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Richness of Marchantiophyta and Bryophyta in a protected area of the Brazilian Amazon[1]

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ABSTRACT

The bryophytes of Gurupi Biological Reserve represent an important component of the biodiversity of the Amazon in the Brazilian state of Maranhão. This study aimed to investigate the richness of bryophytes (Marchantiophyta and Bryophyta) from Gurupi Biological Reserve and compare it with that found in other surveys conducted in Maranhão and in the northeastern part of the state of Pará, because the latter shows similarities with the study area in terms of vegetation, geography, demography, and history of occupation. We recorded 983 occurrences of bryophytes (549 Marchantiophyta and 434 Bryophyta) corresponding to 62 species (43 liverworts and 19 mosses), 39 genera, and 12 families. Of those 62 species, 25 have previously been collected from all regions of Brazil, two are restricted to two regions, and four are restricted to the northern (Amazon) region. The bryophyte species identified within the reserve correspond to 28.9% of the known bryophytes in Maranhão and 31.3% of the known bryophytes in northeastern Pará, the reserve therefore more closely resembling the latter area. The exclusively Amazonian elements found in the reserve underscore their affinity for this biome and their presence in the state of Maranhão. The importance of this conservation area to Maranhão and to the Amazon region of the state is confirmed by the high number of new records for the state (41 species), five of which are also new records for northeastern Brazil.

Key words: Bryophytes, liverworts, Amazonia of Maranhão, mosses, Gurupi Biological Reserve

Introduction

The portion of the Amazon that lies within the Brazilian state of Maranhão, corresponding to the easternmost portion of the Amazon region, encompasses 81,208.40 km^2, including 62 cities, and represents 24.46% of the total area of the state (IBGE 2007; Martins & Oliveira 2011). Until the 1950s, this part of the Amazon was one of the least known, explored and inhabited in Brazil. It currently has the greatest population density in the Brazilian Amazon (IBGE 2007), and its vegetation cover has been reduced to less than 25% of its original size but remains little studied from a scientific standpoint (Moura *et al.* 2011).

According to Martins (2011), the large tracts of savanna and transitional vegetation located in Maranhão have diverted attention from research on the Amazon Biome in the state, and part of this inattention has also had the effect of intensifying changes in the local Amazonian landscape, as well as in land use and agricultural expansion, for more than 50 years. The term *pré-Amazônia* ("pre-Amazon"), coined by Brazilian politicians in the 1980s and adopted by the population, reflects the denial of recognition of elements in the Amazonian landscape and explains the failure of laws for the conservation of the Amazon rain forest, more rigid in terms of size of the legal reserve on rural properties compared with those applied in the savanna (Rocco 2005; Martins 2011). The remaining vegetation of the Amazon in Maranhão is basically composed of rain forest with lianas, alternating between dense and open vegetation, showing a gradual transition from the wetter forest type to semideciduous forest, along a north-south gradient (Muniz 2011). In addition, the region includes a mosaic of disturbed landscapes mainly represented by secondary forests, managed plantations and pastures (Araújo *et al.* 2011).

Among the few federal units of permanent preservation located in Maranhão, only the Gurupi Biological Reserve is located in the Amazon region (Martins 2011; MMA 2011; SEMA 2011). This reserve and the adjacent indigenous lands, such as Alto Turiaçu (530,525 ha), Awá (118,000 ha) and Caru (172,667 ha), form a biological unit of 11,628.42 km^2 that harbors the best and the most homogeneous portion of the Brazilian Amazon in Maranhão (Araújo *et al.* 2011; Oliveira 2011). Therefore, the Gurupi Biological Reserve is the last protected area of Amazonian landscape in the state (Martins & Oliveira 2011).

[1] Based on the Master's dissertation of the first author

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The biggest threats to the Gurupi Biological Reserve arise from the same processes (sprawl and predatory exploitation) that plagued other areas of the Amazon in Maranhão. Among the key events of the territorial occupation of this region were the opening of major roads, such as the Belém-Brasília highway (BR-010) and BR-222, which gave rise to towns and districts where there were forests, and the opening of a new agricultural, forestry and pastoral frontier (Moura *et al.* 2011). Even being a strictly protected area, the reserve has been the target of illegal exploitation of timber resources and wildlife, which is only partially controlled through supervision (Moura *et al.* 2011).

The Amazon in Maranhão presents high species richness of different types of organisms, including environmental bioindicator, endemic and endangered species (Oren & Roma 2011; Oliveira *et al.* 2011; Rebêlo *et al.* 2011). The richness of the flora and floristic composition is partially known through phytosociological surveys of tree species, studies on flowering and fruiting patterns of trees and inventories of bee flora and Orchidaceae (Muniz 1998, 2008, 2011; Silva *et al.* 1999; Marques *et al.* 2011).

The only records published to date on the bryoflora of the Amazon in Maranhão refer to a species of *Ceratolejeunea* that is new to science (Brito & Ilkiu-Borges 2012) and the study of bryophytes from the municipality of Mirinzal (Brito & Ilkiu-Borges *in prep*.) However, in a neighboring region that has a similar history of occupation, the northeastern portion of the state of Pará, much of the bryoflora has already been studied (Santos & Lisboa 2003, 2008; Lisboa & Tavares 2008; Ilkiu-Borges *et al.* 2009; Tavares *et al.* 2014), revealing high species richness, which represents about a third of the bryophytes in the state of Pará.

