Acta Botanica Brasilica - 35(3): 389-417. July-September 2021.
doi: 10.1590/0102-33062020abb0377

Bryophytes of Rio Turvo State Park (SP), Brazil: integrating floristics, geographical distribution, reproduction and ecological traits to support the conservation of an Atlantic Forest fragment

Marina Lemy Koga[1*] and Denilson Fernandes Peralta[1]

Received: August 10, 2020
Accepted: November 17, 2020

ABSTRACT

Rio Turvo State Park (RTSP) is a Conservation Unit located within the Atlantic Forest biome in the Vale do Ribeira region of the State of São Paulo, Brazil. Considering the lack of knowledge regarding its bryoflora, we performed a floristic inventory of RTSP (following the random-walk method), the results of which we report here including discussion of the geographical distribution (Brazil and worldwide), substrate colonization, life forms and reproduction of the species. We found a total of 414 species, which represents 30 % of all known bryophyte species in Brazil. Dioicous species were predominant over monoicous species, the most colonized substrate was tree trunk (40 % of all species) and the predominant life form was mat (47 %), indicating that the floristic composition is influenced by the environmental conditions of the area (high humidity, dense vegetation and shading). Although anthropogenic intervention is present in RTSP, it harbors huge biodiverse potential, since 22 % of the species are rare. Furthermore, 16 new occurrences were recorded for the State of São Paulo. The information provided by this study exalts the importance of this Conservation Unit in the preservation of bryophytes, as well as all the biodiversity of its included ecosystems.

Keywords: Atlantic Forest, bryophytes, Conservation Unit, distribution, floristics, inventory, liverworts, mosses, ombrophilous forest, Vale do Ribeira

Introduction

The SNUC Law 9.985/2000 (Sistema Nacional de Unidades de Conservação – National System of Conservation Units) establishes the importance of conservation units in promoting public policies for the protection of natural landscapes, flora, fauna and historical-cultural heritage, the recovery and restoration of degraded areas, economic valorization by the sustainable use of natural resources that remain the subsistence of local populations and ecological tourism (Brasil 2011). Furthermore, it provides the development of scientific research and environmental monitoring studies, as well as a space for discussion, interpretation and environmental education (Brasil 2011). The Rio Turvo State Park conservation unit (RTSP), São Paulo, Brazil, was founded in 2008. It is located inside the Atlantic Forest biome, harboring several flora and fauna species, including endangered ones, such as *Amazona vinacea* (Psittacidae) and *Panthera onca* (*jaguar*, Felidae) (Portal do

1 Núcleo de Pesquisa em Briologia, Instituto de Botânica, 04301-902, São Paulo, SP, Brazil

* Corresponding author: marina.lemy@gmail.com

Governo do Estado de São Paulo 2018). Moreover, this State Park has a great archaeological significance due to the presence of a fluvial sambaqui, where it was found one of the oldest human fossils in the Americas, dating ca. 10,400 years (Pivetta 2005).

The Atlantic Forest is mostly located on the Brazilian coast and currently comprises only 12 % of its original extension (1,500 Km²) (Ribeiro *et al*. 2011). It is among the areas with the most significant habitat loss and high endemism rates, ranking fourth on the global priority list of conservation hotspots (Myers *et al*. 2000). Due to its enormous importance, the Atlantic Forest was declared a National Heritage by the Federal Constitution of 1988 and was granted the Biosphere Reserve title by Unesco (SOS Mata Atlântica 2018).

Compared to the knowledge on vascular plants accumulated over the years, Bryology is still incipient since little is known on their biology, ecology, distribution and bioprospection (Hallingbäck & Tan 2010). For this reason, efforts on bryophyte research are critical, mainly on species occurring within biodiversity hotspots, such as the Atlantic Forest. These efforts fill the gaps in this group's geographical distribution, population sizes and susceptibility to anthropogenic environmental changes, enabling conscious conservation planning with effective measures to protect biodiversity (Hallingbäck & Tan 2010). Scott *et al*. (1997) emphasize the necessary investment in floristic and endemism studies of different regions to fill the remaining gaps.

According to Costa *et al*. (2011), the Atlantic Forest is the biome with the highest bryophyte richness and endemism in Brazil. Out of the 1,572 species recognized for the country, 334 species are endemic, 1,347 occur in the Atlantic Forest and 915 species occur in the State of São Paulo (Flora do Brasil 2020 2020). For the Atlantic Forest in the State of São Paulo, several publications have consistently contributed to the knowledge of the diversity and distribution of bryophytes, such as: Yano (1998), Visnadi (2002; 2004; 2005), Peralta & Yano (2006), Visnadi (2006), Yano & Peralta (2007), Peralta & Yano (2008), Yano & Peralta (2008), Visnadi (2009), Peralta & Yano (2012), Visnadi (2012; 2013a; 2013b; 2015a; 2015b), Carmo *et al*. (2016), Amélio *et al*. (2019) and Yano *et al*. (2019). These surveys were carried out in State conservation units revealing territories with great species richness: 386 species for Serra do Mar State Park, Núcleo Santa Virgínia (Carmo *et al*. 2016); 490 species for Campos do Jordão State Park (Amélio *et al*. 2019); and 440 species for Ilha do Cardoso State Park (Yano *et al*. 2019).

Bryophytes are land plants that are still water-dependent for sexual reproduction. They are strongly influenced by microclimatic conditions due to their small size (Richards 1984) and the poikilohydric feature – the low capacity to control water loss (Delgadillo & Cárdenas 1990). Due to their property in accumulating nutrients (Oishi & Hiura 2017), heavy metals and other substances, several species are considered appropriate indicators for biomonitoring studies that evaluate air and water pollution (Govindapyari *et al*. 2010). They are also useful in measuring the disturbance in Neotropical rainforests (Drehwald 2005). Chemical studies are relevant to evaluate the atmospheric and other environmental conditions (Oishi & Hiura 2017). However, several ecological studies have demonstrated the relationship between life forms, colonization of different substrates, reproductive strategies, humidity and light tolerance (Batista & Santos 2016; Santos *et al*. 2017b; Batista *et al*. 2018).

Considering the lack of knowledge of the bryoflora of the RTSP, this study aimed to carry out a floristic inventory of the park's bryophytes, discussing the species' geographical distribution in Brazil and worldwide, substrate, life forms and reproductive aspects. These results will provide support to the park's management plan (still under construction), as well as the preservation of conservation units located within the Atlantic Forest biome.

Materials and methods

Study area

The Rio Turvo State Park (24º47'-24º57' S, 48º09'-48º25' W) is located inside the Atlantic Forest biome, in Vale do Ribeira region, southern State of São Paulo. The park consists of 73,893.87 ha across the municipalities of Jacupiranga, Cajati and Barra do Turvo (Portal do Governo do Estado de São Paulo 2018). Its vegetation comprises mixed forest to rainforests (IBGE 2012), with altitudes ranging from 10 to 1,500 m.a.s.l. (Bim & Furlan 2013). The climate can be defined as permanently humid subtropical, influenced by tropical and polar sea air masses (Monteiro 1973). Following the Köppen-Geiger classification, areas at lower altitudes are classified as Cfa (humid subtropical climate), while areas at altitudes above 700 m are classified as Cfb (oceanic climate) (Lepsch *et al*. 1990). The average temperature ranges from 11 to 32 ºC (Ross 2002). Rainfall is recorded throughout the year, with an average annual rainfall ranging from 1,000 to 3,000 mm/year but less intense in June, July and August (Ross 2002). This park is located within the Ribeira do Iguape river basin, with the main rivers being the Turvo, Jacupiranga and Pardo. The pedological aspect presents a montane topography, with deep and narrow valleys (Bim *et al*. 2017). The vegetation cover is predominantly primary, with some secondary patches caused by anthropogenic interventions such as deforestation, farming and *Euterpe edulis* Mart. (*palmito juçara* or solitary açaí palm) extraction (Bim & Furlan 2013).

Sampling

We analyzed 401 samples collected until 2009 and deposited at the SP herbarium (Maria Eneyda P. Kaufmann Fidalgo), and 849 additional samples were collected during

three field expeditions from 2018 to 2019. We adopted the random-walk technique that consists of walking freely (Filgueiras *et al*. 1994) through trails and exploring all available substrates around, such as soil, rocks, leaves, tree trunks, decaying tree trunks and artificial substrates.

Specimens treatment

The methodology for collection, herborization and preservation of specimens followed Gradstein *et al*. (2001) and all samples were included in the SP herbarium. Species identification followed Frahm (1991), Zander (1993), Sharp *et al*. (1994), Buck (1998), Gradstein *et al*. (2001), Gradstein & Costa (2003), Câmara & Costa (2006), Visnadi (2006), Zartman & Ilkiu-Borges (2007), Câmara (2008a; 2008b), Peralta & Yano (2008), Ballejos & Bastos (2009), Bastos & Yano (2009), Yano & Peralta (2009; 2011) and Bordin & Yano (2013).

The classification system followed Renzaglia *et al*. (2009) for Anthocerotophyta, Crandall-Stotler *et al*. (2009) for Marchantiophyta and Goffinet *et al*. (2009) for Bryophyta with adaptation based on recent classification studies of certain genera and families. The abbreviation of the authors' name in the species list was based on Brummitt & Powell (1992).

The list was organized in alphabetical order by division, family, genus and species. The biome classification followed IBGE (2019), information on biomes and worldwide distribution followed Gradstein & Costa (2003), Costa *et al*. (2011) and Flora do Brasil 2020 2020. For life forms, substrate type and reproductive strategies (sexual system and structures), we followed Batista *et al*. (2018). To classify the geographical distribution in Brazil, we followed Valente & Pôrto (2006), which consider three statuses: wide (when a species occurs in ten or more Brazilian states), moderate (in five to nine states) and rare (in one to four states).

The substrates were classified into five categories according to Robbins (1952): soil (terrestrial), rocks (rupicolous), leaves (epiphyllous), tree trunk (corticolous) and decaying trunk (epixylic), plus two additional categories: artificial and humicolous. The life form classification followed Mägdefrau (1982), recognizing nine categories: annual, turf, cushion, mat, weft, pendant, tail, fan and dendroid.

Regarding reproduction, we carefully checked the specimens to identify their sexual system (dioicous or monoicous) and the presence of sexual (male and female gametangia, sporophytes) or asexual propagules (gemmae and tubers).

Results

Species richness

A total of 1,250 samples were analyzed, containing one to twelve species on each envelope. We recorded 414 species: 203 Marchantiophyta (23 families, 62 genera); 204 Bryophyta (38 families, 105 genera); and seven Anthocerotophyta (three families, four genera) (Tab. 1). The total number of species represented 46 % of the total known species for the State of São Paulo, 31 % of the species for the Atlantic Forest, 26 % of the species for Brazil and 10 % of the species for the Neotropical Region (Tab. 2). We recorded 16 new occurrences for the State of São Paulo (6 %).

Among liverworts, the richest families were Lejeuneaceae (98 species), Plagiochilaceae (17 spp.), Lepidoziaceae (14 spp.), Frullaniaceae and Radulaceae (12 spp. each), Aneuraceae (8 spp.), Lophocoleaceae and Metzgeriaceae (7 spp. each) and Pallaviciniaceae (5 spp.). The most well-representative families of mosses were Pilotrichaceae (22 spp.), Fissidentaceae (17 spp.), Sematophyllaceae (16 spp.), Leucobryaceae (12 spp.) and Bryaceae, Calymperaceae, Neckeraceae and Ortothrichaceae (11 spp. each). Finally, the richest family of hornworts, in terms of the number of species, was Dendrocerotaceae (4 spp.).

Geographical distribution (Brazilian States, biomes and worldwide distribution)

Considering their distribution in Brazil, 160 species (39 %) show wide distribution, 161 species (39 %) are moderately distributed and 93 species (22 %) are rarely distributed.

In terms of species occurrence in Brazilian biomes, 94 % occur in the Atlantic Forest (AT), 45 % in the Amazon Forest (AM), 42 % in the Cerrado (CE), 17 % in the Pantanal (PL), 11 % in the Caatinga (CA) and 10 % in the Pampa (PA) (Fig 1).

We highlight that 145 species (35 %) are exclusive to the AT. However, only five species are exclusive to the AM, two to the CE and one to the CA. *Schlotheimia merkelii*, *Pylaisiadelpha tenuirostris* and *Lejeunea herminieri* are new records to the AT. On the other hand, 33 % occur in three to six biomes. The group of biomes that share more species in common (48 spp., which represents 12 % of the list) is composed of AM, AT and CE (Fig. 2). The AM and AT share 57 species (14 %), while the CE and AT share 34 species (8 %).

Concerning worldwide distribution, 215 species (52 %) are Neotropical, 65 spp. (16 %) are disjunctly distributed (species found in one to three countries in the same continent or specific localities in different continents), 46 spp. (11 %) are endemic to Brazil, 45 spp. (11 %) are Pantropical, 25 spp. (6 %) are cosmopolitan and 14 spp. (3 %) are sub-cosmopolitan.

Substrates and life forms

The most common substrate was tree trunks – with 40 % of the species – followed by rocks, decaying trunks, soil and leaves (Fig. 3). About 63 % of the species had a preference for a single type of substrate. Some species demonstrated considerable potential to colonize different substrates: the moss *Thamniopsis langsdorffii* (Pilotrichaceae) and the liverworts *Saccogynidium caldense*, *Chiloscyphus martianus*.

Table 1. List and characteristics of bryophytes species of Rio Turvo State Park. Biomes: AM = Amazon Forest; AT = Atlantic Forest; CA= Caatinga; CE = Cerrado; PA = Pampa; PL = Pantanal. Geographical distribution in Brazil: rare = occurrence in one to four Brazilian States; moderate = in five to nine States; wide = ten or more States. Worlwide = worldwide distribution. 1st = First occurrence to SP State. Life forms: annual; turf; cushion; mat; weft; pendant; tail; fan; dendroid. Substrates: TT = tree trunk, SO = soil, RO = rock, DT = decaying trunk, LE = leaf, HU = humicolous, AR = artificial. Sexual system: FG = Female gametangia, MG = Male gametangia; S = Sporophyte; AS = Asexual propagule. Symbol: * in species = Endemic to Brazil.

