 1995. — Diversidade das briófitas de Belém (PA) e seu potencial como indicadoras de poluição. *Boletim do Museu Paraense Emílio Goeldi, série Botânica* 12: 161-181.

Lisboa R. C. L. & Ilkiu-Borges A. L. 2001. — Briófitas de Sao Luiz do Tapajós, município de Itaituba, com novas adições para o Estado do Pará. *Boletim do Museu Paraense Emílio Goeldi, série Botânica* 17: 75-97.

Lisboa R. C. L. & Ilkiu-Borges F. 1996. — Briófitas da Serra dos Carajás e sua possível utilização como indicadoras de metais. *Boletim do Museu Paraense Emílio Goeldi, série Botânica* 12: 161-181.

Luizi-Ponzo A. P., Siviero T. S., Amorim E. T., Henriques D. K., Rocha L. M., Gomes H. C. S., Paiva L. A., Rodrigues R. S., Silva I. C., Silva A. G. D., Ribeiro G. C., Gomes C. Q. & Campeão A. S. 2013. — Briófitas do Parque Estadual do Ibitipoca no Herbário Prof. Leopoldo Kriegeer, *in* Forzza R. C., Neto L. M., Salimena F. R. G. & Zappi D. (eds), *Flora do Parque Estadual do Ibitipoca e seu entorno*. Vol. 4. Editora UFJF, Juiz de Fora: 95-122.

Macedo L. P. C., Bastos C. P. J. & Ilkiu-Borges A. L. 2020. — On a new species of *Cheilolejeunea* (Spruce) Steph. (Lejeuneaceae, Marchantiophyta) from Amazonian savannas, Brazil. *Nova Hedwigia* 111: 77-85. https://doi.org/10.1127/nova_hedwigia/2020/0594

Moraes E. N. R. & Lisboa R. C. L. 2006. — Musgos (Bryophyta) da Serra dos Carajás, estado do Pará, Brasil. *Boletim do Museu Paraense Emílio Goeldi, Ciências Naturais* 1 (1): 61-63. https://doi.org/10.46357/bcnaturais.v1i1.756

Olarinmoye S. O. 1974. — Ecology of epiphyllous liverworts: growth in three natural habitats in western Nigeria. *Journal of Bryology* 8: 275-289. https://doi.org/10.1179/jbr.1974.8.2.275

Oliveira-da-Silva F. R. & Ilkiu-Borges A. L. 2018. — Bryophytes (Bryophyta and Marchantiophyta) of the canga of the Serra dos Carajás, Pará, Brazil. *Rodriguésia* 69 (3): 1405-1416. https://doi.org/10.1590/2175-7860201869334

Oliveira-da-Silva F. R., Gradstein S. R. & Ilkiu-Borges A. L. 2021. — The genus *Radula* Dumort. (Radulaceae, Marchantiophyta) in Brazil. *Nova Hedwigia* 112 (1-2): 69-163. https://doi.org/10.1127/nova_hedwigia/2020/0606

Oliveira H. C. & Bastos C. J. P. 2014. — Briófitas epífitas de fragmentos de Floresta Atlântica da Reserva Ecológica Michelin, Estado da Bahia, Brasil. *Hoehnea* 41 (4): 631-646. https://doi.org/10.1590/2236-8906-35/2013

Pantoja A. C. C., Ilkiu-Borges A. L., Tavares-Martins A. C. C. & Garcia E. T. 2015. — Bryophytes in fragments of Terra Firme forest on the great curve of the Xingu River, Pará state, Brazil. *Brazilian Journal of Biology* 75 (3): 238-249. https://doi.org/10.1590/1519-6984.02814BM

Pará 1996. — *Lei Estadual n 5.982, de 25 de jul. de 1996.* Cria o Parque Estadual da Serra dos Martírios / Andorinhas e dá outras providências. Belém, DOE n° 28.339, de 12/11/1996.

Peñaloza-Bocajá G. F., Oliveira B. A., Araújo C. A. T., Fantecelle L. B. & Maciel-Silva A. S. 2017. — Bryophyte reproduction on ironstone outcrops: delicate plants on harsh environments. *Flora* 238: 155-161. https://doi.org/10.1016/j.flora.2017.02.017

Peralta D. F., Brito E. S., Varão L. F., Conceição G. M. & Cunha I. P. R. 2011. — Novas ocorrências e lista das briófitas do Estado do Maranhão, Brasil. *Pesquisa em Foco* 19: 63-78.

Pócs T. 1996. — Epiphyllous liverworts diversity at worldwide level and its threat and conservation. *Anales del Instituto de Biologia de la Universidad Nacional Autónoma de Mexico, Serie Botánica* 67: 109-127.

Pócs T., Bernercker A. & Tixier P. 2014. — Synopsis and key to species of Neotropical *Cololejeunea* (Lejeuneaceae). *Acta Botanica Hungarica* 56 (2): 185-226. https://doi.org/10.1556/ABot.56.2014.1-2.14

Reese W. D. 1993. — Calymperaceae. *Flora Neotropica Monograph* 58: 1-102.

Reiner-Drehwald M. E. 1998. — Las Lejeuneaceae (Hepaticae) de Misiones, Argentina V. *Cheilolejeunea* y *Lepidolejeunea*. *Tropical Bryology* 14: 53-68.

Reiner-Drehwald M. E. 2000. — Las Lejeuneaceae (Hepaticae) de Misiones, Argentina VI. *Lejeunea* y *Taxilejeunea*. *Tropical Bryology* 19: 81-132.