In this context, the bryoflora in the Gurupi Biological Reserve represents an important component to the knowledge of the biodiversity of the Amazon ecosystem in the state of Maranhão. This study aimed to investigate the richness of bryophytes (Marchantiophyta and Bryophyta) in the reserve and compare it with that found in other surveys conducted in Maranhão and northeastern Pará.

Material and methods

The Gurupi Biological Reserve (3°38'56"S; 46°41'42"W), created by federal decree (No. 95,614 of January 12, 1988), is located between the municipalities of Bom Jardim, Centro Novo do Maranhão and São João do Carú in the state of Maranhão. It is configured in a polygon slightly larger than 271,000 ha (Moura *et al.* 2011). According to the Köppen classification system (Köppen 1984), the climate of the region is type Am (humid equatorial).

The surveys were conducted from August 28 to September 5 of 2010 and from June 3 to 15 of 2011. The samples were collected on ten parcels of terra firme forest, five parcels each, respectively, in the northern and southern sectors of the Gurupi Biological Reserve, within the limits established by the "Loss of Biodiversity in the Centers of Endemism within the Scope of Deforestation" subproject of the Museu Paraense Emílio Goeldi National Institute of Science and Technology-sponsored project "Biodiversity and Land Use in the Amazon". Each parcel measured 10 × 10 m (100 m^2), totaling 1000 m^2 of study area. For the collection in the interior of a parcel, each was divided into five 2 × 10 m corridors, which traversed all types of substrates, and we avoided collecting samples from the overlapping areas of the parcel. The collection method was based on Yano (1984), and samples were deposited in the Herbarium of the Museu Paraense Emílio Goeldi, in the city of Belém, Brazil (code, MG).

Identification of the material was based on specialized literature, such as but not limited to the works of Florschütz-de Waad (1996), Florschütz-de Waad & Veling (1996), Buck (2003), Dauphin (2003), Gradstein & Costa (2003), Gradstein & Ilkiu-Borges (2009).

The authors adopted the taxonomic classification systems devised by Crandall-Stotler *et al.* (2008) for Marchantiophyta and by Goffinet *et al.* (2008) for Bryophyta. Species were classified according to the substrates of occurrence, as described by Robbins (1952), and Gradstein *et al.* (2001) for classification of epiphylls. The termite mound substrate was treated separately because it does not fit into any of the above categories.

For the analysis of the Brazilian and worldwide distribution, we consulted not only the list of species of Brazilian flora but also the works of Bastos (2004), Lisboa & Osakada (2005), Bastos & Yano (2006), Lisboa *et al.* (2006), Yano & Peralta (2006), Zartman & Ilkiu-Borges (2007), Alvarenga *et al.* (2008), Ilkiu-Borges *et al.* (2009), Bordin & Yano (2010), Peralta *et al.* (2011), Yano (2008; 2011), Yano *et al.* (2009), Reiner-Drehwald & Grolle (2012) and Moura *et al.* (2013). The abbreviations of the Brazilian state names are those established by the Brazilian Institute of Geography and Statistics.

The richness values found were compared numerically with those previously reported for bryophytes in Maranhão and northeastern Pará, using the works of Brito & Ilkiu-Borges (*in prep*.), Santos & Lisboa (2003; 2008), Lisboa & Santos (2005), Lisboa & Tavares (2008), Ilkiu-Borges *et al.* (2009) and Tavares *et al.* (2014).

To assess abundance, the absolute frequency of the species was determined by adopting the classes defined by Silva & Pôrto (2007), which are based on the number of occurrences (number of times that the species occurs in a given parcel): rare = 1-5, infrequent = 6-10, constant = 11-20, frequent = 21-30, and very frequent = 31 or more.

Results and discussion

In Gurupi Biological Reserve, we recorded 983 occurrences of bryophytes (549 Marchantiophyta and 434 Bryophyta), corresponding to 62 species, 39 genera and 12

families. Of that total, 43 species, 20 genera and five families belong to the liverwort group; and 19 species, 12 genera and seven families belong to the moss group (Tab. 1). This study adds 41 new records to the bryoflora of Maranhão and five to that of northeastern Brazil.

The richness of liverworts was higher than was that of the mosses, which is in agreement with the literature on lowland rain forests (Gradstein *et al.* 2001). Lejeuneaceae (37 species), Calymperaceae (5 species), Fissidentaceae (5 species) and Sematophyllaceae (3 species) stood out, with greater specific richness, corroborating the assertions that are among the most representative families in the Neotropics (Gradstein & Pócs 1989; Gradstein 1994).

Eleven species (17.7%) were classified as very abundant, totaling 623 occurrences, and 31 species (50%) were classified as rare, totaling 71 occurrences. The intermediate classes collectively accounted for 289 occurrences and were represented by four frequent species (6.5%), six constant species (9.7%) and ten infrequent species (16.1%). The predominance of rare species and the abundance of a few species in a site has been documented in tropical forests, for nonvascular plants (Santos & Lisboa 2003, 2008; Souza & Lisboa 2005; Silva & Pôrto 2007; Alvarenga & Lisboa 2009; Ilkiu-Borges *et al.* 2009) and vascular plants (Gotelli & Simberloff 1987; Collins & Glenn 1990; Rees 1995; Boecken & Shachak 1998; van Rensburg *et al.* 2000).