Species	Biome	Brazil	Worldwide	1st	Life Form	TT	SO	RO	DT	LE	HU	AR	Sexual System	FG	MG	S	AS	Voucher
Division Anthocerotophyta																		
Dendrocerotaceae																		
Dendroceros breutelii Nees	AT	Rare (SP)	Endemic to Brazil		Mat	X							Monoicous			X		Peralta *et al.* 26698
Dendroceros crispatus Nees	AT	Rare (RJ, SP, PR, SC)	Australia, Africa, Neotropical		Mat	X							Monoicous			X		Peralta *et al.* 25539
Dendroceros crispus (Sw.) Nees	AT	Moderate	Africa, Neotropical		Mat	X							Monoicous			X		Peralta *et al.* 25538
Nothoceros vincentianus (Lehm. & Lindenb.) J.C. Villarreal	AT	Moderate	Neotropical		Mat				X				Monoicous			X		Peralta *et al.* 25397
Notothyladaceae																		
Phaeoceros carolinianus (Michx.) Prosk	CE, AT, PA	Moderate	Cosmopolitan		Mat		X						Monoicous		X	X		Peralta *et al.* 8467
Phaeoceros laevis (L.) Prosk.	AM, CE, AT, PA, PL	Wide	Cosmopolitan		Mat		X	X					Dioicous			X		Koga *et al.* 259
Phymatocerotaceae																		
Phymatoceros bulbiculosus (Broth.) Stotler, W. T. Doyle & Crand.-Stotl.	AT	Rare (ES, SP, PR)	Brazil, China, Russia		Mat		X						Dioicous			X		Peralta *et al.* 8412
Division Bryophyta																		
Bartramiaceae																		
Philonotis elongata (Dumort.) H.A. Crum & Steere	AM, CE, AT	Moderate	Neotropical		Turf			X					Dioicous					Peralta *et al.* 26569 p.p.
Philonotis longiseta (Michx.) E. Britton	AT	Rare (BA, CE)	Neotropical	X	Turf		X	X	X				Monoicous	X	X	X		Peralta *et al.* 26565
Philonotis uncinata (Schwägr.) Brid.	AM, CA, CE, AT, PA, PL	Wide	Cosmopolitan		Turf		X	X					Dioicous					Peralta *et al.* 8228
Brachytheciaceae																		
Aerolindigia capillacea (Hornsch.) M. Menzel	AT	Rare (RJ, SP,SC, RS)	Africa, Neotropical		Turf	X							Monoicous	X		X		Peralta *et al.* 26658
**Brachythecium poadelphus* Müll. Hal.	AT	Rare (MG, RJ, SP)	Endemic to Brazil		Mat		X						Dioicous		X			Peralta *et al.* 8153
Brachythecium ruderale (Brid.) W.R. Buck	AT, PL	Moderate	Pantropical		Mat			X			X		Dioicous					Peralta *et al.* 25580
Helicodontium capillare (Hedw.) A. Jaeger	AM, CE, AT, PA	Wide	Neotropical		Weft	X		X	X				Monoicous	X		X		Peralta *et al.* 8461
Meteoridium remotifolium (Müll. Hal.) Manuel	AM, CE, AT	Wide	Neotropical		Pendant	X	X	X					Dioicous					Peralta *et al.* 8257
Rhynchostegium scariosum (Taylor) A. Jaeger	AT, CE	Moderate	Neotropical		Mat		X		X				Monoicous					Peralta *et al.* 25535
Squamidium brasiliense Broth.	AT	Moderate	Asia, Neotropical		Pendant	X							Dioicous					Peralta *et al.* 25546
Zelometeorium ambiguum (Hornsch.) Manuel	AM, AT	Moderate	Africa, Neotropical		Pendant	X	X						Dioicous					Peralta *et al.* 8268

Table 1. Cont.

Species	Biome	Brazil	Worldwide	1st	Life Form	TT	SO	RO	DT	LE	HU	AR	Sexual System	FG	MG	S	AS	Voucher
Zelometeorium patulum (Hedw.) Manuel	AM, CE, AT, PL	Wide	Neotropical		Pendant	X							Dioicous					Peralta *et al.* 8221
Bryaceae																		
Brachymenium consimile (Mitt.) A. Jaeger	AT	Moderate	Neotropical		Turf	X							Dioicous	X		X		Peralta *et al.* 8143
**Brachymenium hornschuchianum* Mart.	AT	Moderate	Endemic to Atlantic Forest		Turf	X							Dioicous	X		X		Koga *et al.* 99
Brachymenium radiculosum (Schwägr.) Hampe	CE, CA, AT	Wide	Neotropical		Turf	X			X				Dioicous	X		X		Oliveira *et al.* 41
Bryum argenteum Hedw.	AM, CA, CE, AT, PA	Wide	Cosmopolitan		Cushion							X	Dioicous	X		X		Oliveira *et al.* 50
Bryum atenense Williams	CA, CE, AT, PL	Moderate	South Hemisphere		Turf			X					Dioicous	X		X		Peralta *et al.* 25543
Bryum caespiticium Hedw.	CE, AT	Rare (MG, RJ, SP, TO)	Cosmopolitan		Turf			X					Monoicous	X	X			Peralta *et al.* 26639
Bryum limbatum Müll. Hal.	CE, AT	Wide	Neotropical		Turf			X					Dioicous					Peralta *et al.* 25352
Rhodobryum roseum (Hedw.) Limpr.	AT	Moderate	Cosmopolitan		Dendroid				X				Dioicous	X				Koga *et al.* 319
Rhodobryum subverticillatum Broth.	AM, AT	Moderate	Brazil, Uruguay		Dendroid				X				Dioicous	X		X		Peralta *et al.* 25396
Rosulabryum billarderi (Schwägr.) Spence	AM, CE, AT, PA, PL	Wide	Sub cosmopolitan		Turf		X	X					Dioicous					Canestraro *et al.* 1568
Rosulabryum densifolium (Brid.) Ochyra	CA, AT, PA	Wide	Australia, Neotropical		Turf		X	X					Dioicous		X			Koga *et al.* 268
Calymperaceae																		
Calymperes afzelii Sw.	AM, CE, AT	Wide	Pantropical		Turf	X		X					Dioicous				X	Koga *et al.* 41
Octoblepharum albidum Hedw.	AM, CA, CE, AT, PA, PL	Wide	Pantropical		Turf	X							Monoicous	X		X		Peralta *et al.* 25577
Octoblepharum cocuiense Mitt.	AM, CE, AT	Wide	Neotropical		Turf					X			Monoicous				X	Peralta *et al.* 26557
Octoblepharum pulvinatum (Dozy & Molk.) Mitt.	AM, CA, CE, AT, PL	Wide	Neotropical		Turf			X					Monoicous				X	Koga *et al.* 279
Syrrhopodon africanus (Mitt.) Paris	AM, AT	Moderate	Neotropical		Turf	X			X				Monoicous				X	Peralta *et al.* 26570
Syrrhopodon cymbifolius Müll. Hal.	AM, CE, AT	Moderate	Neotropical		Turf	X					X		Monoicous	X		X		Peralta *et al.* 25530
Syrrhopodon gaudichaudii Mont.	AM, CA, CE, AT, PL	Wide	Pantropical		Turf	X			X				Dioicous				X	Peralta *et al.* 8489
Syrrhopodon incompletus Schwägr.	AM, CE, AT	Wide	Africa, Neotropical		Turf	X							Dioicous					Peralta *et al.* 8277
Syrrhopodon lycopodioides (Sw. ex Brid.) Müll. Hal.	AT	Rare (MG, RJ, SP)	Neotropical		Turf	X							Dioicous					Peralta *et al.* 25449
Syrrhopodon parasiticus (Brid.) Besch.	AM, CE, AT, PL	Wide	Pantropical		Turf	X							Dioicous					Koga *et al.* 51 p.p.
Syrrhopodon prolifer Schwägr.	AM, CA, CE, AT	Wide	Pantropical		Turf	X		X	X				Dioicous				X	Peralta *et al.* 8193

Table 1. Cont.

Species	Biome	Brazil	Worldwide	1st	Life Form	TT	SO	RO	DT	LE	HU	AR	Sexual System	FG	MG	S	AS	Voucher
Cryphaeaceae																		
Schoenobryum concavifolium (Griff.) Gangulee	AM, CE, AT, PA, PL	Wide	Cosmopolitan		Tail	X						X	Monoicous	X		X		Oliveira *et al.* 55
Daltoniaceae																		
Adelothecium bogotense (Hampe) Mitt.	AT, PA	Moderate	Africa, Neotropical		Fan	X							Dioicous					Peralta *et al.* 26600 p.p.
Calyptrochaeta setigera (Mitt.) W. R. Buck	AM, AT	Moderate	Brazil, Venezuela		Dendroid				X				Dioicous	X		X		Peralta *et al.* 25491
Daltonia marginata Griff.	AT	Moderate	Neotropical		Turf	X							Monoicous	X		X		Peralta *et al.* 8284
Daltonia splachnoides (Sm.) Hook. & Taylor	AT	Rare (ES, MG, SP)	Neotropical		Turf	X							Monoicous					Peralta *et al.* 8365 p.p.
**Leskeodon aristatus* (Geh. & Hampe) Broth.	AT	Moderate	Endemic to Brazil		Turf	X							Monoicous	X	X	X		Peralta *et al.* 26598
Dicranaceae																		
Bryohumbertia filifolia (Hornsch.) J.-P. Frahm	AM, CA, AT	Wide	Neotropical		Turf		X		X				Dioicous	X		X		Peralta *et al.* 8347
Dicranella lindgiana (Hampe) Mitt.	AM, CE, AT	Wide	Neotropical		Turf		X						Dioicous	X		X		Koga *et al.* 270
**Dicranella pabstiana* (Müll. Hal.) Mitt.	AT	Rare (MG, SC)	Endemic to Brazil	X	Turf		X						Dioicous	X		X		Peralta *et al.* 8249
Holomitrium arboreum Mitt.	AM, CE, AT	Wide	Neotropical		Turf	X		X					Dioicous	X		X		Peralta *et al.* 8230
Holomitrium crispulum Mart.	AM, CE, AT, PL	Wide	Neotropical		Turf	X		X	X				Dioicous	X		X		Peralta *et al.* 8477
Leucoloma serrulatum Brid.	AT	Moderate	Neotropical		Turf	X		X					Dioicous					Peralta *et al.* 8487
**Leucoloma triforme* (Mitt.) A. Jaeger	AT	Rare (ES, RJ, SP, PR)	Endemic to Brazil		Turf	X			X				Dioicous					Peralta *et al.* 8248
Entodontaceae																		
**Entodon virens* (Hook. f. & Wilson) Mitt.	AT	Rare (RJ, SP)	Endemic to Brazil		Mat		X						Dioicous					Peralta *et al.* 26637
Erpodiaceae																		
Solmsiella biseriata (Austin) Steere	CE, AT	Wide	Neotropical		Mat	X							Monoicous					Amélio *et al.* 866
Fissidentaceae																		
Fissidens acacioides Schrad.	CE, AT	Moderate	Brazil, Paraguay		Fan			X					Monoicous					Peralta *et al.* 8483
Fissidens asplenioides Hedw.	CE, AT	Wide	Pantropical		Fan			X					Dioicous	X				Peralta *et al.* 8513
Fissidens crispus Mont.	AM, CA, CE, AT, PA, PL	Wide	Pantropical		Fan	X	X	X					Dioicous/ Monoicous	X				Bordin *et al.* 2143
Fissidens curvatus Hornsch.	CE, AT	Moderate	Pantropical		Fan			X					Monoicous					Peralta *et al.* 26641
Fissidens flaccidus Mitt.	AM, CA, CE, AT, PA, PL	Wide	Pantropical		Fan		X						Monoicous				X	Koga *et al.* 245
Fissidens hornschuchii Mont.	AM, CA, CE, AT, PA, PL	Wide	Neotropical		Fan	X		X					Monoicous					Peralta *et al.* 25373

Table 1. Cont.

Species	Biome	Brazil	Worldwide	1st	Life Form	TT	SO	RO	DT	LE	HU	AR	Sexual System	FG	MG	S	AS	Voucher
Fissidens lagenarius Mitt.	CA, CE, AT, PL	Wide	Neotropical		Fan	X							Monoicous	X		X		Peralta *et al.* 2140
Fissidens oblongifolius Hook. f. & Wilson	AT	Rare (RJ, SP)	Pantropical		Fan		X						Monoicous	X		X		Peralta *et al.* 8478
Fissidens oediloma Müll. Hal. ex Broth.	AT	Moderate	Brazil, Paraguay		Fan		X	X					Monoicous	X		X		Peralta *et al.* 8499
Fissidens pellucidus Hornsch.	AM, CA, CE, AT, PA, PL	Wide	Pantropical		Fan		X		X				Monoicous	X		X		Bordin *et al.* 2148
**Fissidens pseudoplurisetus* Bordin, Pursell & O. Yano	AT	Rare (SP, PR)	Endemic to Brazil		Fan	X							Monoicous	X		X		Bordin *et al.* 2139
Fissidens scariosus Mitt.	AM, CE, AT	Wide	Neotropical		Fan		X						Monoicous					Peralta *et al.* 25419
Fissidens serratus Müll. Hal.	AM, CA, CE, AT	Wide	Neotropical		Fan	X							Monoicous	X		X		Peralta *et al.* 2146
Fissidens submarginatus Bruch	AM, CA, CE, AT, PA, PL	Wide	Africa, Neotropical		Fan		X	X					Monoicous	X		X		Peralta *et al.* 8223
Fissidens weirii Mitt.	CE, AT	Moderate	Africa, Neotropical		Fan	X							Monoicous					Bordin *et al.* 2147
**Fissidens yanoae* Pursell	AT	Rare (SP, RS)	Endemic to Brazil		Fan	X							Monoicous	X	X			Bordin *et al.* 2142
Fissidens zollingeri Mont.	AM, CA, CE, AT, PL	Wide	Pantropical		Fan	X	X						Monoicous	X		X		Bordin *et al.* 2149
Funariaceae																		
Entosthodon bonplandii (Hook.) Mitt.	CE, AT	Moderate	Neotropical		Turf		X						Monoicous	X		X		Peralta *et al.* 8447
Funaria calvescens Schwägr.	AM, CE, AT, PA	Wide	Cosmopolitan		Turf		X						Monoicous	X		X		Peralta *et al.* 8211
Helicophyllaceae																		
Helicophyllum torquatum (Hook.) Brid.	AM, CA, CE, AT, PA, PL	Wide	Neotropical		Weft			X					Dioicous					Peralta *et al.* 26657 p.p.
Hypnaceae																		
Chryso-hypnum diminutivum (Hampe) W. R. Buck	AM, CE, AT, PA, PL	Wide	Cosmopolitan		Mat				X				Monoicous	X		X		Peralta *et al.* 25381
Chryso-hypnum elegantulum (Hook.) Hampe	AM, CE, AT, PL	Wide	Neotropical		Weft	X		X	X				Monoicous	X	X	X		Amélio *et al.* 870
Mittenothamnium reptans (Hedw.) Cardot	CE, AT, PA	Wide	Neotropical		Weft			X	X				Monoicous	X		X		Peralta *et al.* 25477
Pseudotaxiphyllum distichaceum (Mitt.) Z. Iwats.	AT	Rare (DF, PR)	Asia, Neotropical	X	Mat			X					Monoicous					Peralta *et al.* 26651 p.p.
Puiggariopsis aurifolia (Mitt.) M. Menzel	AT	Moderate	Neotropical		Weft	X							Dioicous				X	Peralta *et al.* 8181
Vesicularia vesicularis (Schwägr.) Broth.	AM, CE, AT, PL	Wide	Neotropical		Mat		X						Monoicous					Peralta *et al.* 25478 p.p.

Table 1. Cont.

