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Original Paper
The importance of Serra do Mar State Park for liverworts conservation in the Atlantic Rainforest

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Abstract

Serra do Mar State Park (PESM) is located in southeastern São Paulo state, Brazil, and is the largest Atlantic Rainforest conservation area in the country. The park is divided into 10 nuclei, and the Itutinga-Pilões nucleus (NIP) was selected for study since no survey of liverworts species richness had yet been conducted there. The floristic similarities between the NIP and different areas of Atlantic Rainforest in São Paulo state were also assessed. One hundred and eighty liverworts species were identified in the three vegetation types (lowland, submontane, and montane ombrophilous forests) encountered in the NIP, distributed among 62 genera and 21 families. Lejeuneaceae showed the highest species richness with 80 species. The high number of epiphyllous species found in the study area (26% of all species) was notable. In terms of their worldwide distributions, 57% of the species are Neotropical. Clustering analysis showed that the areas of the PESM and Jureia-Itatins Ecological Station were grouped together with the highest similarity values. The liverworts flora of the NIP demonstrates the importance of that nucleus for the conservation of liverworts diversity in the Atlantic Rainforest of the São Paulo state, as well as in Brazil.
Key words: Atlantic rainforest, floristic, Itutinga-Pilões, liverworts, similarity.

Resumo

O Parque Estadual da Serra do Mar (PESM) está localizado no sudeste do estado de São Paulo, Brasil sendo a maior unidade de conservação de Mata Atlântica do país. O parque é dividido em 10 núcleos, sendo o Núcleo Itutinga-Pilões (NIP) selecionado para este estudo, visto que não foi realizado nenhum estudo analisando a riqueza de espécies de hepáticas nessa área. As similaridades florísticas entre o NIP e diferentes áreas da Mata Atlântica no estado de São Paulo também foram avaliadas. Cento e oitenta espécies de hepáticas foram identificadas nos três tipos de vegetação (floresta ombrófila de terras baixas, submontana e montana) encontradas no NIP, distribuídas em 62 gêneros e 21 famílias. A família Lejeuneaceae apresentou a maior riqueza com 80 espécies. O elevado número de espécies epífilas encontradas na área de estudo (26% de todas as espécies) foi notável. Em termos de suas distribuições mundiais, 57% das espécies são Neotrópicais. A análise de agrupamento mostrou que as áreas do PESM e Estação Ecológica Jureia-Itatins foram agrupadas com os maiores valores de similaridade. A flora de hepática do NIP demonstra a importância desse núcleo para a conservação da diversidade de hepáticas na Mata Atlântica do estado de São Paulo, bem como no Brasil.
Palavras-chave: Mata Atlântica, florística, Itutinga-Pilões, hepáticas, similaridade.

Introduction

Approximately 1,550 species of bryophytes are recognized for Brazil, of which 661 are liverworts (Marchantiophyta), among then 558 species are found in the Brazilian Atlantic Rainforest, with 415 recorded for São Paulo state (Bryophytes in Flora do Brasil 2020 under construction).

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Our current knowledge concerning liverworts species in the Atlantic Rainforest of São Paulo state reflects the contributions of Puiggari (1881- four species); Loefgren (1896 - 25 species), Schiffner & Arnell (1964 - 403 species), and Hell (1969 - 30 species). Starting in 1989, several floristic and ecological studies were carried out in that state (Giancotti & Vital 1989; Visnadi & Vital 1989; Vital & Visnadi 1994; Rebelo *et al.* 1995; Visnadi 1998, 2005; Santos 2011; Santos *et al.* 2011; Visnadi 2011, 2012, 2013a,b, 2015; Carmo *et al.* 2016), encompassing approximately 360 species of liverworts. In contrast, there has been only three studies with the liverworts of Serra do Mar State Park.

The Serra do Mar State Park (PESM) was created in 1977 to help preserve remnants of the Atlantic Rainforest in the Serra do Mar mountain range of São Paulo state. It is the largest conservation area of Brazilian Atlantic Rainforest covering 332,000 hectares and encompassing 25 municipalities (IF 2008). The park was divided into 10 nuclei, and the Itutinga-Pilões (NIP), in the central area of the park, was selected for the present study as no survey liverworts species richness had yet been conducted there.