In terms of worldwide distribution, the Neotropical/Subtropical pattern predominated (in 37.1%), followed by exclusively Neotropical (in 32.6%) and Pantropical/Subtropical (in 11.3%). Only 4.8% of the species are endemic to the Amazon region: *Lejeunea obidensis* Spruce, *Cheilolejeunea neblinensis* Ilkiu-Borges & Gradstein and *Vitalianthus urubuensis* Zartman & Ackerman. Among the remaining species, the distributions were African-American (in 4.8%), America/Australian (in 1.6%), Amazon/Guineas (in 1.6%), restricted to the Guineas (in 1.6%) and Pantropical (in 1.6%). The distribution of two species, identified only to the genus level, was not evaluated.

Regarding the distribution in Brazil, 25 species (40.3%) have already been collected in all regions of Brazil, two (3.2%) are restricted to two regions and four (6.4%) are restricted to the northern region (Amazonia). The remaining species occurred in three and four regions of the country (22.6% and 24.2%, respectively). It was expected that the bryoflora of the study area would harbor species of great ecological amplitude and therefore widely distributed but also common in the Amazon Biome, due to being in a region impacted by population growth and landscape changes. The presence of restricted species in the Amazon supports the argument of Martins (2011) for official recognition of the Amazonian landscape in the state of Maranhão.

Lejeunea obidensis was common in the Gurupi Biological Reserve. However, it is a little-known species, which has recently been rediscovered on an island in the opposite shore of Belém, in Pará (Moura *et al.* 2013), after more than a century of collecting the type (Spruce 1885). This indicates that the state of knowledge of some species is quite limited and can be amplified only through additional biological inventories .

Cheilolejeunea neblinensis was known only in Pico da Neblina, in the portion that belongs to Venezuela (Ilkiu-Borges & Gradstein 2008) and was recorded in an upland forest glade, in the oil province of Urucu, in the Brazilian state of Amazonas (Gradstein, unpublished data). It is cited for the state of Amazonas in the list of species of Brazilian flora (Costa 2013).

In addition to the type species, collected in secondary vegetation of upland in central Amazonia (Zartman & Ackerman 2002), *Vitalianthus urubuensis* was recorded in floodplain forest in the National Forest of Caxiuanã, in eastern Amazonia, by Lisboa & Osakada (2005).

As can be seen in Tab. 1, the most widely colonized substrate was tree trunk (living or decomposing), supporting data in the literature on tropical forests, in which these are reported to be the substrates most widely used by bryophytes, due to their abundance and ability to retain moisture (Pócs 1982; Richards 1984; Germano & Pôrto 1998). This result was expected, because this pattern was the same as that reported in other studies of bryophytes in the Amazon, including those in northeastern Pará (Santos & Lisboa 2003, 2008; Lisboa & Santos 2005; Lisboa & Tavares 2008; Ilkiu-Borges *et al.* 2009; Tavares *et al.* 2014).

The richness found in the Gurupi Biological Reserve was higher than that reported in most studies conducted in the Amazon in northeastern Pará, with the exception of Santos & Lisboa (2003) and Tavares *et al.* (2014). In most of the studies compared in Tab. 2, collection effort and study area were not measured, the exception being that conducted by Tavares *et al.* (2014).

Among the studies conducted in northeastern Pará, only those of Ilkiu-Borges *et al.* (2009) and Tavares *et al.* (2014) included liverworts in their analyses, which might explain the low liverwort richness attributed to that region (Tab. 2). However, observing the richness of the divisions separately, the Gurupi Biological Reserve presents lower richness of mosses and liverworts than that recorded by Tavares *et al.* (2014) in Capitão-Poço, in Pará. It also presents lower richness of mosses in relation to the areas studied by Santos & Lisboa (2003; 2008) and Lisboa & Tavares (2008). Santos & Lisboa (2003; 2008) included several municipalities in their analysis and therefore evaluated an area much larger than that evaluated in the present study, which could explain why the richness of mosses was less pronounced in the Gurupi Biological Reserve. If the taxa are analyzed qualitatively, it appears that the species recorded in the reserve can be considered common, being distributed in several Brazilian states, as shown in Tab. 1.

In relation to other studies reporting on the bryoflora of Maranhão, the Gurupi Biological Reserve had richness that was lower than that recorded by Peralta *et al.* (2011)

Table 1. Bryophyte species identified in the Amazon region of the state of Maranhão, Brazil, and its number of occurrences per substrate, occurrence classes, geographic distribution, records in the literature, voucher specimens, description and illustration citations.
Co – Corticicolous; Ep – Epixylous; Ef - Epiphyllous; Te – Terrestrial; Cu – On termite mound; N. O. – Number of occurrences; NE. PA – northeastern Pará; MA – Maranhão.
*New record for Maranhão; **new record for northeastern Brazil.