Species	Biome	Brazil	Worldwide	1st	Life Form	TT	SO	RO	DT	LE	HU	AR	Sexual System	FG	MG	S	AS	Voucher
Hypopterygiaceae																		
Hypopterygium tamarisci (Sw.) Brid. ex Müll. Hal.	AT	Moderate	Cosmopolitan		Dendroid	X		X	X				Dioicous/ Monoicous	X	X			Peralta *et al.* 8458
Lopidium concinnum (Hook.) Wilson	AT	Moderate	South Hemisphere		Dendroid	X							Monoicous	X	X			Peralta *et al.* 8313
Lembophyllaceae																		
Orthostichella pachygastrella (Müll. Hal.) B. H. Allen & Magill	AT	Moderate	Neotropical		Pendant	X							Dioicous				X	Peralta *et al.* 8356
Orthostichella versicolor (Müll.Hal.) B. H. Allen & W. R. Buck	AM, AT	Wide	Africa, Neotropical		Pendant	X							Dioicous					Peralta *et al.* 26638
Leskeaceae																		
Haplocladium microphyllum (Hedw.) Broth.	CE, AT	Moderate	Asia, Neotropical		Weft				X				Monoicous	X		X		Koga *et al.* 236
Leucobryaceae																		
Campylopus arctocarpus (Hornsch.) Mitt.	CA, CE, AT, PA	Wide	Pantropical		Turf	X			X				Dioicous	X		X		Peralta *et al.* 8306
Campylopus flexuosus (Hedw.) Brid.	AT	Wide	Cosmopolitan		Turf	X							Dioicous	X		X		Peralta *et al.* 8404 p.p.
**Campylopus fragilis* (Brid.) Bruch & Schimp.	AT	Rare (MG, RJ, SC, SP)	Endemic to Brazil		Turf	X			X				Dioicous				X	Peralta *et al.* 8420
**Campylopus gemmatus* (Müll. Hal.) Paris	CE, AT	Moderate	Endemic to Brazil		Turf			X	X				Dioicous				X	Peralta *et al.* 25553
Campylopus heterostachys (Hampe) A. Jaeger	AM, CA, CE, AT	Wide	Neotropical		Turf		X						Dioicous	X		X		Peralta *et al.* 8170
Campylopus pilifer Brid.	AM, CA, CE, AT, PA	Wide	Cosmopolitan		Turf			X					Dioicous	X		X		Koga *et al.* 295
**Campylopus subcuspidatus* (Hampe) A. Jaeger	AT	Rare (MG, RJ, SP)	Endemic to Brazil		Turf			X					Dioicous					Peralta *et al.* 8154
Leucobryum albicans (Schwägr.) Lindb.	AM, CA, CE, AT	Wide	Neotropical		Cushion			X					Dioicous				X	Koga *et al.* 293
**Leucobryum clavatum* Hampe	CE, AT	Wide	Endemic to Brazil		Cushion		X		X				Dioicous				X	Peralta *et al.* 25536
Leucobryum crispum Müll. Hal.	AM, CE, AT	Wide	Neotropical		Cushion	X	X		X				Dioicous		X			Koga *et al.* 218
Leucobryum giganteum Müll. Hal.	AM, AT	Wide	Neotropical		Cushion		X						Dioicous					Koga *et al.* 324
Leucobryum martianum (Hornsch.) Hampe ex Müll. Hal.	AM, CA, CE, AT, PL	Wide	Neotropical		Turf	X		X					Dioicous					Koga *et al.* 289
Leucomiaceae																		
Leucomium steerei B. H. Allen & Veling	AT	Rare (PA, RJ)	Brazil, French Guiana, Venezuela	X	Weft				X				Monoicous	X	X	X		Peralta *et al.* 25522 p.p.
Leucomium strumosum (Hornsch.) Mitt.	AM, AT	Wide	Pantropical		Weft			X					Monoicous	X	X	X		Peralta *et al.* 26536
**Rhynchostegiopsis brasiliensis* Broth.	AT	Rare (SP)	Endemic to Brazil		Weft	X							Dioicous					Peralta *et al.* 25380
Meteoriaceae																		
Aerobryopsis capensis (Müll. Hal) M. Fleisch	AT	Rare (SE, SP)	Pantropical		Pendant	X							Dioicous					Peralta *et al.* 8335
Floribundaria flaccida (Mitt.) Broth.	AM, CE, AT, PL	Wide	Neotropical		Pendant	X				X			Dioicous					Peralta *et al.* 8163

Table 1. Cont.

Species	Biome	Brazil	Worldwide	1st	Life Form	TT	SO	RO	DT	LE	HU	AR	Sexual System	FG	MG	S	AS	Voucher
Meteorium deppei (Hornsch.) Mitt.	CE, AT, PL	Wide	Neotropical		Pendant	X							Dioicous					Peralta *et al.* 8180
**Meteorium latifolium* (Lindb.) Broth.	AT	Moderate	Endemic to Brazil		Pendant	X							Dioicous					Peralta *et al.* 8184
Meteorium nigrescens (Hedw.) Dozy & Molk.	AM, CE, AT, PL	Wide	Pantropical		Cushion	X						X	Dioicous				X	Peralta *et al.* 8411
Meteorium teres Mitt.	AT	Moderate	Neotropical		Pendant	X							Dioicous					Peralta *et al.* 8234
Pseudotrachypus martinicensis (Broth.) W. R. Buck	AT	Rare (BA)	Brazil, Caribbean	X	Pendant					X			Dioicous					Peralta *et al.* 26606 p.p.
Neckeraceae																		
Homaliodendron piniforme (Brid.) Enroth	AT	Moderate	Pantropical		Fan	X							Dioicous					Peralta *et al.* 25411
Neckera villae-ricae Besch.	AT	Moderate	Neotropical		Fan	X							Monoicous					Peralta *et al.* 25565
Neckeropsis disticha (Hedw.) Kindb.	AM, CE, AT, PL	Wide	Pantropical		Fan	X							Monoicous	X		X		Peralta *et al.* 25533
Neckeropsis undulata (Hedw.) Reichardt	AM, CA, CE, AT, PL	Wide	Neotropical		Fan	X							Monoicous					Koga *et al.* 22 p.p.
Pinnatella minuta (Mitt.) Broth.	AM, AT	Moderate	Pantropical		Fan	X							Dioicous	X		X		Peralta *et al.* 26688 p.p.
Porotrichodendron superbum Menz. ex Brid.	AT	Rare (PR, RS, SC)	Neotropical	X	Fan	X		X					Dioicous				X	Koga *et al.* 240
Porotrichum lancifrons (Hampe) Mitt.	AT	Moderate	Neotropical		Fan	X							Dioicous					Koga *et al.* 26
Porotrichum longirostre (Hook.) Mitt.	CE, AT	Moderate	Neotropical		Fan	X							Dioicous				X	Koga *et al.* 9
Porotrichum mutabile Hampe	AT	Moderate	Neotropical		Fan	X							Dioicous					Bordin *et al.* 2140 p.p.
Porotrichum substriatum (Hampe) Mitt.	AM, CE, AT	Wide	Africa, Neotropical		Fan	X		X					Dioicous				X	Peralta *et al.* 25387
Thamnomalia glabella (Hedw.) S. Olsson, Enroth & D. Quandt	AT	Moderate	Neotropical		Fan	X		X					Dioicous				X	Peralta *et al.* 8385
Orthodontiaceae																		
Hymenodon aeruginosus (Hook. f. & Wilson)	AT, PA	Moderate	Neotropical		Turf	X							Dioicous	X		X		Peralta *et al.* 8311
Orthotrichaceae																		
**Macrocoma brasiliensis* (Mitt.) Vitt	AT	Rare (SP, PR, SC, RS)	Endemic to Brazil		Mat				X				Monoicous	X	X	X		Oliveira *et al.* 54
Macrocoma orthotrichoides (Raddi) Wijk. & Margad.	AT	Moderate	India, Neotropical		Mat	X							Dioicous	X		X		Peralta *et al.* 8148
Macromitrium longifolium (Hook.) Brid.	AT	Moderate	Neotropical		Mat	X							Dioicous					Peralta *et al.* 8239
Macromitrium microstomum (Hook. & Grev.) Schwägr.	AT	Rare (PR, RJ, SP)	Cosmopolitan		Mat	X							Monoicous					Koga *et al.* 96 p.p.
Macromitrium richardii Schwägr.	AM, AT	Wide	Africa, Neotropical		Mat	X							Monoicous	X		X		Peralta *et al.* 8179
Schlotheimia appressifolia Mitt.	AT	Moderate	Neotropical		Cushion	X			X				Dioicous	X		X		Peralta *et al.* 8270
Schlotheimia jamesonii (Arn.) Brid.	AM, CE, AT, PA	Wide	Neotropical		Cushion	X			X				Dioicous	X		X		Peralta *et al.* 8395

Table 1. Cont.

Species	Biome	Brazil	Worldwide	1st	Life Form	TT	SO	RO	DT	LE	HU	AR	Sexual System	FG	MG	S	AS	Voucher
**Schlotheimia merkelii* Hornsch.	CE	Moderate	Endemic to Brazil		Cushion	X			X				Dioicous	X		X		Oliveira *et al.* 42
Schlotheimia rugifolia (Hook. f.) Schwägr.	AM, CE, AT	Wide	India, Neotropical		Cushion	X							Dioicous	X		X		Peralta *et al.* 8348
Schlotheimia tecta Hook. f. & Wilson	AT	Moderate	Neotropical		Cushion	X							Dioicous	X	X			Peralta *et al.* 8175
Schlotheimia torquata (Sw. ex Hedw.) Brid.	AM, AT	Wide	Neotropical		Cushion	X							Dioicous	X		X		Peralta *et al.* 8271
Phyllogoniaceae																		
Phyllogonium viride Brid.	AT	Wide	Africa, Neotropical		Pendant	X							Dioicous					Peralta *et al.* 8397
Pilotrichaceae																		
**Callicostella apophysata* (Hampe) A. Jaeger	CE, AT	Rare (GO, RJ, SP)	Endemic to Brazil		Mat		X		X				Monoicous	X		X		Peralta *et al.* 25479
**Callicostella martiana* (Hornsch.) A. Jaeger	CE, AT	Moderate	Endemic to Brazil	X	Mat				X				Monoicous	X		X		Peralta *et al.* 25491 p.p.
Callicostella merkelii (Hornsch.) A. Jaeger	AM, CE, AT	Wide	Neotropical		Mat		X						Monoicous	X		X		Peralta *et al.* 8515
Callicostella microcarpa Ångström	AM, AT	Moderate	Neotropical		Mat			X					Monoicous					Koga *et al.* 303 p.p.
Crossomitrium epiphyllum (Mitt.) Müll. Hal.	AT	Rare (BA, SP)	Neotropical		Mat	X				X			Dioicous				X	Koga *et al.* 272
Cyclodictyon albicans (Hedw.) Kuntze	CE, AT	Wide	Neotropical		Mat	X		X	X				Monoicous	X		X		Peralta *et al.* 8429
Cyclodictyon limbatum (Hampe) Kuntze	AT	Moderate	Neotropical		Mat				X				Monoicous	X		X		Peralta *et al.* 25522 p.p.
Cyclodictyon varians (Sull.) O. Kuntze	AM, CE, AT	Moderate	Neotropical		Mat				X				Monoicous					Peralta *et al.* 25378
**Lepidopilidium brevisetum* (Hampe) Broth.	AT	Moderate	Endemic to Brazil		Mat	X							Dioicous					Peralta *et al.* 25462
Lepidopilidium nitens (Hornsch.) Broth.	AT	Moderate	Neotropical		Mat	X		X	X				Dioicous	X		X	X	Peralta *et al.* 8423
**Lepidopilum caudicaule* (Müll. Hal.) Broth.	AT	Moderate	Endemic to Brazil		Mat	X							Monoicous					Peralta *et al.* 25473
Lepidopilum longifolium Hampe	AT	Rare (RJ, SP)	Neotropical		Mat	X			X				Monoicous	X		X	X	Peralta *et al.* 8197
Lepidopilum muelleri (Hampe) Mitt.	AT	Moderate	Neotropical		Mat					X			Monoicous	X		X		Koga *et al.* 54
Lepidopilum scabrisetum (Schwägr.) Steere	AM, CE, AT	Wide	Neotropical		Mat	X							Dioicous					Koga *et al.* 244 p.p.
**Lepidopilum subsubulatum* Geh. & Hampe	AT	Moderate	Endemic to Brazil		Mat	X							Dioicous	X		X		Peralta *et al.* 25526
Lepidopilum surinamense Müll. Hal.	AM, CE, AT	Wide	Neotropical		Mat	X							Monoicous					Oliveira *et al.* 22 p.p.
Pilotrichum evanescens (Müll. Hal.) Crosby	AM, CE, AT	Wide	Neotropical		Fan	X							Dioicous					Peralta *et al.* 26643 p.p.
Thamniopsis incurva (Hornsch.) W. R. Buck	AM, AT	Wide	Neotropical		Mat			X	X				Monoicous	X		X		Peralta *et al.* 8308
Thamniopsis langsdorffii (Hook.) W. R. Buck	AT	Moderate	Neotropical		Mat	X	X	X	X				Monoicous	X		X		Peralta *et al.* 8392
Thamniopsis undata (Hedw.) W. R. Buck	CE, AT	Moderate	Neotropical		Mat	X		X					Monoicous	X		X		Peralta *et al.* 8211 p.p.
Trachyxiphium guadalupense (Brid.) W. R. Buck	AT	Moderate	Neotropical		Mat				X				Dioicous/ Monoicous					Peralta *et al.* 25521 p.p.
Trachyxiphium saxicola (R. S. Williams) Vaz-Imbassahy & Costa	CE, AT	Moderate	Neotropical		Mat			X					Monoicous					Peralta *et al.* 26569 p.p.
Plagiomniaceae																		
Plagiomnium rhynchophorum (Hook. F.) T. J. Kop.	AM, CE, AT	Moderate	Cosmopolitan		Weft		X	X					Monoicous	X	X			Koga *et al.* 239

Table 1. Cont.