As such, this represents the first investigation providing an overview of the liverworts flora of Itutinga-Pilões nucleus, and incorporates new reports of liverworts taxa. We aimed analyze the liverworts species richness, floristic composition, substrate colonization, phytogeographic patterns in different vegetation types found there, and assessed the floristic similarities between the NIP and different areas of Atlantic Rainforest in the São Paulo state.

Material and Methods

Study area

The Itutinga-Pilões nucleus is located in the Serra do Mar State Park, wich borders eight cities (Cubatão, Mogi das Cruzes, Praia Grande, Santos, Santo André, São Bernardo do Campo, São Paulo, and São Vicente) and covers 43,800 ha, with altitudes ranging from 5 to 1,020 m a.s.l., with average annual rainfall of approximately 3,000 to 5,500 mm (IF 2008).

According to Veloso *et al.* (1991), there are three different types of Dense Ombrophilous Forest in the Itutinga-Pilões nucleus: lowland forest (5–50 m a.s.l.); submontane forest (50–500 m); and montane forest (500–1,020 m).

Data collection and identification

Three hundred and thirty-five samples from the study area were encountered in the HUSC and SP herbaria. Most of these samples were collected by two researchers from the Institute of Botany of São Paulo, Daniel Moreira Vital from 1974 to 1989 along the Mogi river valley (20–800 m) and Dr. Olga Yano from 1991 to 1999 on a section of the Imigrantes Highway (ca. 500 m) and Calçada do Lorena (500–800 m). In addition, some samples collected by Alfons Schäfer-Verwimp and Zélia Rodrigues de Mello (SP and HUSC) were studied.

Six field expeditions were made in the different vegetation types of the NIP, between 2016 and 2017, one for lowland forests, two for submontane forest, two for montane forest, and one for the riverbanks on the three vegetions. The collections were made by randomly searching through all of the available microhabitats and substrates. Samples were collected on the tree trunks at heights up to two meters. The procedures of collecting and herborization of material followed the methodology described by Yano (1984). All voucher specimens were deposited in the RB herbarium, with duplicates in HUSC.

Identification of the taxa followed Gradstein *et al.* (2001), Gradstein & Costa (2003), Dauphin (2003), Reiner-Drehwald (2007), Costa (2008), Pócs *et al.* (2014), Gradstein (2015, 2017), and Ilkiu-Borges (2005, 2016). When necessary comparisons were made with the collections housed at HUSC and RB herbaria.

The classification system adopted was based on Crandall-Stotler *et al.* (2009) for Marchantiophyta, with updates published by Söderström *et al.* (2016) in the World Checklist of Liverworts and Hornworts.

Data analysis

The results of the floristic analyses are presented in alphabetical order by family, genera, and species, including vegetation type, elevational range, substrate, Brazilian and worldwide distributions, and voucher.

Global geographic distribution patterns were determined according to the data available in the literature (Gradstein & Costa 2003; Dauphin 2003; Reiner-Drehwald 2007; Costa 2008; Pócs *et al.* 2014; Gradstein 2015, 2017; Ilkiu-Borges 2016); the Brazilian distribution

according to Bryophytes, in the Flora do Brasil 2020 site, under construction.

Liverworts floristic compositions were compared among six different areas from São Paulo state that contain ombrophilous dense forests among their vegetations (Tab. 1), calculating their similarities using the Sörensen coefficient and the dendrogram were made using the UPGMA (unweighted pair group method analysis), performed on PAST software (Hammer *et al.* 2001). The Sörensen index was chosen because it is a qualitative index that gives more weight to the species that are common to the different samples and not those that only occur in a sample.

Table 1 – Areas of Atlantic Rainforest of the São Paulo state included in this study for the analysis of floristic similarity. MAN = mangrove; FR = restinga forest; LL = lowland forest; SM = submontane forest; MT = montane forest; AM = upper montane forest.