FAMILY/SPECIES	Co	Ex	Ep	Te	Cu	N.O.	OCCURRENCE CLASSES	GEOGRAPHIC DISTRIBUTION	RECORDS IN LITERATURE		VOUCHER	DESCRIPTION AND ILLUSTRATION
									NE. PA	MA		
MARCHANTIOPHYTA												
Frullaniaceae												
**Frullania apiculata* (Reinw. *et al.*) Nees	1	1				2	rare	Pantropical and Subtropical. AL, AM, BA, DF, GO, MS, PA, PE, RJ, SC and SP.			Macedo 985; 1025	Gradstein & Ilkiu-Borges (2009)
Lejeuneaceae												
**Archilejeunea auberiana* (Mont.) A. Evans	4	3				7	infrequent	Neotropical and Subtropical. AC, AM, AP, BA, ES, MS, MT, PA, PE, PR, RJ, RO, RR, RS and SP.	Tavares *et al.* (2013)		Macedo 873; 882	Gradstein & Ilkiu-Borges (2009)
**Archilejeunea fuscescens* (Hamp. ex. Lehm.) Fulf.	2	3				5	rare	Neotropical. AC, AL, AM, BA, ES, MG, PA, PE, RJ, RR and SP.	Tavares *et al.* (2013)		Macedo 985; 996	Gradstein (1994); Gradstein & Ilkiu-Borges (2009)
**Archilejeunea parviflora* (Nees) Schiffn.	35	6			1	42	very frequent	Neotropical and Subtropical. AC, AL, AM, AP, BA, ES, MS, MT, MG, PA, PE, RJ, RO, RR, RS, SC and SP.	Tavares *et al.* (2013)		Macedo 968; 989	Gradstein & Ilkiu-Borges (2009)
**Caudalejeunea lehmanniana* (Gottsche) A. Evans			1			1	rare	Pantropical and Subtropical. AL, AM, AP, BA, CE, ES, GO, MT, PA, PE, PR, RJ, RS, RO, RR, SC, SE and SP.	Tavares *et al.* (2013)		Bonadeu 623	Ilkiu-Borges (2000)
Ceratolejeunea coarina (Gottsche) Steph.	27	4				31	very frequent	Neotropical. AC, AL, AM, AP, BA, MA, PA, PR, SE and SP.	Tavares *et al.* (2013)	Yano *et al.* (2009)	Macedo 992; 1000	Dauphin (2003)
**Ceratolejeunea cornuta* (Lindenb.) Schiffn.		1				1	rare	Neotropical and Subtropical. AC, AL, AM, AP, BA, CE, MG, PA, PE, PR, RJ, RO, RR, RS, SC, SE and SP.	Tavares *et al.* (2013)		Macedo 1025	Dauphin (2003)
**Ceratolejeunea guianensis* (Nees e Mont.) Steph.		1				1	rare	Neotropical. AL, AM, BA, PA and PE.	Tavares *et al.* (2013)		Macedo 873	Dauphin (2003)
**Ceratolejeunea laetefusca* (Austin) R. M. Schust.	44	3				47	very frequent	Neotropical. AC, AL, AM, BA, ES, GO, MG, PA, PE, RJ, RR and SP.	Tavares *et al.* (2013)		Macedo 724; 873	Dauphin (2003)
**Ceratolejeunea minuta* Dauphin	10					10	infrequent	Guianas. AL, AM, BA, PA and PE.	Tavares *et al.* (2013)		Macedo 716; 996	Dauphin (2003)
**Cheilolejeunea adnata* (Kunze) Grolle	37	5				42	very frequent	Neotropical and Subtropical. AC, AL, AM, AP, BA, ES, PA, PE, MT, RN, RR, PR, SC and SP.	Tavares *et al.* (2013)		Macedo 1002; 1003	Gradstein & Ilkiu-Borges (2009)
**Cheilolejeunea aneogyna* (Spruce) A. Evans	2	1				3	rare	Neotropical. AM, BA, ES, PA, PE, RO and SP.			Macedo 1025, 1027	Gradstein & Ilkiu-Borges (2009)

Continues.

Table 1. Continuation.