Species	Biome	Brazil	Worldwide	1st	Life Form	TT	SO	RO	DT	LE	HU	AR	Sexual System	FG	MG	S	AS	Voucher
Polytrichaceae																		
Pogonatum pensilvanicum (E. B. Bartram ex Hedw.) P. Beauv.	CE, AT	Wide	Neotropical		Turf	X							Dioicous	X	X	X		Peralta *et al.* 8446
Polytrichadelphus pseudopolytrichum (Raddi) G. L. Sm.	AT	Moderate	Neotropical		Turf	X							Dioicous					Peralta *et al.* 8204
**Polytrichum angustifolium* Mitt.	AT, PA	Moderate	Endemic to Brazil		Turf			X					Dioicous		X			Peralta *et al.* 8518
Polytrichum commune L. ex Hedw.	AM, CE, AT	Wide	Cosmopolitan		Turf		X	X					Dioicous					Peralta *et al.* 8178
Polyrichum juniperinum Willd. ex Hedw.	AM, CE, AT	Wide	Cosmopolitan		Turf		X	X	X				Dioicous	X		X		Peralta *et al.* 8226
Pottiaceae																		
Barbula indica (Hook.) Spreng.	AM, CA, CE, AT,PL	Wide	Sub cosmopolitan		Cushion		X	X					Dioicous					Peralta *et al.* 25563
Chenia leptophylla (Müll. Hal.) R. H. Zander	AT	Moderate	Afro, Neotropical		Turf			X					Dioicous	X				Peralta *et al.* 25568
Didymodon australasiae (Hook. & Grev.) R. H. Zander	AT	Rare (SP, PR, RS)	Cosmopolitan		Cushion			X					Dioicous					Peralta *et al.* 26648
Hymenostylium aurantiacum Mitt.	CE, AT	Moderate	Asia, Neotropical, Oceania		Turf			X					Dioicous					Amélio *et al.* 861
Hyophila involuta (Hook.) A. Jaeger	AM, CA, CE, AT, PA, PL	Wide	Cosmopolitan		Turf		X	X					Dioicous					Peralta *et al.* 26691 p.p.
Leptodontium araucarieti (Müll. Hal.) Paris	AT	Moderate	Brazil, Bolivia, Peru		Turf		X						Dioicous					Peralta *et al.* 26529
Tortella humilis (Hedw.) Jenn.	CA, CE, AT, PA, PL	Wide	Cosmopolitan		Cushion			X	X			X	Monoicous	X	X	X		Peralta *et al.* 8208
Weissia jamaicensis (Mitt.) Grout	CE, AT	Moderate	Neotropical		Cushion		X	X					Dioicous					Koga *et al.* 243
Prionodontaceae																		
Prionodon densus (Sw. ex Hedw.) Müll. Hal.	AT, PA	Moderate	Pantropical		Tail	X							Dioicous					Peralta *et al.* 8409
Pterobryaceae																		
Henicodium geniculatum (Mitt.) W. R. Buck	AM, CE, AT, PL	Wide	Neotropical		Tail	X							Dioicous					Koga *et al.* 292
Orthostichidium quadrangulare (Schwägr.) B. H. Allen & Magill	CE, AT	Moderate	Neotropical		Pendant	X							Dioicous					Peralta *et al.* 26674
Orthostichopsis praetermissa W. R. Buck	AM, CE, AT	Moderate	Neotropical		Pendant	X							Dioicous					Koga *et al.* 207
Orthostichopsis tenuis (A. Jaeger) Broth.	AT	Moderate	Brazil, Argentina		Pendant	X							Dioicous					Peralta *et al.* 8235
Orthostichopsis tortipilis (Müll. Hal.) Broth.	AM, AT	Wide	Neotropical		Pendant	X							Dioicous					Peralta *et al.* 8449
Pireella pohlii (Schwägr.) Cardot	AM, CE, AT	Wide	Neotropical, USA		Fan			X					Dioicous					Peralta *et al.* 26683
Spiridentopsis longissima (Raddi) Broth.	AT	Moderate	Neotropical		Pendant	X							Monoicous					Peralta *et al.* 8337
Pylaisiadelphaceae																		
Isopterygium tenerifolium Mitt.	AM, CE, AT	Wide	Neotropical		Weft	X	X						Monoicous	X		X		Peralta *et al.* 8425
Isopterygium tenerum (Sw.) Mitt.	AM, CA, CE, AT, PA, PL	Wide	Cosmopolitan		Mat	X			X				Monoicous	X		X		Peralta *et al.* 8305

Table 1. Cont.

Species	Biome	Brazil	Worldwide	1st	Life Form	TT	SO	RO	DT	LE	HU	AR	Sexual System	FG	MG	S	AS	Voucher
**Pylaisiadelpha brasiliensis* H. A. Crum	AM	Rare (SP)	Endemic to Brazil		Mat	X			X				Monoicous	X		X		Oliveira *et al.* 13
Pylaisiadelpha tenuirostris (Bruch & Schimp.) W. R. Buck	CE	Rare (MS)	Pantropical	X	Mat				X				Monoicous	X		X		Peralta *et al.* 8363
Wijkia flagellifera (Broth.) H. A. Crum	AT	Moderate	Neotropical		Mat	X		X					Dioicous				X	Peralta *et al.* 8472
Racopilaceae																		
Racopilum tomentosum (Hedw.) Brid.	AM, CE, AT, PA, PL	Moderate	Cosmopolitan		Mat	X	X						Monoicous	X	X	X		Koga *et al.* 244
Rhizogoniaceae																		
Pyrrhobryum spiniforme (Hedw.) Mitt.	AM, CE, AT, PA	Wide	Cosmopolitan		Turf	X		X	X				Monoicous					Peralta *et al.* 8242
Rutenbergiaceae																		
Pseudocryphaea domingensis (Spreng.) W. R. Buck	AM, CE, AT, PA	Wide	Neotropical		Tail	X							Dioicous				X	Peralta *et al.* 26679
Sematophyllaceae																		
Aptychopsis estrellae (Müll. Hal.) P. S. Câmara, W. R. Buck & Carv.-Silva	AM, CE, AT	Wide	Neotropical		Mat	X							Monoicous	X		X		Peralta *et al.* 8237
Brittonodoxa subpinnata (Brid.) W. R. Buck, P. E. A. S. Câmara & Carv.-Silva	AM, CA, CE, AT, PA	Wide	Pantropical		Mat	X	X	X	X				Monoicous	X		X		Peralta *et al.* 8470
Colobodontium vulpinum (Mont.) S. P. Churchill & W. R. Buck	AM, CE, AT	Wide	Neotropical		Mat			X					Monoicous	X		X		Peralta *et al.* 8479
Donnellia commutata (Müll. Hal.) W. R. Buck	AM, CE, AT, PL	Moderate	Neotropical		Mat	X							Monoicous	X		X		Peralta *et al.* 25544
**Donnellia lageniformis* (Müll. Hal.) W. R. Buck	CE, AT	Moderate	Endemic to Brazil		Mat	X							Monoicous	X	X	X		Oliveira *et al.* 22
Microcalpe subsimplex (Hedw.) W. R. Buck	AM, CE, AT, PA	Wide	Neotropical		Mat	X							Monoicous	X		X		Koga *et al.* 288
**Pterogoniopsis paulista* (W.R. Buck & Vital) Carv.-Silva *et al.*	AT	Rare (SP, PR)	Endemic to Brazil		Mat	X							Monoicous	X		X		Peralta *et al.* 25415
Sematophyllum adnatum (Michx.) Brid.	AM, CA, CE, AT	Wide	Neotropical		Mat	X	X	X					Monoicous	X		X		Peralta *et al.* 8159
Sematophyllum lithophilum (Hornsch.) Ångström	AT	Moderate	Neotropical		Mat			X					Monoicous					Koga *et al.* 309 p.p.
Sematophyllum subpiliferum (Broth.) Broth.	AT	Moderate	Afro, Neotropical		Mat				X				Monoicous					Peralta *et al.* 25339
Sematophyllum tequendamense (Hampe) Mitt.	AT	Rare (BA, RJ, SC, SP)	Neotropical		Mat				X				Monoicous					Koga *et al.* p.p. 65
Taxithelium planum (Brid.) Mitt.	AM, CE, AT, PL	Wide	Pantropical		Mat			X					Monoicous					Koga *et al.* 312
Taxithelium pluripunctatum (Renauld & Cardot) W. R. Buck	AM, AT	Moderate	Neotropical		Mat				X				Monoicous	X		X		Oliveira *et al.* 8
Trichosteleum sentosum (Sull.) A. Jaeger	AM, AT	Moderate	Neotropical		Mat				X				Monoicous	X		X		Koga *et al.* 273
**Trichosteleum sublaevigatum* Herzog	AT	Rare (SP)	Endemic to Brazil		Mat				X				Monoicous	X		X		Peralta *et al.* 25470
Vitalia galipensis (Müll. Hal.) P. E. A. S. Câmara, Carv.-Silva & W. R. Buck	AM, CE, AT	Wide	Neotropical		Mat		X	X					Monoicous	X		X		Koga *et al.* 214

Table 1. Cont.

Species	Biome	Brazil	Worldwide	1st	Life Form	TT	SO	RO	DT	LE	HU	AR	Sexual System	FG	MG	S	AS	Voucher
Sphagnaceae																		
Sphagnum recurvum P. Beauv.	CE, AT	Moderate	Cosmopolitan		Turf		X						Monoicous					Peralta *et al.* 25359 p.p.
Stereophyllaceae																		
Eulacophyllum cultelliforme (Sull.) W. R. Buck & Ireland	AM, CE, AT, PL	Wide	Neotropical		Mat			X					Monoicous					Peralta *et al.* 26664
Stereophyllum radiculosum (Hook.) Mitt.	AM, CE, AT, PL	Wide	Pantropical		Mat	X							Monoicous					Peralta *et al.* 26688 p.p.
Thuidiaceae																		
Pelekium involvens (Hedw.) A. Touw	AM, CE, AT, PL	Wide	Africa, Neotropical		Weft			X					Monoicous	X	X	X		Peralta *et al.* 26681
Pelekium minutulum (Hedw.) A. Touw	AM, CE, AT, PL	Wide	Neotropical		Weft			X					Monoicous					Koga *et al.* 226 p.p.
Pelekium muricatulum (Hampe) A. Touw	CE, AT	Moderate	Neotropical		Weft		X						Monoicous					Amélio *et al.* 874 p.p.
Pelekium schistocalyx (Müll. Hal.) A. Touw	AM, CE, AT, PL	Wide	Neotropical		Weft			X					Monoicous					Peralta *et al.* 26651 p.p.
Pelekium sparsum (Hook. f. & Wilson) Soares, A. E. R. & Câmara, P. E. A. S.	AT	Moderate	America, Oceania		Weft		X		X				Monoicous	X	X			Peralta *et al.* 8200
Thuidium assimile (Mitt.) A. Jaeger	AT	Rare (RJ, SP)	Cosmopolitan		Weft		X						Monoicous					Koga *et al.* 333
Thuidium tomentosum Schimp.	AM, CE, AT, PL	Wide	Neotropical		Weft			X					Dioicous					Peralta *et al.* 26633
Division Marchantiophyta																		
Aneuraceae																		
Aneura pinguis (L.) Dumort.	AT, PL	Wide	Sub cosmopolitan		Mat			X	X				Monoicous	X	X	X		Koga *et al.* 252
Riccardia chamedryfolia (With.) Grolle	CE, AT	Moderate	Sub cosmopolitan		Mat		X	X	X				Monoicous	X	X			Koga *et al.* 246
Riccardia digitiloba (Spruce ex Steph.) Pagán	AM, CE, AT, PL	Wide	Neotropical		Mat			X	X				Dioicous	X			X	Koga *et al.* 249
**Riccardia emarginata* (Steph.) Hell	AT	Rare (BA, MG, RJ, SP)	Endemic to Brazil		Dendroid		X						Monoicous	X	X			Peralta *et al.* 26565 p.p.
Riccardia fucoidea (Sw.) Schiffn.	AT	Rare (BA, ES, RJ, SP)	Neotropical		Dendroid			X					Dioicous/ Monoicous		X			Peralta *et al.* 26561
Riccardia glaziovii (Spruce) Meenks	AM, AT	Moderate	Brazil, Bolivia, Peru		Dendroid		X						Dioicous	X				Peralta *et al.* 26569 p.p.
**Riccardia regnellii* (Ángstr.) K. G. Hell	CE, AT	Wide	Endemic to Brazil		Dendroid				X				Monoicous	X	X	X		Amélio *et al.* 833
Balantiopsida																		
Isotachis aubertii (Schwägr.) Mitt.	AT	Moderate	Africa, Neotropical		Weft		X						Dioicous	X		X		Peralta *et al.* 8149
Neesioscyphus homophyllus (Nees) Grolle	AT	Rare (BA, MG, RJ, SP)	Brazil, Argentina		Weft		X						Dioicous	X		X		Peralta *et al.* 8435

Table 1. Cont.

Species	Biome	Brazil	Worldwide	1st	Life Form	TT	SO	RO	DT	LE	HU	AR	Sexual System	FG	MG	S	AS	Voucher
Calypogeiaceae																		
Calypogeia lechleri (Steph.) Steph.	AT	Rare (BA, RJ, SP, RS)	Neotropical		Mat		X						Dioicous					Peralta *et al.* 26577
Calypogeia peruviana Nees & Mont.	AM, CE, AT	Wide	Neotropical		Mat	X	X	X					Dioicous					Peralta *et al.* 8316
Calypogeia uncinulatula Herzog	CE, AT	Rare (DF, MG, RJ, SP)	Neotropical		Mat				X				Dioicous					Koga *et al.* 305
Mnioloma cyclostipa (Spruce) R. M. Schust.	AT	Rare (MG, RJ, PR)	Neotropical	X	Mat		X						Dioicous					Peralta *et al.* 26631
Cephaloziaceae																		
Odontoschisma denudatum (Nees) Dumort.	AM, CE, AT	Moderate	Sub cosmopolitan		Weft		X						Dioicous				X	Peralta *et al.* 8424
Cephaloziellaceae																		
**Fuscocephaloziopsis crassifolia* (Lindenb. & Gottsche) Váňa & L. Söderstr.	AT	Moderate	Endemic to Brazil		Weft	X							Monoicous					Peralta *et al.* 26603
Kymatocalyx dominicensis (Spruce) Vána	AT	Moderate	Madagascar, Neotropical		Weft			X					Monoicous					Peralta *et al.* 8401
Dumortieraceae																		
Dumortiera hirsuta (Sw.) Nees	AM, CE, AT, PL	Wide	Sub cosmopolitan		Mat		X	X					Monoicous	X	X			Koga *et al.* 233
Frullaniaceae																		
Frullania apiculata (Reinw., Blume & Nees) Dumort.	AM, CE, AT	Wide	Pantropical		Pendant	X							Monoicous					Oliveira *et al.* 45 p.p.
Frullania atrata (Sw.) Nees	AM, AT	Wide	Neotropical		Pendant	X			X	X			Dioicous	X				Koga *et al.* 111
Frullania brasiliensis Raddi	AM, AT	Wide	Neotropical		Pendant	X							Dioicous	X				Peralta *et al.* 8202
Frullania caulisequa (Nees) Nees	AM, CA, CE, AT, PA	Wide	Neotropical		Weft	X							Monoicous	X	X			Peralta *et al.* 8393
Frullania ericoides (Nees) Mont.	AM, CA, CE, AT, PA, PL	Wide	Pantropical		Weft	X							Dioicous	X		X		Peralta *et al.* 26676 p.p.
Frullania flexicaulis Spruce	AT	Rare (SP, SC)	Neotropical		Mat	X			X				Dioicous	X				Peralta *et al.* 25345
Frullania involuta Hampe ex Steph.	AT	Rare (MA, PE, RJ, SP)	Neotropical		Pendant	X							Dioicous	X				Peralta *et al.* 26622
Frullania kunzei (Lehm. & Lindenb.) Lehm. & Lindenb.	AM, CE, AT, PL	Wide	Neotropical		Weft	X							Monoicous	X	X	X		Peralta *et al.* 25353 p.p.
Frullania obscura (Sw.) Dumort.	CE, AT	Wide	Pantropical		Weft	X		X					Monoicous	X				Peralta *et al.* 8501
Frullania riojaneirensis (Raddi) Spruce	AM, CE, AT, PL	Wide	Pantropical		Weft	X		X	X				Monoicous	X				Koga *et al.* 114
Frullania setigera Steph.	AT	Moderate	Neotropical		Mat	X							Dioicous	X				Peralta *et al.* 8238
**Frullania vitalii* Yuzawa & Hatt.	CE, AT	Moderate	Endemic to Brazil		Mat	X							Monoicous	X	X	X		Peralta *et al.* 25572
Geocalycaceae																		
**Saccogynidium caldense* (Angstr.) Grolle	AT	Moderate	Endemic to Brazil		Weft	X	X	X	X				Dioicous					Peralta *et al.* 8346
Herbertaceae																		
Herbertus divergens (Steph.) Herzog	AT, CE	Wide	Neotropical		Turf				X				Dioicous					Koga *et al.* 322

Table 1. Cont.