Reiner-Drehwald M. E. & Schäfer-Verwimp A. 2008. — *Lejeunea oligoclada* and *L. rionegrensis* (Lejeuneaceae) in tropical America: new data on morphology and geographical distribution. *Nova Hedwigia* 87 (1-2): 175-184. https://doi.org/10.1127/0029-5035/2008/0087-0175

Ribeiro J. F. & Walter B. M. T. 1998. — Fitofisionomias do bioma Cerrado, *in* Sano S. M. & Almeida S. P. (eds), *Cerrado: ambiente e flora.* EMBRAPA-CPAC, Planaltina: 89-166.

Richards P. W. 1984. — The ecology of tropical forest bryophytes, *in* Schuster R. M. (ed.), *New Manual of Bryology*. Vol. 2. The Hattori Botanical Laboratory, Nichinan: 1233-1270.

Robbins R. G. 1952. — Bryophyte ecology of a dune area in New Zealand. Vegetation. *Acta Geobotanica* 4: 1-31.

Santos N. D. & Costa D. P. 2010. — Altitudinal zonation of liverworts in the Atlantic Forest, southeastern Brazil. *The Bryologist* 113 (3): 631-645. https://doi.org/10.1639/0007-2745-113.3.631

Sectam 2006. — *Plano de Manejo do Parque Estadual Serra dos Martírios-Andorinhas.* Secretaria Executiva de Ciências, Tecnologia e Meio Ambiente, Brasília: 1-942.

Silva T. O. S., Silva M. P. P & Pôrto K. C. 2014. — Briófitas de Afloramentos Rochosos do Estado de Pernambuco, Brasil. *Boletim do Museu de Biologia Mello Leitão* 36: 85-100.

Silva J. P., Oliveira-da-Silva F. R., Ilkiu-Borges A. L. & Fernandes R. S. 2021. — Leafy liverworts of Chapada das Mesas National Park: a floristic survey and checklist of the leafy liverworts of Maranhão state, Brazil. *Check List* 17 (2): 479-495. https://doi.org/10.15560/17.2.479

Shi X. Q., Gradstein S. R. & Zhu R. L. 2015. — Phylogeny and taxonomy of *Archilejeunea* (Marchantiophyta: Lejeuneaceae) based on molecular markers and morphology. *Taxon* 64 (5): 881-892. https://doi.org/10.12705/645.1

Sukkharak P. & Gradstein S. R. 2017. — Phylogenetic study of *Mastigolejeunea* (Marchantiophyta: Lejeuneaceae) and an amended circumscription of the genus *Thysananthus*. *Phytotaxa* 326 (2): 91-107. https://doi.org/10.11646/phytotaxa.326.2.1

Tavares-Martins A. C. C., Lisboa R. C. L. & Costa D. P. 2014. — Bryophyte flora in upland forests at different successional stages and in the various strata of host trees in northeastern Pará, Brazil. *Acta Botanica Brasilica* 28 (1): 46-58. https://doi.org/10.1590/S0102-33062014000100005

Valente E. B., Pôrto K. C. & Bastos C. J. P. 2013. — Species richness and distribution of bryophytes within different phytophysiognomies in the Chapada Diamantina region of Brazil. *Acta Botanica Brasilica* 27 (2): 294-310. https://doi.org/10.1590/S0102-33062013000200006

Valente E. B., Pôrto K. C. & Bastos C. J. P. 2017. — Habitat heterogeneity and diversity of bryophytes in campos rupestres. *Acta Botanica Brasilica* 31 (2): 241-249. https://doi.org/10.1590/0102-33062016abb0450

Vieira I. C. G., Toledo P. D., Silva J. D. & Higuchi H. 2008. — Deforestation and threats to the biodiversity of Amazonia. *Brazilian Journal of Biology* 68 (4): 949-956. https://doi.org/10.1590/S1519-69842008000500004

Wynns J. T. 2020. — New names and new combinations for hypnalean mosses. *The Bryologist* 123 (4): 633-656. https://doi.org/10.1639/0007-2745-122.4.633

Yano O. 1984. — Briófitas, *in* Fidalgo O. & Bononi V. L. R. (eds), *Técnicas de coleta, preservação e herborização de material botânico*. Instituto de Botânica, São Paulo: 27-30.

Yano O. 1992. — *Leucobryaceae (Bryopsida) do Brasil.* PhD Thesis, Universidade de São Paulo, São Paulo.

Yano O. 2006. — *Catálogo de antóceros e hepáticas brasileiros. literatura original basiônimo localidade tipo e distribuição geográfica*. Instituto de Botânica, São Paulo: 1-120.

Yano O. 2011. — *Catálogo de musgos brasileiros: literatura original, basiônimo, localidade-tipo e distribuição geográfica*. Instituto de Botânica, São Paulo: 1-182.

Yano O. & Peralta D. F. 2009. — Flora de Grão-Mongol, Minas Gerais: Briófitas (Bryophyta e Marchantiophyta). *Boletim de Botânica da Universidade de São Paulo* 27 (1): 1-26. https://doi.org/10.11606/issn.2316-9052.v27i1p1-26

Yano O. & Peralta D. F. 2011. — Flora da Serra do Cipó, Minas Gerais: Briófitas (Anthocerothophyta, Bryophyta e Marchantiophyta). *Boletim de Botânica da Universidade de São Paulo* 29 (2): 135-299. https://doi.org/10.11606/issn.2316-9052.v29i2p135-299

*Submitted on 2 July 2021;*
*accepted on 11 April 2022;*
*published on 9 June 2022.*