FAMILY/SPECIES	Co	Ex	Ep	Te	Cu	N.O.	OCCURRENCE CLASSES	GEOGRAPHIC DISTRIBUTION	RECORDS IN LITERATURE		VOUCHER	DESCRIPTION AND ILLUSTRATION
									NE. PA	MA		
**Cheilolejeunea comans* (Spruce) R. M. Schust.	1					1	rare	Neotropical and Subtropical. AM, BA, ES, MG, PA, SC and SP.			Bonadeu 630	Reiner-Drehwald (1998)
Cheilolejeunea discoidea (Lehm. & Lindenb.) Kachr. & R. M. Schust.	23	10	1			34	very frequent	Neotropical. AL, BA, DF, ES, GO, MA, MG, MS, MT, PA, SE and SP.	Tavares *et al.* (2013)	Peralta *et al.* (2011)	Bonadeu 544; 616	Reiner-Drehwald (1998)
**Cheilolejeunea holostipa* (Spruce) Grolle & R. L. Zhu		1				1	rare	Neotropical and Subtropical. AL, AM, BA, ES, MG, PA, PE, PR, RJ and SP.	Tavares *et al.* (2013)		Bonadeu 519	Gradstein & Ilkiu-Borges (2009)
***Cheilolejeunea neblinensis* Ilkiu-Borges & Gradstein	5					5	rare	Amazônia. AM			Macedo 985; 1009	Ilkiu-Borges & Gradstein (2008)
**Cheilolejeunea oncophylla* (Ångstr.) Grolle & E. Reiner	42	9				51	very frequent	Neotropical and Subtropical. AL, AP, BA, MG, PA, PR, RJ, RR, SC and SP.	Tavares *et al.* (2013)		Macedo 920; 899	Grolle & Reiner-Drehwald (1997); Reiner-Drehwald (1998)
Cololejeunea camillii (Lehm.) A. Evans	11	3	1			15	constant	Neotropical. AL, AM, CE, MA, MG, PA, RJ and SP.		Peralta *et al.* (2011)	Bonadeu 389; 616	Gradstein & Costa (2003) como *Aphanolejeunea camillii* (Lehm.)R. M. Schust.
**Cololejeunea contractiloba* A. Evans	2	2				4	rare	Neotropical. BA, PA, PE, RJ and SP.			Bonadeu 618	Gradstein & Ilkiu-Borges (2009)
Cololejeunea diaphana A. Evans	6	1	1			8	infrequent	Pantropical and Subtropical. AL, AM, BA, DF, ES, GO, MG, MA, MS, MT, PA, PE, RJ, RS, SC and SP.			Macedo 877; 898	Gradstein & Ilkiu-Borges (2009) como *Aphanolejeunea truncatifolia* Horik.
**Diplasiolejeunea brunnea* Steph.			1			1	rare	Neotropical and Subtropical. AC, AL, AM, AP, BA, CE, ES, MT, PA, PE, RJ, RO, SC and SP.			Bonadeu 495	Reyes (1982); Ilkiu-Borges (2000)
Haplolejeunea sp.	8					8	infrequent				Macedo 946; 970	
**Harpalejeunea stricta* (Lindenb. & Gottsche) Steph.	1	2				3	rare	Neotropical and Subtropical. AC, AL, BA, MG, PA, PE, RJ, SC and SP.	Tavares *et al.* (2013)		Macedo 905; 1020	Gradstein & Ilkiu-Borges (2009)
**Lejeunea adpressa* Nees	49	5				54	very frequent	Neotropical and Subtropical. AC, AL, AM, BA, CE, ES, MS, MT, PA, PE, PR, RJ, RR, SC, SE and SP.	Tavares *et al.* (2013) como *L. magnoliae* Lindenb. & Gottsche		Macedo 987; 993	Reiner-Drehwald (2009)
**Lejeunea boryana* Mont.	1					1	rare	Neotropical. AC, AM, BA, PA, RJ and RR.			Macedo 993	Reiner-Drehwald & Goda (2000)
**Lejeunea caulicalyx* (Steph.) E. Reiner & Goda	29	24				53	very frequent	Neotropical and Subtropical. AC, AL, BA, CE, ES, MS, MT, PA, PE, PR, RJ, RR and SP.	Tavares *et al.* (2013)		Macedo 856; 860	Reiner-Drehwald & Goda (2000)

Continues.

Table 1. Continuation.

FAMILY/SPECIES	Co	Ex	Ep	Te	Cu	N.O.	OCCURRENCE CLASSES	GEOGRAPHIC DISTRIBUTION	RECORDS IN LITERATURE		VOUCHER	DESCRIPTION AND ILLUSTRATION
									NE. PA	MA		
****Lejeunea obidensis* Spruce	18	7				25	frequent	Amazônia. AM (c. l.) and PA			Bonadeu 427; 538	Spruce (1884); Moura *et al.* (2013)
Lejeunea phyllobola Ness & Mont.		1				1	rare	Neotropical and Subtropical. AC, AL, AM, BA, CE, DF, ES, GO, MA, MG, MS, MT, PA, RJ, RN, RS, SC and SP.		Yano *et al.* (2009)	Bonadeu 427	Reiner-Drehwald (2000)
Lejeunea sp.	4					4	rare				Macedo 967; 900	
**Lejeunea tapajosensis* Spruce	2	2				4	rare	Neotropical. AC, AL, AM, BA, ES, PA, PE and RJ.	Tavares *et al.* (2013)		Bonadeu 424	Reiner-Drehwald (2000)
**Leptolejeunea elliptica* (Lehm. & Lindenb.) Schiffn.			1			1	rare	Neotropical and Subtropical. AC, AL, AM, AP, BA, CE, DF, ES, GO, MG, MT, PA, PE, PR, RJ, RR, SC, SE and SP.	Tavares *et al.* (2013)		Macedo 877	Gradstein & Ilkiu-Borges (2009)
Microlejeunea epiphylla Bischl.	11	2				13	constant	Neotropical. AL, AP, BA, CE, ES, GO, MA, MG, MS, PA, PB, PE, RJ, SE, SP and TO.	Tavares *et al.* (2013)	Yano *et al.* (2009)	Macedo 902; 1010	Bischler *et al.* (1963)
***Pictolejeunea picta* (Gottsche ex Steph.) Grolle	2					2	rare	Neotropical and Subtropical. AM, PA, RJ and SC.	Tavares *et al.* (2013)		Macedo 852; 978	Gradstein & Ilkiu-Borges (2009)
**Prionolejeunea denticulata* (Weber) Schiff.	4	1				5	rare	Neotropical. AM, BA, CE, ES, PA, PE, RJ, RR and SP.	Tavares *et al.* (2013)		Macedo 874; 995	Ilkiu-Borges (2006)
**Rectolejeunea emarginuliflora* (Gottsche) A. Evans	1					1	rare	Neotropical. AM, BA, PA and SP.			Macedo 1023	Evans (1906); Gradstein & Ilkiu-Borges (2009)
**Rectolejeunea fragelliformis* A. Evans	5	2				7	infrequent	Neotropical. AM, BA, PE and SP.			Macedo 986; 1000	Gradstein & Ilkiu-Borges (2009)
Stictolejeunea squamata (Willd. ex Weber) Schiffn.	9	1				10	infrequent	Neotropical and Subtropical. AC, AL, AM, AP, BA, ES, MA, MG, PA, PE, RJ, RS, SC and SP.	Tavares *et al.* (2013)	Yano *et al.* (2009)	Macedo 992; 993	Gradstein & Ilkiu-Borges (2009)
***Vitalianthus urubuensis* Zartman & Ackerman		1				1	rare	Amazônia. AM and PA.			Macedo 928	Zartman & Ackerman (2002); Lisboa & Osakada (2005)
Lophocoleaceae												
**Chiloscyphus liebmannianus* (Gottsche) J. J. Engel & R. M. Schust.	2					2	rare	Neotropical. AC, AM, AP, DF, MT, PA, PE, and SP.			Macedo 696; 866	Gradstein & Ilkiu-Borges (2009)
Plagiochilaceae												
**Plagiochila montagnei* Nees	19					19	constant	Neotropical. AC, AL, AM, AP, BA, CE, ES, PA, PE, RJ and SP.			Macedo 885; 710	Gradstein & Ilkiu-Borges (2009)
**Plagiochila rutilans* Lindenb.	3					3	rare	Neotropical and Subtropical. AC, AM, AP, BA, CE, ES, MG, MT, PA, PE, RJ, RR, RS, SC and SP.	Tavares *et al.* (2013)		Macedo 893; 889	Gradstein & Ilkiu-Borges (2009)