Species	Biome	Brazil	Worldwide	1st	Life Form	TT	SO	RO	DT	LE	HU	AR	Sexual System	FG	MG	S	AS	Voucher
Herbertus juniperoideus (Sw.) Grolle	AM, AT	Wide	Neotropical		Turf				X				Dioicous					Peralta *et al.* 8260
Jamesoniellaceae																		
Syzygiella concreta (Gottsche) Spruce	AT	Rare (MG, SP)	Neotropical		Weft	X							Dioicous					Peralta *et al.* 8485
Lejeuneaceae																		
Acanthocoleus aberrans (Lindenb. & Gottsche) Kruijt	CE, AT, PA	Wide	Africa, Neotropical		Mat	X							Monoicous	X	X	X		Peralta *et al.* 8214 p.p.
Anoplolejeunea conferta (C. F. W. Meissn.) A. Evans	AM, AT	Wide	Neotropical		Mat	X			X				Monoicous	X		X		Peralta *et al.* 8292
Archilejeunea ludoviciana (De Not. ex Lehm.) Gradst. & Geissler	AM, MA	Rare (AM, PR, SP)	Neotropical		Mat	X							Monoicous	X	X			Peralta *et al.* 26643
Bryopteris diffusa (Sw.) Nees	AM, CE, AT	Wide	Neotropical		Pendant	X			X				Dioicous	X				Peralta *et al.* 8367
Bryopteris filicina (Sw.) Nees	AM, CE, AT, PL	Wide	Neotropical		Pendant	X			X				Dioicous		X			Peralta *et al.* 8264
**Ceratolejeunea atlantica* Alvarenga & Ilk.-Borg.	AT	Rare (AL, BA, MG, SP)	Endemic to Brazil		Mat	X							Dioicous		X			Peralta *et al.* 8394
Ceratolejeunea ceratantha (Nees & Mont.) Steph.	AM, AT	Moderate	Brazil, Cuba, French Guiana		Mat	X							Dioicous					Peralta *et al.* 26541 p.p.
Ceratolejeunea cornuta (Lindenb.) Schiffn.	AM, AT	Wide	Neotropical		Mat	X		X					Dioicous/ Monoicous	X				Koga *et al.* 314
Ceratolejeunea fallax (Lehm. & Lindenb.) Bonner	AM, AT	Moderate	Neotropical		Mat	X		X					Dioicous		X			Peralta *et al.* 8256
Ceratolejeunea laetefusca (Austin) R. M. Schust.	AM, CE, AT	Wide	Neotropical		Mat	X							Dioicous					Peralta *et al.* 25394 p.p.
**Ceratolejeunea temnantha* (Spruce) Reiner-Drehwald	AM	Moderate	Endemic to Brazil		Mat					X			Monoicous	X	X			Peralta *et al.* 25430
Cheilolejeunea acutangula (Nees) Grolle	AM, CE, AT	Wide	Neotropical		Mat	X							Monoicous					Peralta *et al.* 8484
Cheilolejeunea clausa (Nees & Mont.)	AM, CE, AT, PL	Wide	Neotropical		Mat	X							Monoicous	X	X			Koga *et al.* 300
Cheilolejeunea discoidea (Lehm. & Lindenb.) Kachroo & R. M. Schust.	CE, AT, PL	Wide	Neotropical		Mat	X							Monoicous	X	X	X		Peralta *et al.* 26676
Cheilolejeunea filiformis (Sw.) W. Ye, R. L. Zhu & Gradst.	AT	Moderate	Neotropical		Weft	X	X	X	X	X			Dioicous	X	X			Peralta *et al.* 8190
Cheilolejeunea holostipa (Spruce) Grolle & R.-L. Zhu	AM, AT	Moderate	Neotropical		Mat			X					Dioicous					Peralta *et al.* 8247
Cheilolejeunea insecta Grolle & Gradst.	AT	Rare (MG, RJ, SP)	Brazil, Bolivia		Mat	X							Dioicous					Peralta *et al.* 25348 p.p.
Cheilolejeunea rigidula (Nees ex Mont.) R. M. Schust.	AM, CA, CE, AT, PL	Wide	Pantropical		Mat	X							Dioicous		X			Peralta *et al.* 8280
Cheilolejeunea unciloba (Lindenb.) Malombe	AT, CE	Moderate	Pantropical		Mat	X		X					Dioicous					Peralta *et al.* 8246
Cheilolejeunea xanthocarpa (Lehm. & Lindenb.) Malombe	AT, CE	Moderate	Pantropical		Mat	X							Monoicous					Peralta *et al.* 8144
**Cololejeunea contractiloba* A. Evans	AM	Rare (BA, PA, RJ, SP)	Endemic to Brazil		Mat				X	X			Monoicous	X	X			Peralta *et al.* 26684
**Cololejeunea diaphana* A. Evans	AM, CE, AT	Moderate	Endemic to Brazil		Mat	X							Monoicous	X				Peralta *et al.* 25376 p.p.

Table 1. Cont.

Species	Biome	Brazil	Worldwide	1st	Life Form	TT	SO	RO	DT	LE	HU	AR	Sexual System	FG	MG	S	AS	Voucher
Cololejeunea lanciloba Steph.	AT	Rare (AL, PE)	Africa, Asia, Australia, Brazil	X	Mat					X			Monoicous					Peralta *et al.* 26540
Cololejeunea obliqua (Nees & Mont.) Schiffn.	AM, AT	Wide	Neotropical		Mat					X			Monoicous	X	X	X		Peralta *et al.* 26673
**Cololejeunea papilliloba* (Steph). Steph.	AT, PA	Rare (MG, SP, RS)	Endemic to Brazil		Mat					X			Monoicous				X	Peralta *et al.* 26540
Cololejeunea verwimpii P. Tixier	AT, PL	Moderate	Neotropical		Mat					X			Monoicous	X	X	X		Koga *et al.* 220
Colura calyptrifolia (Hook.) Dumort.	AT	Rare (MG, RJ)	Sub cosmopolitan		Mat	X							Monoicous	X	X	X		Peralta *et al.* 25427
Colura tenuicornis (A. Evans) Steph.	AT	Moderate	Pantropical		Mat					X			Dioicous	X		X		Peralta *et al.* 26595
Colura tortifolia (Nees & Mont.) Steph.	AM, AT	Rare (AC, PA, PE, SP)	Neotropical		Mat					X			Dioicous	X		X		Koga *et al.* 329
Cyclolejeunea luteola (Spruce) Grolle	AM, CE, AT	Moderate	Neotropical		Mat	X							Dioicous				X	Peralta *et al.* 25531
Dibrachiella parviflora (Nees) X. Q. Shi, R. L. Zhu & Gradst.	AM, AT	Moderate	Neotropical		Mat					X			Monoicous	X	X			Koga *et al.* 227
Diplasiolejeunea brunnea Steph.	AM, CE, AT	Wide	Neotropical		Mat					X			Dioicous	X		X		Peralta *et al.* 8378
Diplasiolejeunea cavifolia Steph.	AT	Moderate	Pantropical		Mat	X				X			Monoicous					Peralta *et al.* 25361 p.p.
Diplasiolejeunea pellucida (C. F. W. Meissn. ex Spreng)	AM, AT	Wide	Neotropical		Mat					X			Monoicous	X	X			Peralta *et al.* 25463
Diplasiolejeunea rudolphiana Steph.	AM, AT	Wide	Pantropical		Mat					X			Monoicous	X				Peralta *et al.* 25487 p.p.
Drepanolejeunea anoplantha (Spruce) Steph.	AM, AT	Moderate	Neotropical		Mat	X							Dioicous		X			Peralta *et al.* 8368
Drepanolejeunea campanulata (Spruce) Steph.	CA, AT	Moderate	Neotropical		Mat					X			Dioicous		X			Peralta *et al.* 8382
Drepanolejeunea granatensis (J. B. Jack & Steph.) Bischl.	AT	Rare (MG, RJ, SP)	Brazil, Colombia		Mat	X							Dioicous					Peralta *et al.* 8232 p.p.
Drepanolejeunea lichenicola (Spruce) Steph.	AT	Rare (BA, RJ, SP, PR)	Neotropical		Mat	X							Dioicous					Peralta *et al.* 25349 p.p.
Drepanolejeunea mosenii (Steph.) Bischl.	AM, AT	Wide	Neotropical		Mat				X	X			Dioicous		X			Peralta *et al.* 8281
Frullanoides densifolia Raddi	AM, CE, AT	Moderate	Neotropical		Mat	X			X				Dioicous	X		X		Peralta *et al.* 8514
Frullanoides tristis (Steph.) van Slageren	AT	Moderate	Pantropical		Mat	X							Monoicous	X				Peralta *et al.* 25560
Harpalejeunea molleri (Steph.) Grolle	AT, CE	Moderate	Neotropical, Europe		Mat	X							Dioicous	X		X		Peralta *et al.* 8216
Harpalejeunea oxyphylla (Nees & Mont.) Steph.	AM, AT	Moderate	Neotropical		Mat	X							Dioicous	X				Peralta *et al.* 25476
**Harpalejeunea schiffneri* S. W. Arnell	CE, AT, PL	Moderate	Endemic to Brazil		Mat	X							Monoicous	X	X	X		Peralta *et al.* 26675
Harpalejeunea stricta (Lindenb. & Gottsche) Steph.	AM, AT	Moderate	Brazil, Mexico, USA		Mat	X							Dioicous	X				Peralta *et al.* 25511
Harpalejeunea subacuta A. Evans	CA, AT	Rare (BA, MG, SP)	Neotropical		Mat	X			X				Dioicous	X		X		Peralta *et al.* 8212
Lejeunea adpressa Nees	AM, AT	Wide	Asia, Neotropical		Mat					X			Monoicous	X	X	X		Koga *et al.* 228
Lejeunea aphanes Spruce	AT	Rare (BA, CE)	Neotropical		Mat	X				X			Monoicous	X	X	X		Peralta *et al.* 25409
Lejeunea asthenica Spruce	AM, AT	Rare (AM, BA, SP)	Neotropical		Mat					X			Monoicous	X				Peralta *et al.* 26659
Lejeunea caulicalyx (Steph.) E. Reiner & Goda	AM, CE, AT, PL	Wide	Neotropical		Mat	X							Monoicous	X	X	X		Peralta *et al.* 8463

Table 1. Cont.

Species	Biome	Brazil	Worldwide	1st	Life Form	TT	SO	RO	DT	LE	HU	AR	Sexual System	FG	MG	S	AS	Voucher
Lejeunea cerina (Lehm. & Lindenb.) Gottsche *et al.*	AM, AT	Moderate	Neotropical		Mat				X				Dioicous					Peralta *et al.* 8294 p.p.
Lejeunea cladogyna A. Evans	AT	Moderate	Brazil, Mexico, USA		Mat	X		X		X			Monoicous	X	X	X		Peralta *et al.* 25428
**Lejeunea cristulata* (Steph.) E. Reiner & Goda	AT	Moderate	Endemic to Brazil		Mat	X							Monoicous	X	X	X		Peralta *et al.* 25394
**Lejeunea cristuliflora* (Gottsche ex Steph.) E. Reiner & Goda	AT	Moderate	Endemic to Brazil		Mat				X	X			Monoicous	X				Oliveira *et al.* 58
**Lejeunea deplanata* Nees	CE, AT	Moderate	Endemic to Brazil		Mat	X				X			Monoicous					Peralta *et al.* 25403
Lejeunea elliottii Spruce	AT	Rare (BA)	Neotropical		Mat				X				Monoicous	X	X	X		Peralta *et al.* 26585
Lejeunea flagellifera C. J. Bastos, M. E. Reiner & Schäf.-Verw.	AT	Rare (BA, ES, SP)	Endemic to Brazil		Mat	X							Monoicous				X	Peralta *et al.* 25556 p.p.
Lejeunea flava (Sw.) Nees	AM, CA, CE, AT, PA, PL	Wide	Pantropical		Mat	X				X			Monoicous	X	X	X		Peralta *et al.* 8496
Lejeunea grossitexta (Steph.) M. E. Reiner & Goda	CA, AT	Moderate	Neotropical		Mat	X				X			Monoicous	X				Peralta *et al.* 8266
Lejeunea herminieri (Steph.) R. L. Zhu	CA	Rare (BA)	Neotropical		Mat	X							Monoicous					Peralta *et al.* 8195
Lejeunea laeta (Lehm. & Lindenb.) Gottsche	AT	Moderate	Neotropical		Mat					X			Monoicous	X	X			Peralta *et al.* 8355
Lejeunea laetevirens Nees & Mont.	AM, CA, CE, AT, PL	Wide	Cosmopolitan		Mat			X					Dioicous	X				Peralta *et al.* 25405 p.p.
Lejeunea lusoria (Lindenb. & Gottsche) Steph.	AT, CE	Moderate	Neotropical		Mat				X	X			Monoicous	X	X			Koga *et al.* 60
Lejeunea minutiloba A. Evans	AT	Rare (BA, MS, SP)	Neotropical		Mat					X			Dioicous	X	X	X		Koga *et al.* 271
Lejeunea obtusangula Spruce	AM, AT	Moderate	Neotropical		Mat	X	X			X			Monoicous	X	X	X		Koga *et al.* 50
**Lejeunea oligoclada* Spruce	AT	Wide	Endemic to Brazil		Mat	X							Dioicous		X			Peralta *et al.* 26567
Lejeunea pterigonia (Lehm. & Lindenb.) Mont.	AM, AT	Moderate	Neotropical		Mat		X	X		X	X		Monoicous					Peralta *et al.* 8150
Lejeunea puiggariana Steph.	AT, PL	Moderate	Neotropical		Mat	X							Dioicous	X		X		Peralta *et al.* 8436
Lejeunea raddiana Lindenb.	CA, AT	Moderate	Brazil, Bolivia		Mat			X		X			Dioicous	X				Peralta *et al.* 26554
Lejeunea subplana (Steph.) C. Bastos	AT	Rare (SP)	Endemic to Brazil		Mat	X				X			Monoicous	X	X	X		Peralta *et al.* 25527
Lejeunea terricola Spruce	AT	Rare (BA)	Neotropical		Mat	X				X			Monoicous	X		X		Peralta *et al.* 26645
Lepidolejeunea cuspidata (Gottsche) Heinrichs & Schäf.-Verw.	AT	Rare	Neotropical		Mat	X				X			Monoicous				X	Koga *et al.* 193
Lepidolejeunea involuta (Gottsche) Grolle	AM, AT	Wide	Pantropical		Mat					X			Dioicous				X	Peralta *et al.* 25476 p.p.
Leptolejeunea diversilobulata Bischl.	AT	Moderate	Brazil, Cuba, Peru		Mat					X			Dioicous	X	X			Peralta *et al.* 8320
Leptolejeunea elliptica (Lehm. & Lindenb.) Schiffn.	AM, CA, CE, AT	Wide	Neotropical		Mat					X			Dioicous/ Monoicous		X			Peralta *et al.* 8295
Leptolejeunea exocellata (Spruce) A. Evans	AM, CE, AT, PL	Wide	Neotropical		Mat					X			Monoicous					Peralta *et al.* 26534
Leptolejeunea maculata (Mitt.) Schiffn.	AM, AT	Rare (AM, BA, RJ)	Pantropical	X	Mat					X			Dioicous					Koga *et al.* 329 p.p.