Continues.

Table 1. Continuation.

FAMILY/SPECIES	Co	Ex	Ep	Te	Cu	N.O.	OCCURRENCE CLASSES	GEOGRAPHIC DISTRIBUTION	RECORDS IN LITERATURE		VOUCHER	DESCRIPTION AND ILLUSTRATION
									NE. PA	MA		
Radulaceae												
**Radula flaccida* Lindenb. & Gottsche ex Steph.	13	2	1			16	constant	Afro-Americana. AC, AL, AM, BA, ES, MG, PA, RR and SP.	Tavares *et al.* (2013)		Macedo 966; 997	Gradstein & Costa (2003); Gradstein & Ilkiu-Borges (2009)
**Radula mammosa* Spruce			3			3	rare	Neotropical. AM, BA, PA, RJ and SP.	Tavares *et al.* (2013)		Macedo 862; 864	Gradstein & Costa (2003); Tavares *et al.* (2014)
BRYOPHYTA												
Calymperaceae												
Calymperes erosum Müll. Hal.	3	3				6	infrequent	Pantropical. AC, AM, AP, BA, CE, ES, GO, MA, MG, MT, PA, PB, PE, RJ, RO, RR, SP and TO.	Lisboa & Tavares (2008); Ilkiu-Borges *et al.* (2009); Santos & Lisboa (2003, 2008); Tavares *et al.* (2013)	Peralta *et al.* (2011)	Bonadeu 537; Macedo 926	Reese (1993); Buck (2003)
Calymperes lonchophyllum Schwägr.	7					7	infrequent	Pantropical and Subtropical. AC, AL, AM, AP, BA, ES, GO, MA, MG, MS, MT, PA, PE, PR, RJ, RO, RR, SP and TO.	Santos & Lisboa (2003, 2008); Tavares *et al.* (2013)	Peralta *et al.* (2011)	Bonadeu 618; Macedo 859	Florschütz (1964); Reese (1993)
Octoblepharum albidum Hedw.	13	1				14	constant	Pantropical and Subtropical. AC, AL, AM, AP, BA, CE, DF, ES, GO, MA, MG, MS, MT, PA, PB, PE, PI, PR, RJ, RN, RO, RR, RS, SC, SE, SP and TO.	Lisboa & Tavares (2008); Santos & Lisboa (2003, 2008); Tavares *et al.* (2013)	Peralta *et al.* (2011)	Bonadeu 447; Macedo 805	Florschütz (1964); Yano (1992)
***Syrrhopodon cymbifolius* Müll. Hal.	19	11				30	frequent	Neotropical. AM, AP, ES, GO, PA and SP.			Macedo 917; 921	Reese (1981; 1993); Buck (2003)
Syrrhopodon incompletus Schwägr.	8					8	infrequent	Afro-Americana. AC, AL, AM, AP, BA, DF, GO, MA, MG, MS, MT, PA, PE, PB, PR, RJ, RO, RR, SC, SP and TO.	Santos & Lisboa (2003, 2008); Tavares *et al.* (2013)	Peralta *et al.* (2011)	Macedo 946; 949	Florschütz (1964); Peralta (2005)
Fissidentaceae												
Fissidens angustifolius Sulliv.		1		1	1	3	rare	Pantropical and Subtropical. AC, AM, BA, CE, GO, MA, PA, PB, PE, PI, RJ, RS, RO and SP.		Peralta *et al.* (2011)	Bonadeu 493; 496	Lisboa (1993); Pursell (2007)
Fissidens guianensis Mont.	119	15		1		135	very frequent	Neotropical and Subtropical. AC, AL, AM, AP, BA, CE, DF, ES, GO, MA, MG, MS, MT, PA, PB, PE, PI, PR, RJ, RO, RR, RS, SC, SP and TO.	Lisboa & Tavares (2008); Santos & Lisboa (2003, 2008); Tavares *et al.* (2013)	Peralta *et al.* (2011); Yano *et al.* (2009)	Bonadeu 502; Macedo 815	Buck (2003); Pursell (2007)