Table 1. Cont.

Species	Biome	Brazil	Worldwide	1st	Life Form	TT	SO	RO	DT	LE	HU	AR	Sexual System	FG	MG	S	AS	Voucher
Lopholejeunea nigricans (Lindenb.) Schiffn.	AM, CE, AT, PL	Wide	Pantropical		Mat	X							Dioicous/ Monoicous	X				Peralta *et al.* 8236
Marchesinia bongardiana (Lehm. & Lindb.) Trevis.	AT	Rare (BA, RJ, PR, MG)	Neotropical	X	Mat		X	X	X	X			Dioicous		X			Peralta *et al.* 8410
Marchesinia brachiata (Sw.) Schiffn.	AM, CE, AT	Wide	Neotropical		Mat				X				Dioicous/ Monoicous					Koga *et al.* 232
Metalejeunea cucullata (Reinw., Blume & Nees) Grolle	AT	Rare (BA, RJ, SP)	Neotropical		Mat	X							Monoicous	X				Peralta *et al.* 8254
Microlejeunea bullata (Taylor) Steph.	AM, CA, CE, AT, PA, PL	Wide	Neotropical		Mat					X			Dioicous					Peralta *et al.* 25349 p.p.
Microlejeunea cystifera Herzog	AT	Rare (BA, SP)	Brazil, French Guiana		Mat					X			Dioicous					Peralta *et al.* 25562
Microlejeunea globosa (Spruce) Steph.	AT	Moderate	Neotropical		Mat	X				X			Dioicous	X				Peralta *et al.* 8340
Neurolejeunea breutelii (Gottsche) A. Evans	AT	Moderate	Neotropical		Mat			X					Dioicous/ Monoicous	X				Peralta *et al.* 8245
Odontolejeunea lunulata (F. Weber) Schiffn.	AM, CE, AT	Wide	Pantropical		Mat	X				X			Monoicous	X	X	X		Peralta *et al.* 8372
Otigoniolejeunea huctumalcensis (Lindenb. & Gottsche) Y. M. Wei, R. L. Zhu & Gradst.	AM, AT	Moderate	Neotropical		Mat	X							Monoicous				X	Peralta *et al.* 25531
Prionolejeunea aemula (Gottsche) A. Evans	AM, CE, AT	Moderate	Neotropical		Mat	X		X					Monoicous		X			Peralta *et al.* 25379
Prionolejeunea denticulata (F. Weber) Schiffn.	AM, AT	Moderate	Endemic to Brazil		Mat			X					Monoicous					Koga *et al.* 310 p.p.
Prionolejeunea galliotii Steph.	AT, CE	Rare (BA)	Neotropical	X	Mat			X					Monoicous	X	X			Koga *et al.* 307
Pycnolejeunea densistipula (Lehm. & Lindenb.) Steph.	AT	Rare (BA, RJ, SP, SC)	Neotropical		Mat	X							Dioicous	X				Koga *et al.* 301
Rectolejeunea emarginuliflora (Gott. ex Schiffn.) Evans	AT	Rare (BA, SP)	Neotropical		Mat	X							Dioicous				X	Peralta *et al.* 26644
**Rectolejeunea versifolia* (Schiffn.) L. Söderstr. & A. Hagborg	AT	Wide	Endemic to Brazil		Mat	X							Dioicous/ Monoicous				X	Peralta *et al.* 26663
Stictolejeunea squamata (Willd. ex Weber) Schiffn.	AM, AT	Wide	Neotropical		Mat			X					Dioicous					Peralta *et al.* 26666
Vitalianthus aphanellus (Spruce) Bechteler, G.E. Lee, Schäf.-Verw. & Heinrichs	AM, AT	Rare (AM, AL, BA, SP)	Neotropical		Mat				X				Dioicous		X			Peralta *et al.* 25409 p.p.
**Vitalianthus bischlerianus* (K. C. Pôrto & Grolle) R. M. Schust. & Giancotti	AT	Moderate	Endemic to Brazil		Mat	X							Monoicous	X				Peralta *et al.* 25370
Xylolejeunea crenata (Nees & Mont.) X.-L. He & Grolle	AM, AT	Wide	Neotropical		Mat				X				Monoicous	X	X			Koga *et al.* 303
Lepidoziaceae																		
Bazzania aurescens Spruce	AM, CE, AT	Moderate	Neotropical		Weft		X	X					Dioicous	X			X	Peralta *et al.* 8166
Bazzania cuneistipula (Gottsche & Lindenb.) Trevis.	AT	Rare (MG, RJ, SP)	Neotropical		Weft			X					Dioicous				X	Peralta *et al.* 26576 p.p.
Bazzania gracilis (Hampe & Gottsche) Steph.	AM, AT	Moderate	Neotropical		Weft	X							Dioicous				X	Peralta *et al.* 25393
**Bazzania heterostipa* (Steph.) Fulford	AT	Moderate	Endemic to Brazil		Weft	X			X				Dioicous				X	Peralta *et al.* 8494
Bazzania hookeri (Lindenb.) Trevis.	AM, AT	Wide	Neotropical		Weft	X		X	X				Dioicous				X	Peralta *et al.* 8243

Table 1. Cont.

Species	Biome	Brazil	Worldwide	1st	Life Form	TT	SO	RO	DT	LE	HU	AR	Sexual System	FG	MG	S	AS	Voucher
Bazzania longistipula (Lindenb.) Trevis.	AT	Rare (MG, RJ, SP, PR)	Neotropical		Weft	X		X					Dioicous				X	Peralta *et al.* 8224
Bazzania phyllobola Spruce	AM, AT	Moderate	Neotropical		Weft			X					Dioicous				X	Peralta *et al.* 26575
Bazzania stolonifera (Sw.) Trevis.	CE, AT	Moderate	Neotropical		Weft	X							Dioicous				X	Peralta *et al.* 8345
Bazzania taleana (Gottsche) Fulford	AT	Rare (ES, RJ, SP, SC)	Neotropical		Weft	X							Dioicous				X	Peralta *et al.* 8146
Kurzia capillaris (Sw.) Grolle	AM, CE, AT	Wide	Africa, Neotropical		Weft	X							Dioicous					Peralta *et al.* 26553
Lepidozia brasiliensis Steph.	AT	Moderate	Neotropical		Weft	X		X					Dioicous					Peralta *et al.* 26609
Lepidozia cupressina (Sw.) Lindenb.	AT	Rare (BA, PE, RJ, SP)	Africa, Europe, Neotropical		Weft				X				Dioicous					Peralta *et al.* 8329 p.p.
Lepidozia inaequalis (Lehm. & Lindenb.) Lehm. & Lindenb.	AT	Moderate	Neotropical		Weft	X			X				Dioicous					Peralta *et al.* 25512
Telaranea nematodes (Gottsche ex Austin) M. A. Howe	AM, CE, AT	Wide	Pantropical		Weft		X		X		X		Monoicous	X				Peralta *et al.* 8417
Lophocoleaceae																		
Chiloscyphus leptanthus (Hook. f. & Taylor) J. J. Engel & R. M. Schust.	AT	Rare (PA, MG, SP, RS)	South America		Weft			X					Dioicous					Koga *et al.* 261 p.p.
Chiloscyphus mandonii (Steph.) J. J. Engel & R. M. Schust.	AT	Rare	Neotropical		Weft		X		X				Dioicous					Peralta *et al.* 8452
Chiloscyphus martianus (Nees) J. J. Engel & R. M. Schust.	AM, CE, AT, PL	Wide	Africa, Neotropical		Weft	X	X	X	X				Monoicous	X	X			Peralta *et al.* 8307
Chiloscyphus muricatus (Lehm.) J. J. Engel & R. M. Schust.	AT	Moderate	America, Africa, Oceania		Mat	X			X				Monoicous	X	X			Peralta *et al.* 8289
Lophocolea bidentata (L.) Dumort.	AM, CE, AT	Wide	Sub cosmopolitan		Weft				X				Dioicous/ Monoicous					Peralta *et al.* 8468
Lophocolea heterophylla (Schrad.) Dumort.	AT, CE	Rare (BA, GO,SP)	Sub cosmopolitan		Weft						X		Dioicous					Peralta *et al.* 25552 p.p.
Lophocolea trapezoidea Mont.	AT	Rare (MG, RJ, RR, SP)	Neotropical		Weft		X						Dioicous					Peralta *et al.* 26620
Marchantiaceae																		
Marchantia berteroana Lehm. & Lindenb.	AT	Rare (MG, RJ, RS)	America, Africa, Oceania	X	Mat		X						Dioicous		X			Peralta *et al.* 25346
Marchantia chenopoda L.	AM, CE, AT, PL	Wide	Africa, Neotropical		Mat			X					Dioicous				X	Koga *et al.* 262
Marchantia papillata Raddi	AM, CE, AT, PL	Moderate	Pantropical		Mat		X						Dioicous				X	Peralta *et al.* 8506
Metzgeriaceae																		
Metzgeria albinea Spruce	CE, AT	Wide	Pantropical		Mat	X			X	X			Dioicous	X		X	X	Peralta *et al.* 8463

Table 1. Cont.

Species	Biome	Brazil	Worldwide	1st	Life Form	TT	SO	RO	DT	LE	HU	AR	Sexual System	FG	MG	S	AS	Voucher
Metzgeria ciliata Raddi	AT	Wide	Neotropical		Mat	X							Dioicous				X	Peralta *et al.* 8252
Metzgeria conjugata Lindb.	AT	Moderate	Sub cosmopolitan		Mat	X				X			Dioicous		X			Peralta *et al.* 8353
Metzgeria dichotoma (Sw.) Nees	AT, CE	Moderate	Neotropical		Mat	X							Dioicous	X	X	X		Peralta *et al.* 8379
Metzgeria fruticola Spruce	AT	Moderate	Neotropical	X	Mat	X		X					Dioicous	X				Peralta *et al.* 25405
Metzgeria furcata (L.) Dumort	AM, CE, AT	Wide	Sub cosmopolitan		Mat	X			X				Dioicous		X			Koga *et al.* 70
Metzgeria hegewaldii Kuwah.	AT	Rare (SP, RS)	Neotropical		Mat	X			X	X			Dioicous		X			Koga *et al.* 59
Monocleaceae																		
Monoclea gottschei Lindb.	AM, AT, PA	Moderate	Neotropical		Mat		X	X					Dioicous					Peralta *et al.* 25401
Pallaviciniaceae																		
Pallavicinia lyellii (Hook. f.) S. F. Gray	AM, CE, AT,PL	Wide	Sub cosmopolitan		Dendroid		X						Dioicous	X				Koga *et al.* 248
Symphyogyna aspera Steph.	AM, CE, AT, PL	Wide	Neotropical		Dendroid		X		X				Dioicous	X				Peralta *et al.* 8462
Symphyogyna brasiliensis (Nees) Nees & Mont.	AM, CE, AT	Wide	Neotropical		Dendroid	X	X		X				Dioicous	X	X			Peralta *et al.* 8199
Symphyogyna brongniartii Mont.	AM, AT	Moderate	Neotropical		Dendroid		X		X				Dioicous					Peralta *et al.* 25478
Symphyogyna podophylla (Thunb.) Mont. & Nees	AT	Moderate	Africa, Neotropical		Dendroid		X						Dioicous	X				Peralta *et al.* 8506
Pelliaceae																		
Noteroclada confluens Taylor ex Hook. & Wilson	CE, AT	Moderate	Neotropical		Mat		X						Monoicous	X	X	X		Peralta *et al.* 8451
Plagiochilaceae																		
Plagiochila adianthoides (Sw.) Lindenb.	CE, AT	Moderate	Neotropical		Tail	X		X					Dioicous		X			Peralta *et al.* 8164
Plagiochila aerea Taylor	AT	Moderate	Neotropical		Tail	X			X				Dioicous				X	Peralta *et al.* 8405
Plagiochila bifaria (Sw.) Lindenb.	AM, AT	Moderate	Neotropical		Tail	X		X					Dioicous					Peralta *et al.* 8182
Plagiochila corrugata (Nees) Nees & Mont.	AM, CE, AT	Wide	Neotropical		Tail	X		X					Dioicous				X	Peralta *et al.* 8517
Plagiochila crispabilis Lindenb.	AT	Rare (MG, RJ, SC, SP)	Neotropical		Tail	X		X	X				Dioicous	X	X			Peralta *et al.* 8384
Plagiochila cristata (Sw.) Lindenb.	AM, AT	Moderate	Neotropical		Tail	X		X	X				Dioicous		X			Peralta *et al.* 8375
Plagiochila exigua (Taylor) Taylor	AT	Rare (BA, MG, RJ,SP)	Africa, Neotropical		Tail			X					Dioicous				X	Peralta *et al.* 8225
Plagiochila gymnocalycina (Lehm. & Lindenb.) Lindenb.	AT	Moderate	Neotropical		Tail	X							Dioicous				X	Koga *et al.* 28
Plagiochila laetevirens Lindenb.	AT	Rare (AC, MT, PA, SP)	Neotropical		Tail	X							Dioicous	X		X		Peralta *et al.* 25520
Plagiochila macrostachya Lindenb.	AM, AT	Moderate	Neotropical		Tail	X							Dioicous					Peralta *et al.* 8428
Plagiochila patula (Sw.) Lindenb.	AM, AT	Moderate	Neotropical		Tail	X			X				Dioicous		X			Peralta *et al.* 8321
Plagiochila punctata (Taylor) Taylor	AT	Rare	Sub cosmopolitan	X	Tail	X		X					Dioicous				X	Peralta *et al.* 8162
Plagiochila raddiana Lindenb.	AM, CE, AT	Wide	Neotropical		Tail	X							Dioicous	X				Peralta *et al.* 8422
Plagiochila rutilans Lindenb.	AM, CE, AT	Wide	Neotropical		Tail	X							Dioicous	X				Peralta *et al.* 25371
Plagiochila simplex (Sw.) Lindenb.	AM, CE, AT	Wide	Neotropical		Tail	X							Dioicous	X				Peralta *et al.* 8314
Plagiochila subbindentata Taylor	AT	Moderate	Neotropical		Tail	X		X	X				Dioicous	X		X		Peralta *et al.* 8244

Table 1. Cont.