Continues.

Table 1. Continuation.

FAMILY/SPECIES	Co	Ex	Ep	Te	Cu	N.O.	OCCURRENCE CLASSES	GEOGRAPHIC DISTRIBUTION	RECORDS IN LITERATURE		VOUCHER	DESCRIPTION AND ILLUSTRATION
									NE. PA	MA		
Fissidens palmatus Hedw.				2		2	Rare	Neotropical. AC, AM, BA, CE, DF, FN, GO, MA, MG, MT, PA, PE, RJ, RO and SP.		Peralta *et al.* (2011)	Macedo 704; 837	Florschütz (1964) como *Fissidens reticulosus* (Mull. Hal.) A. Jaeger; Pursell (2007)
**Fissidens pellucidus* Hornsch.	6	4		4	4	18	constant	Neotropical and Subtropical. AC, AM, BA, CE, DF, ES, GO, MG, MT, PA, PB, PE, PR, RJ, RO, RR, RS, SC, SP and TO.	Santos & Lisboa (2003); Tavares *et al.* (2013)		Bonadeu 401; 460	Florschütz (1964); Pursell (2007)
**Fissidens prionodes* Mont.				2		2	rare	Guiana and Amazônia. AC, AM, MT, PA, RO and RR.			Macedo 934; 965	Florschütz (1964); Pursell (2007)
Pilotrichaceae												
Callicostella pallida (Hornsch.) Ångstr.	1	7			1	9	infrequent	Neotropical and Subtropical. AC, AL, AM, AP, BA, CE, DF, ES, GO, MA, MG, MS, MT, PA, PE, PR, RJ, RO, RR, RS, SC, SE, SP and TO.	Santos & Lisboa (2003, 2008), Tavares *et al.* (2013)	Peralta *et al.* (2009)	Bonadeu 400; Macedo 860	Florschütz-de Waard (1986) como *Schizomitrium pallidum* (Hornsch.) Crum & Anderson; Buck (2003)
**Lepidopilum scabrisetum* (Schwägr.) Steere	1					1	rare	Neotropical and Subtropical. AC, AL, AM, AP, BA, CE, MG, MT, PA, PE, PR, RJ, RO, RR RS, SC and SP.			Bonadeu 428	Buck (2003); Peralta (2005)
Pylaisiadelphaceae												
**Isopterygium subbrevisetum* (Hampe) Broth.	2	2				4	rare	Neotropical and Subtropical. AC, AL, AM, AP, BA, CE, MG, PA, PR, RJ, RR, RO, RS, SC and SP.	Lisboa & Tavares (2008), Santos & Lisboa (2003, 2008), Tavares *et al.* (2013)		Bonadeu 443; 461	Florschütz-de Waard & Veling (1996); Buck (2003)
Taxithelium planum (Brid.) Mitt.		2				2	rare	Pantropical and Subtropical. AC, AL, AM, AP, BA, DF, ES, GO, MA, MG, MS, MT, PA, PB, PE, PR, RJ, RO, RR, SC, SP and TO.	Santos & Lisboa (2003, 2008), Tavares *et al.* (2013)	Peralta *et al.* (2011)	Macedo 752; 994	Florschütz-de Waard (1996); Buck (2003)
Sematophyllaceae												
Sematophyllum subpinnatum (Brid.) E. Britton		1				1	rare	Américas and Austrália. AC, AL, AM, AP, BA, CE, DF, ES, GO, MA, MG, MS, MT, PA, PB, PE, PR, RJ, RO, RR, RS, SC e SP and TO.	Lisboa & Tavares (2008), Santos & Lisboa (2003, 2008);	Peralta *et al.* (2011)	Macedo 1025	Florschütz-de Waard (1996); Buck (2003)
Sematophyllum subsimplex (Hedw.) Mitt.	12	16		1		29	frequent	Afro-americana. AC, AM, AP, BA, CE, DF, ES, GO, MA, MG, MS, MT, PA, PB, PE, PI, PR, RJ, RO, RR, RS, SC, SE, SP and TO.	Santos & Lisboa (2003, 2008), Tavares *et al.* (2013)	Peralta *et al.* (2011)	Bonadeu 538; Macedo 980	Florschütz-de Waard (1996); Buck (2003)

Continues.

Table 1. Continuation.