Species	Biome	Brazil	Worldwide	1st	Life Form	TT	SO	RO	DT	LE	HU	AR	Sexual System	FG	MG	S	AS	Voucher
Plagiochila subplana Lindenb.	AM, AT	Wide	Neotropical		Tail			X	X				Dioicous	X	X			Koga *et al.* 80
Porellaceae																		
Porella brasiliensis (Raddi) Schiffn.	CE, AT	Moderate	Neotropical		Pendant	X		X					Dioicous		X			Koga *et al.* 294
Radulaceae																		
**Radula brasilica* K. Yamada	AT	Rare (SP, RJ)	Endemic to Brazil		Mat	X							Dioicous		X			Peralta *et al.* 8263
Radula complanata (L.) Dumort.	AT, CE	Wide	Sub cosmopolitan		Mat	X	X						Dioicous	X				Peralta *et al.* 8400
Radula fendleri Gottsche ex Steph.	AT	Moderate	Neotropical		Mat				X				Dioicous				X	Peralta *et al.* 8259
Radula javanica Gottsche	AM, CE, AT, PL	Wide	Pantropical		Mat	X	X	X					Dioicous	X		X		Peralta *et al.* 8373
Radula ligula Steph.	AT	Moderate	Brazil, Argentina		Mat	X							Dioicous					Peralta *et al.* 25400
Radula mammosa Spruce	AM, AT	Moderate	Neotropical		Mat					X			Dioicous					Peralta *et al.* 8309
Radula mexicana Lindenb. & Gottsche	AT	Moderate	Africa, Europe, Neotropical		Mat	X	X	X	X				Dioicous		X			Peralta *et al.* 8185
Radula quadrata Gottsche	AM, AT	Wide	Neotropical		Mat	X							Dioicous				X	Peralta *et al.* 25343
Radula sinuata Gottsche ex Steph.	AT	Moderate	Brazil, Bolivia, Colombia		Mat	X							Dioicous	X				Peralta *et al.* 25551
Radula stenocalyx Mont.	AM, AT	Moderate	Africa, Neotropical		Mat					X			Dioicous				X	Peralta *et al.* 26530 p.p.
Radula tectiloba Steph.	CE, AT, PL	Wide	Neotropical		Mat	X							Dioicous	X			X	Peralta *et al.* 8349 p.p.
Radula tenera Mitt. ex Steph.	AT	Moderate	Brazil, Colombia		Mat	X							Monoicous	X	X	X		Peralta *et al.* 8493
Ricciaceae																		
Riccia stenophylla Spruce	CA, CE, AT, PA, PL	Wide	Neotropical		Annual			X					Monoicous	X		X		Koga *et al.* 211
Trichocoleaceae																		
**Leiomitra flaccida* Spruce	AT	Moderate	Endemic to Brazil		Weft	X							Dioicous		X			Peralta *et al.* 8171
Trichocolea brevifissa Steph.	AT	Moderate	Neotropical		Weft				X				Dioicous					Peralta *et al.* 25490
Trichocolea tomentosa (Sw.) Gottsche	AT	Moderate	Neotropical		Weft	X							Dioicous					Peralta *et al.* 25490

Table 2. Distribution and richness of species found in the Rio Turvo State Park (RTSP) in relation to other regional scales. The percentage represents the richness found in the RTSP compared with the total number of species in each region.

Region	Richness (number of spp.)	References
Rio Turvo State Park	414	This Study
SP State	915 (45 %)	Flora do Brasil 2020 (2020)
Atlantic Forest	1,349 (31 %)	Flora do Brasil 2020 (2020)
Brazil	1,572 (26 %)	Flora do Brasil 2020 (2020)
Neotropics	3,980 (10 %)	Gradstein *et al.* 2001

(Lophocoleaceae) and *Radula mexicana* (Radulaceae) occurred simultaneously in tree trunks, soil, decaying trunks and rocks. *Cheilolejeunea filiformis* (Lejeuneaceae) was found inhabiting all four substrates, plus leaves. The dominant life form was mat (present in 47 % of the total species), followed by turf, weft, fan, pendant, tail, cushion and dendroid (Fig. 4).

Reproductive aspects

The prevailing sexual system was dioicous (56 %), followed by monoicous (41 %), and 3 % of the total species exhibited both sexual systems. Regarding sexual expression, 53 % of the species were sexual - meaning the species possess male (antheridia) and/or female gametangia (archegonia) – 32 % exhibited sporophytes and 13 % presented asexual reproduction (that included caducous leaves, gemmae, fragmented leaves, brood leaves and flagelliform-branches).

Of all the sexual species, 46 % were dioicous, 51 % monoicous and only 3 % presented both sexual systems. Of all the asexual species, 82 % were dioicous and only 16 % were monoicous. Finally, of all species that bore sporophytes, 65 % were monoicous and 35 % were dioicous (Fig. 5).

Discussion

Species richness

The richness of liverworts overcoming the mosses represents a common pattern in the floristic surveys in well-preserved areas in the Atlantic Forest, as pointed out by Gradstein *et al.* (2001) for the Neotropics. This pattern was described for Northeastern Brazil, in the State of Bahia by Valente & Pôrto (2006), Bastos & Bôas-Bastos (2008), Bastos & Valente (2008) and Bôas-Bastos & Bastos (2009). In Southeastern Brazil, it was described in the State of Rio de Janeiro by Santos & Costa (2008) and in the State of São Paulo by Yano *et al.* (2009; 2019), Carmo *et al.* (2016) and Visnadi (2012).

Our study recorded practically equal quantities of liverworts and mosses. Although the predominant

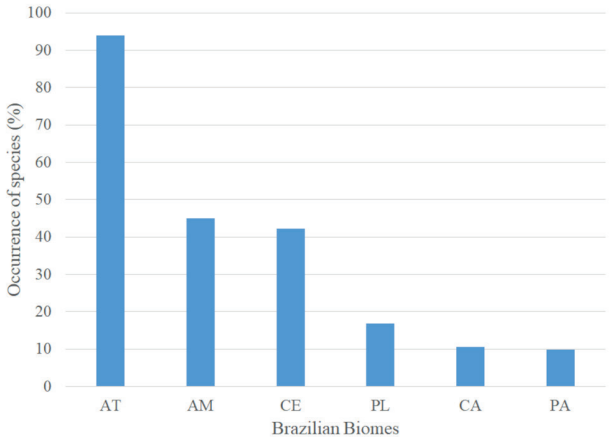

Figure 1. Percentage of species' occurrence in each Brazilian biome.

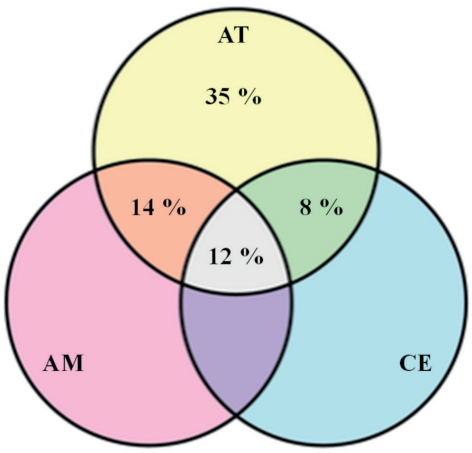

Figure 2. Percentage of species shared among Atlantic Forest (AT), Amazon Forest (AM) and Cerrado (CE).

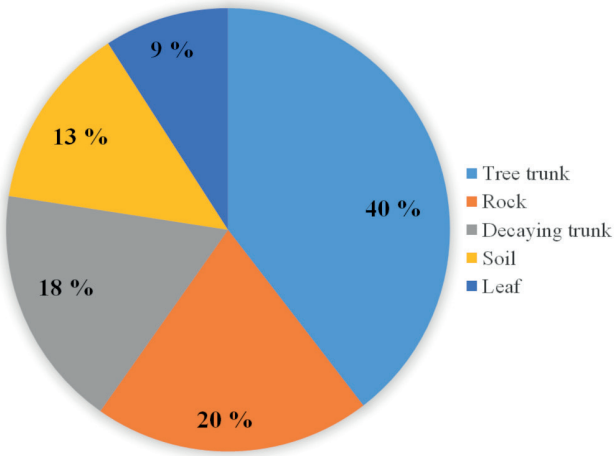

Figure 3. Percentage of species' occurrence per substrate.

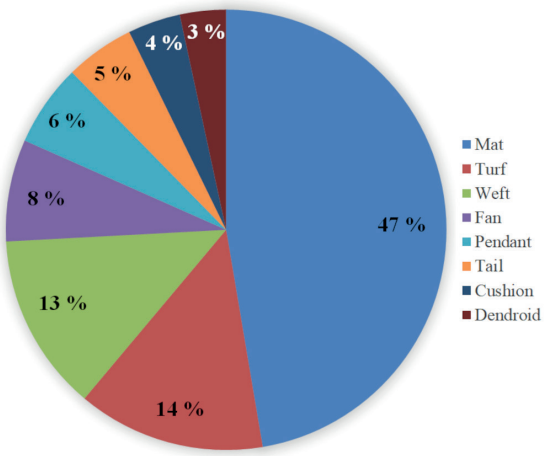

Figure 4. Percentage of species per life form.

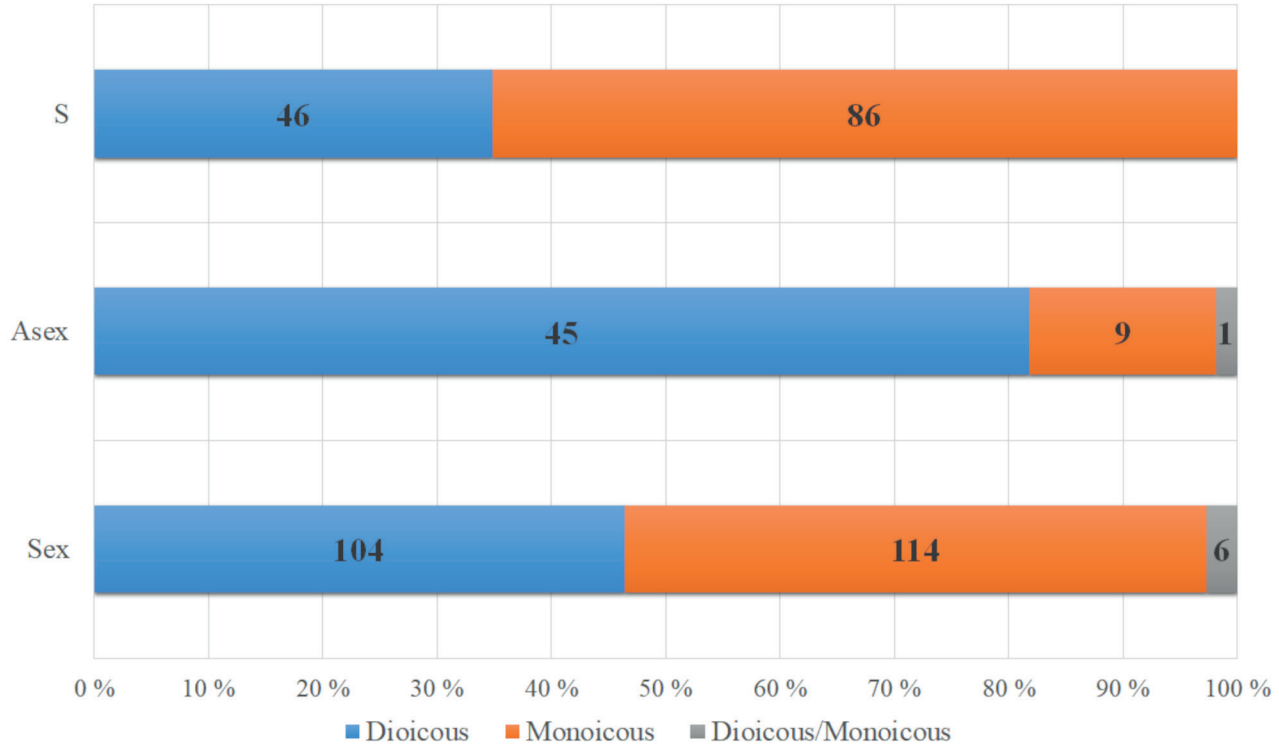

Figure 5. Number of species according to their reproductive strategies: dioicous and/or monoicous. Types of reproduction: S = presence of sporophyte, Asex = asexual reproduction, Sex = sexual reproduction.

vegetation is composed of Dense Ombrophilous Forest, there are patches of Open Ombrophilous Forest (due to the presence of bamboo) and Mixed Ombrophilous Forest (evidenced by *Araucaria angustifolia*). Furthermore, the fragments of secondary vegetation and the presence of rocky outcrops and waterfalls imply a heterogeneous landscape. Mosses usually exhibit morphological traits that allow them to tolerate desiccation (*i.e.*, leaf arrangement, hyaline cells near the leaf bases, papillae on the leaf surface; Schofield 1981; Goffinet *et al*. 2009), which also contribute to this division's elevated species richness in dry forests. In contrast, liverworts are predominant in humid forests since they do not have the same morphological variation as mosses, so they are more sensitive to oscillations in temperature, rainfall and humidity, hence, more susceptible to climatic changes (Henriques *et al*. 2016). Therefore, the equal species number of liverworts and mosses can be explained by the park's heterogeneity, which provides different humidity and shading conditions.

According to Gradstein *et al*. (2001), in lowland rainforests, there is the predominance of four moss families: Calymperaceae, Fissidentaceae, Pilotrichaceae and Sematophyllaceae, which coincide with the results of this study. Further inventory surveys carried out in Atlantic Forest areas in the States of São Paulo (Visnadi 2005; Yano & Peralta 2007; Peralta & Yano 2008; Visnadi 2009; Carmo *et al*. 2016), Rio de Janeiro (Santos & Costa 2008) and Bahia (Valente *et al*. 2009), presented Pilotrichaceae as the most well-representative moss family, followed by Fissidentaceae, Sematophyllaceae, Bryaceae, Orthotrichaceae and Leucobryaceae (not necessarily in the same order).

As mentioned in Vaz-Imbassahy *et al*. (2008), Pilotrichaceae has 11 genera and 51 species and occurs mainly in the Amazon Forest and Atlantic Forest biomes, with the greatest richness in Southern and Southeastern Brazil. Pilotrichaceae is characterized by a well-developed and elongate double-costae, a hyaloderm in most species (Buck 1998; Gradstein *et al*. 2001) and complanate tristichously-arranged leaves, which are laterally- and medially symmetric (Vaz & Costa 2006). These aspects might help them absorb and transport more water, contributing to their colonization success.

Out of 38 moss families, 18 are represented by only one or two species, a ratio confirmed by Gradstein *et al*. (2001), which stated that in lowland rainforests, approximately 50 % of the families possess only one or two species each. The most well-representative family was Lejeuneaceae, with a richness of 48 % of the total number of liverworts. This percentage is compatible with the pattern observed in Gradstein (1995), which points out Lejeuneaceae as the most species-rich family, with a richness of 70 % in lowland rainforests. However, this percentage tends to decrease as the altitude increases, as seen in lower montane rainforests, where Lejeuneaceae constitutes 45 % of liverworts species.