FAMILY/SPECIES	Co	Ex	Ep	Te	Cu	N.O.	OCCURRENCE CLASSES	GEOGRAPHIC DISTRIBUTION	RECORDS IN LITERATURE		VOUCHER	DESCRIPTION AND ILLUSTRATION
									NE. PA	MA		
**Trichosteleum papillosum* (Hornsch.) A. Jaeger.	10	19		1		30	frequent	Neotropical and Subtropical. AC, AL, AM, AP, BA, ES, GO, MG, MT, PA, PE, RJ, RO, RR, SC, SE, SP and TO.	Santos & Lisboa (2003, 2008), Tavares *et al.* (2013)		Macedo 991; 996	Florschütz-de Waard (1996); Buck (2003)
Stereophyllaceae												
Pilosium chlorophyllum (Hornsch.) Müll. Hal.	43	39		1	1	84	very frequent	Neotropical and Subtropical. AC, AL, AM, AP, BA, CE, DF, ES, GO, MG, MS, MT, PA, PE, RJ, RO, RR, RS, SP and TO.	Santos & Lisboa (2003, 2008), Tavares *et al.* (2013)	Peralta *et al.* (2011)	Macedo 1005; 1013	Ireland & Buck (1994); Peralta (2005)
**Pelekium scabrosulum* (Mitt.) Touw	28	22				50	very frequent	Neotropical. AC, AM, AP, BA, DF, GO, MT, PA, PE, RO and RR.	Santos & Lisboa (2003, 2008), Tavares *et al.* (2013)		Bonadeu 423; 497	Florschütz-de Waard (1996) como *Cyrtohypnum scabrosulum* (Mitt.) W. R. Buck & Crum.
TOTAL OF OCCURRENCE OF SPECIES	705	247	10	13	8	983						
TOTAL OF SPECIES	48	42	8	8	5	62						

Table 2. Richness of bryophytes recorded in the Gurupi Biological Reserve, at other localities within the state of Maranhão and in the northeastern part of the state of Pará.
*Group not included in the study cited.

PAPERS	Municipality/State	Liverworts	Mosses	Hornworts
Santos & Lisboa 2003	Vários municípios/PA	*	79	*
Lisboa & Santos 2005	Capanema/PA	1	5	*
Lisboa & Tavares 2008	Santarém Novo/ PA	11	27	*
Santos & Lisboa 2008	Vários municípios/ PA	*	36	*
Ilkiu-Borges *et al.* 2009	Maracanã/ PA	6	8	*
Tavares *et al.* 2013	Capitão-Poço/ PA	66	33	*
Yano *et al.* 2009	Vários municípios/MA	24	30	1
Peralta *et al.* 2011	Vários municípios/MA	42	99	2
Costa 2013	Vários municípios/MA	26	55	2
REBIO do Gurupi	Bom Jardim e Centro Novo/MA	43	19	*

and Costa (2013). However, those studies included species collected in different ecosystems and types of vegetation, whereas Maranhão presents not only Amazonian landscapes but also areas of savanna and shrublands (Yano *et al.* 2009; Oren & Roma 2011), which could explain the high number of species, especially mosses, recorded for the state.

The richness found in the Gurupi Biological Reserve was higher than that recorded for the state of Maranhão by Yano *et al.* (2009). However, that study was based on samples collected in five states in northeastern Brazil and did not deal with the study of a locality or specific area in Maranhão.

Comparing the species collected in the Gurupi Biological Reserve with those recorded for the state of Maranhão in general and for northeastern Pará (Tab. 1), the bryophytes from the reserve represent 28.9% of the bryophytes in the state as a whole and 31.3% of the those in northeastern Pará. Regarding the species collected in the reserve, 42 (28 liverworts and 14 mosses) have already been reported for northeastern Pará (Tab. 2) and 17 (5 liverworts and 12 mosses) have already been reported for the state of Maranhão (Tab. 1).

Our results lead us to assert that in terms of its bryoflora, the Gurupi Biological Reserve has more similarities with

northeastern Pará than with the rest of the state of Maranhão. In addition, the reserve includes 15 species that have yet to be cited for northeastern Pará but have already been recorded for other localities in the Amazon, demonstrating the relevance of this area for the state of Maranhão and northeastern Pará (Tab. 1). The presence of typical Amazon species such as *Cheilolejeunea neblinensis*, *Fissidens prionodes* Mont., *Lejeunea obidensis* and *Vitalianthus urubuensis* increase the importance of conserving the remaining areas of the Amazon Biome in Maranhão.

It was expected that the bryoflora of the study area would be similar to that of northeastern Pará (Santos & Lisboa 2003, 2008; Lisboa & Santos 2005; Lisboa & Tavares 2008; Ilkiu-Borges *et al.* 2009; Tavares *et al.* 2014), because both belong to the same biome and are areas impacted by occupancy and modification of the landscape, which explains the occurrence of species with wide ecological amplitude, which usually have a broad distribution.

Conclusion

Many of the species found in the Gurupi Biological Reserve were expected, given the degree of knowledge of the bryoflora of northeastern Pará, because the two areas belong to the same biome and have similar histories of occupation and modification of the landscape. The unique Amazon elements found in this reserve underscore their affinity for this biome. The importance of this conservation area to the state of Maranhão and to the portion of the Amazon within the state is confirmed by the high number of new records for the state, five of which are also new records for northeastern Brazil.

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