Tropical forests, mainly the Atlantic Forest, are characterized by wet climate and a wide range of substrates (e.g., tree trunks, decaying tree trunks, soil, rocks and leaves)

that allow the colonization by Lejeuneaceae (Gradstein *et al*. 2001; Carmo *et al*. 2016). Several inventories in this biome point out Lejeuneaceae as the richest liverwort family: Visnadi (2005), Yano & Peralta (2007), Peralta & Yano (2008), Santos & Costa (2008), Valente *et al*. (2009), Visnadi (2009; 2015a), Carmo *et al*. (2016), Santos *et al*. (2017a) and Amélio *et al*. (2019).

As discussed in Gradstein (1992), Schuster (1983) and Wilson *et al*. (2007), the recent diversification of Lejeuneaceae can be attributed to the expansion of angiosperm forests, which provided a wide range of habitats.

Geographical distribution

Although most species have wide or moderate distribution, 22 % of the bryoflora is rarely distributed. This is a significant number, demonstrating the potential of the Rio Turvo State Park for the conservation of species concentrated in restricted geographical areas or habitats. Notwithstanding, the State of São Paulo has been well sampled. Considering all surveys, the number of 16 new species records emphasizes this study's importance to the Brazilian bryoflora knowledge. The addition of geographical distribution data is vital to elaborate lists of regionally threatened species based on the number of localities where those species usually occur (IUCN 2001).

Philonotis longiseta was reported only for Northeastern Brazil, in the States of Bahia and Ceará (Oliveira & Peralta 2015). This is the third citation for Brazil. It has been usually found on rocks and wet tree trunks, next to waterfalls (Sharp *et al*. 1994). *Dicranella pabstiana* is restricted to the Atlantic Forest at altitudes between 500-1000 m. The species has been recorded in Santa Catarina, the location of the type material, and recently in Minas Gerais (Carmo & Peralta 2020). Other species such as *Callicostella martiana* occurs in a large range, between 0-1,000 m a.s.l. (Vaz & Costa 2006). *Leucomium steerei* has been collected in montane rainforests, with records only in Serra dos Órgãos (RJ) and Serra dos Carajás (PA) (Moraes & Lisboa 2006).

Porotrichodendron superbum has been found in warm and humid montane rainforests and at the mountain bases (Fuertes *et al*. 2015). In Brazil, it occurs from average altitudes in Mixed Ombrophilous Forest (this study: 400 m a.s.l.) to elevated altitudes in Dense High Mountain Ombrophilous Forest, or the Cloud Forest from Pico do Marumbi (alt.: 1213 m a.s.l.), in the State of Paraná (Santos *et al*. 2017a).

The first and only reference for *Pylaisiadelpha tenuirostris* in Brazil is from the municipality of Selviria, State of Mato Grosso do Sul, growing in *cerradão* phytophysiognomy (Yano 2004). The specimen was collected at the base of a tree trunk, while we found this species growing on decaying tree trunks.

Mnioloma cyclostipa represents a peculiar species from the Montane Belt to the Upper Montane Belt transition. It had been recorded only above 1,000 m elevation (Santos & Costa 2010). However, in the present study, the species occurs in a distinct altitude range (660 m a.s.l.), on soil, along the Turvo River banks.

Prionolejeunea galliotii is typical of Dense Ombrophilous Forest, between altitudes 0-700 m a.s.l. It had been only cited for the State of Bahia (Bastos & Bôas-Bastos 2019).

Daniels *et al*. 2010 highlight *Cololejeunea lanciloba* as a polymorphic species, with several synonyms, such as *Cololejeunea katiae* (the synonymization was published in Pócs *et al*. 2014), which has been recorded only for Recife (PE).

Marchantia berteroana is classified as an Endangered (EN), according to the IUCN Red List. It occurs in Dense Ombrophilous Forest and Semideciduous Mesophytic Forest (CNC Flora 2020). Deforestation and human-made forest fires are the factors that most contribute to the fragmentation of tropical rainforests. Consequently, damaging the reproduction and dispersion of the species. Furthermore, we take into consideration the hypothesis of low sampling effort caused by the lack of studies in Marchantiaceae (CNC Flora 2020).

The fact that the park harbors 5 % of all Brazilian endemic species (275 spp. according to Costa & Luizi-Ponzo 2010), and that 35 % of the species listed in our survey occur exclusively in the Atlantic Forest biome enhances the importance of preserving the RTSP to maintain the region's current biodiversity.

The most well-representative biomes (*i.e.*, the Amazon Forest, Atlantic Forest and Cerrado) share several species. This can be explained by the first two being tropical rainforests, which are located in the lower zone of the humid tropics (up to an altitude of 1,500 m.a.s.l. near the Equator and up to 600-700 m within the Tropics of Cancer and Capricorn), comprising evergreen, tall trees, shrubs, lianas and epiphytes, with an annual rainfall of 1,500 mm up to 6,000-8,000 mm (Pócs 1982). Regarding the Cerrado, there are several phytophysiognomies (*e.g.*, *capões de mat*a, slope forests or *matas de encosta* and gallery forests or *matas de galeria*) that constitute a green oasis, providing humid microhabitats for the establishment of bryophytes (Pinheiro *et al*. 2012).

Concerning the global scale, almost 50 % of the species have a Neotropical distribution. The Neotropics comprise a very heterogeneous landscape, including hot tropical rainforests (*e.g.*, the Amazon and Atlantic Forests), the high and frozen Andean mountains, dry savannas and scrubby vegetation in central Brazil, and the exuberant tropical islands of the West Indies (Gradstein *et al*. 2001). This wide range of phytophysiognomies provides a very diverse flora, responsible for supplying habitats for almost 4,000 bryophytes species (Gradstein *et al*. 2001).

Schuster (1983) assumes there are few genuinely pantropical species. It is worth mentioning *Octoblepharum albidum*, *Calymperes afzelii* and *Fissidens asplenioides*. In liverworts, it was observed that most of the species occur

in low and medium elevations, such as *Lejeunea flava* and *Cheilolejeunea xanthocarpa* Malombe (Schuster 1983).

About 8 % of the bryoflora is cosmopolitan or subcosmopolitan. Mosses with this distribution are usually found in disturbed or open areas (Schuster 1983), like *Bryum argenteum* (collected on cement) and *Polytrichum juniperinum* (harvested on a ravine at the edge of the highway). In the case of cosmopolitan hornworts, Schuster (1983) recorded *Phaeoceros laevis* in cultivated fields (we collected in the ravine behind an abandoned house). Its long-viable spores are man-dispersed and typically mixed with seed grains and nursery stock (Schuster 1983).

Substrates and life form aspects

As we can see in our study, in tropical forests, most bryophytes spread on tree trunks and branches – acting as epiphytes – and on decaying trunks (Richards 1984; Visnadi 2015a). It is essential to highlight that in ombrophilous forests, the most available substrate are trees, shrubs and liana trunks.

Several studies have demonstrated the relationship between the composition of corticolous bryophyte species and the phorophyte conditions, such as pH, roughness and water retention capacity. Furthermore, they associate the bryophyte coverage percentage with the diameter at breast height (DBH) (Batista & Santos 2016). Oliveira & Mota de Oliveira (2016) show that in Atlantic Forest fragments in Northeastern Brazil, the species composition varies along a height gradient. These diverse factors provide many microhabitats and niches that can be colonized by different communities (Smith 1982; Frahm 1990). This wide range of microhabitats is not available in other substrates such as soil (Batista *et al*. 2018). Within forests, it is not common to find bryophytes on soil due to the significant amount of litter and its fast decomposition (Frahm 2003). However, rupicolous species had great representativeness in our study area due to the presence of rock outcrops and rocks at the edge of waterfalls.

The presence of epiphyllous bryophytes is an iconic feature of tropical forests and is an indicator of preserved native areas (Gradstein *et al*. 2001). Furthermore, the more humid, the greater the migration rate from the trunks and branches to leaves. By far, Lejeuneaceae is the most well-represented family of epiphyllous bryophytes (Frahm 2003). As the leaves represent an ephemeral substrate, the most successful colonizing species exhibited morphological adaptations, such as neoteny (reduction of the gametophyte), short life cycle, high fertility, asexual reproduction by gemmae and mucilaginous structure for fixation on the surface (Frahm 2003; Zartman 2003). The occurrence of epiphylls suggests the importance of protecting the RTSP.

The fact that 63 % of the bryoflora is specific to a single substrate type means that the RTSP has predominantly stable environments, unlike regeneration areas, which bryophytes use to establish in a wide range of substrates (Peralta & Yano 2008; Visnadi 2015a).

According to the model proposed by Bates (1998), mats are common in places with high to medium desiccation tolerance, shaded and lit, due to the morphology of their gametophytes, which are branched and creeping, forming a moisture containment and carbon stock grid. In shaded habitats, it is possible to associate the flat arrangement of the stems and leaves of fans and mats with optimizing the light-capturing surface area.

Turfs, which have dense foliage, are capable of storing water in the spaces between the leaves and gametophytes by capillarity (Glime 2017). They also have a protective layer against desiccation, which allows them to live under medium to high luminosity conditions, favoring their proliferation in very damp places (Bates 1998).

Wefts are found in moist and moderately shaded conditions (Bates 1998). Sollows *et al*. (2001) tested *Bazzania trilobata* and observed that the overlapping leaves protect against direct exposure that could harm the inner shoots' net photosynthesis. Furthermore, they realized that the overlapping leaves conserve more water.

In tropical and subtropical cloud forests, there is a high rate of precipitation throughout the year. Consequently, there is high air humidity, so pendants and tails stand out due to their feathery stems, which make it possible to collect water vapor droplets from the atmosphere (Richards 1984; Glime 2017).

Cushions are found more frequently in dry environments, with a high incidence of light. Their gametophytes bundle in a compressed colony, causing a self-shading effect - when individuals physically very close to one another end up shading each other, protecting colonies from direct sun radiation (Bates 1998). As the stems are the same height, the wind turbulence and water evaporation are reduced (Glime 2017). Furthermore, the colony shape provides stability and support for gametophytes, which do not have lignin (During *et al*. 2015).

Dendroids, which stand out in environments with medium humidity and brightness, climb higher layers towards the light elevating the stems from their horizontal shoots since they grow from the trunk bases (Bates 1998).

On certain occasions, particular species may vary their way of life according to the environment's conditions. Rincon and Grimes (1989) attribute the phenotypic plasticity of life forms to foraging behavior towards water retention adaptation, then representing a competitive strategy to enhance the absorption of nutrients in the soil and water.

Reproductive aspects

As reported in Hedenäs & Bisang (2011), there are more dioicous than monoicous species. According to Villarreal & Renner (2013), 68 % of liverworts species, 57 % of mosses and 40 % of hornworts are dioicous. In the study

of Hedderson & Longton (1995), a proportion of 60 % dioicous to 40 % monoicous species was observed, which is a similar result to our survey.

Ando (1980) assumes monoicous individuals – which possess both male and female sexual organs – as the sexual system with more chances for fertilization. For this reason, bryophytes that inhabit recent and ephemeral substrates, such as decaying wood and leaves, have a greater tendency to monoecy. In fact, all twenty species found growing exclusively over decaying trees and/or leaves were monoicous. In order to avoid self-fertilization, several species have developed adaptations, as protandry (*i.e.*, maturation of antheridia before archegonia on the same plant) and protogyny (*i.e.*, maturation of archegonia before antheridia) (Maciel-Silva & Pôrto 2014).

According to Villarreal and Renner (2013), mating systems depend on the spores' size, but the inverse is yet to be confirmed. For instance, dioicous species have smaller and more numerous spores that guarantee the colonization of a larger territory since the spores are more easily dispersed, forming mats of gametophytes, achieving even disturbed and ephemeral habitats. In addition, dioicous species generally grow more in size and have a more expansive lifestyle, such as mats, to compensate for the lower production of sporophytes (Crawford *et al*. 2009). Our results confirm this statement since 35 % of the dioicous species present mat life form, followed respectively by turf (18 %), weft (13 %), pendant (10 %), tail (9 %), cushion (6 %), fan (5 %) and dendroid (4 %).

Places subjected to the seasonal effects – long dry periods and irregular precipitation - like the humid enclave of Chapada do Araripe, located in the Caatinga biome, monoecy prevails – given this sexual system likely guarantees a higher fertilization rate (Batista *et al*. 2018). Alternatively, Santos *et al*. (2017b) assume that there is a higher tendency to dioecy in more humid environments, such as the ombrophilous forests of the Atlantic Forest, considering the substantial water availability that contributes to the higher frequency of sexual reproduction events. Moreover, our study confirmed this assumption.

One of the advantages of dioecy is that cross-breeding increases genetic variability, contributing to the broader morphological range of character states, as observed in *Campylopus* (Frahm 1991), currently included in Leucobryaceae (Flora do Brasil 2020 2020). However, dioecy also presents disadvantages. For instance, many bryophyte species, when establishing themselves in a new area, form a colony generally consisting of only one sex, making cross-breeding difficult, as antherozoids (male gametes) need to travel great distances through the water surface to reach the archegonia (female gametes) (Haig 2016). For this reason, many dioicous species end up investing in asexual reproduction to guarantee dispersal and growth (Frahm 2003; Maciel-Silva & Pôrto 2014). This pattern was observed in our study, where 86 % of the species that showed vegetative reproduction were dioicous.

Vegetative reproduction can be stimulated as a dispersion and colonization strategy when plants are submitted to some selective environmental pressure, such as temperature increase, the direct incidence of sunlight and desiccation. During (1979) realized that in rainforests, it was common to find *Campylopus flexuosus* forming large turfs without vegetative reproduction, while in dry forests, the plants were behaved forming dense cushions with detachable branches.

Conclusion

The Rio Turvo State Park has a very rich bryoflora, counting with 414 species, which represent 10 % of the Neotropic, 30 % of Brazil and approximately 50 % of the species known for the State of São Paulo. Despite the human influence in the area, the RTSP harbors species that are not very well known – 16 new occurrences for the State of São Paulo were recorded – and have restricted geographical distribution, such as *Pylaisiadelpha tenuirostris* and *Prionolejeunea galliotii* (both representing the second citation for Brazil) and *Marchantia berteroana* (an endangered species).

It is possible to understand the predominance of some families over others when we analyze the area's ecological aspects since they reflect the area's environmental conditions. As expected for areas with great water availability, the probability of sexual reproduction is directly higher. Thus, dioicous species are likely to predominate. Similarly, the moist climate and abundant shade caused by the forest canopy allowed the prevalence of the mat life form, which morphology enables greater water storage and an optimized surface area to capture light.

The predominance of corticolous species can be associated with the higher availability of tree trunks and branches, highlighting the dense forest structure in the RTSP territory. The considerable presence of epiphylls is one more indicator of well-preserved vegetation. These data reinforce the importance of this conservation unit for the preservation not only of the RTSP's bryoflora but of all biodiversity.

Acknowledgements

We acknowledge the team of Rio Turvo State Park, mainly the park manager T.L.Vecki, the guards and monitors for assistance during the field excursions; L.A. Amélio, D.S. Oliveira, J.S. Lima, G.J. Silva, B.K. Canestraro, E.D. Lozano, O. Koga and I.T.O. Koga for supporting field trip; B.K. Canestraro, D.M. Carmo, J. Bordin and M.E. Reiner-Drehwald for confirming the identification of some species. This work was supported through a research grant from the CNPq (133891/2018-6).

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