Localities	Hectares	Altitude	Vegetation	Reference
PESM - NIP	43.800	5-1.020 m	LL, SM e MT	This study
PESM - Núcleo Picinguaba (PESM-NPC)	47.500	0-1.280 m	LL, SM e MT	Visnadi 2005; Santos 2011
PESM - Núcleo Santa Virginia (PESM-NSV)	17.500	400-1.650 m	SM, MT, AM	Santos 2011; Carmo *et al.* 2016
Reserva Biológica Alto da Serra de Paranapiacaba (RB-ASP)	336	750-900 m	MT	Visnadi 2005; Hell 1969
Estação Ecológica Juréia-Itatins (EEJI)	92.223	0-450 m	MAN, FR, LL, SM	Visnadi 2012
Parque Estadual Intervales (PEI)	41.704	80-1.200 m	SM, MT	Visnadi 2015

Results and Discussion

Species richness

A total of 831 samples were analyzed, 496 were collected in the present study (97 from lowland forest, 222 from submontane forest, and 177 from montane forest), and 335 samples were encountered housed at the SP and HUSC herbaria (112 from lowland forest, 87 from submontane forest, 47 from montane forest, and 89 with no vegetation type specified on the herbarium label).

We identified 21 families, 62 genera, 180 species of liverworts (Tab. S1, available on supplementary material <https://doi.org/10.6084/m9.figshare.13017746.v1) - representing approximately 44% of the liverworts species known to São Paulo state, and 27% of thoses known to Brazil (Bryophytes in BFG 2018 and Flora do Brasil 2020 under construction), demonstrating that the NIP is an important remnant of Atlantic Rainforest.

Analyzes of liverworts species richness in the three vegetation types showed 88 species from lowland forests (22 exclusive; 24%); 111 from submontane forests, (37 exclusive; 33%); and 96 from montane forests (31 exclusive; 32%). Thirty-six species occurred in all three vegetation types. The submontane forest therefore had the highest species richness and number of exclusive taxa. Those results were different from Costa & Lima (2005), Santos (2008), and Costa *et al.* (2015) for the Atlantic Rainforest in southeastern Brazil, where the montane forests concentrate the highest number of species. That difference may reflect the fact that our study did not sample the forest canopy or a necessity of more sampling efforts in the montane forests.

Floristic composition

A total of 21 liverwort families were found representing 68% of the families known to São Paulo state and 52.5% of those known to Brazil. In terms of their number of taxa, the most well represented families were Lejeuneaceae (80 spp. - 45% of the total species number), Plagiochilaceae (14 spp. - 7.8%), Lepidoziaceae (12 spp. - 6.7%) Metzgeriaceae (11 spp. - 6.1%), and Aneuraceae (11 spp. - 6.1%) - altogether accounting for 70% of the total taxa. The three families with the greatest

representation [Lejeuneaceae (26% of the total taxa known for Brazil), Plagiochilaceae (57%), and Lepidoziaceae (25%)] are common in all floristic surveys undertaken in tropical forests (Gradstein & Pócs 1989).

Costa (2008) recognized 26 species of the family Metzgeriaceae for Brazil, and considered the Atlantic Rainforest as a center of its diversity (46% of total taxa for Brazil). The NIP harbors 41% of the Brazilian species of Metzgeriaceae. The family Aneuraceae has 15 species recognized for Brazil (three species of *Aneura* and 12 of *Riccardia* - Bryophytes in Flora do Brasil 2020 under construction), and 10 species found in the NIP (83%). Those two families are among the most well represented families in the study area, being the species of Aneuraceae almost always found in very humid places, near waterfalls or water courses, while Metzgeriaceae were also found in humid places so as in the understoryes, mainly in living trunks, and both were found in the three vegetation formations.

The family Lejeuneaceae was well-represented in the three vegetation types of the NIP. That result was expected, and as it that specially species-rich in the Atlantic Rainforest (Costa 2009), and concentrates 70% of all liverworts species encountered in floristic inventories in the tropical Americas (Gradstein *et al.* 2001) and in the Atlantic Rainforest of the São Paulo state (Visnadi 2005; Yano & Peralta 2007; Peralta & Yano 2008; Visnadi 2009, 2012, 2013a,b, 2015; Carmo *et al.* 2016).

The family Trichocoleaceae was only found in the montane forest sites above 700 m. That result was similar to reports by Visnadi (1998), Santos (2011), and Carmo *et al.* (2016) that also found it in the montane forests of São Paulo state.

The most representative genera in NIP were *Lejeunea* (21 species); *Plagiochila* (13 species); *Metzgeria* (11 species); *Riccardia* and *Cheilolejeunea* (10 species each); *Cololejeunea*, *Drepanolejeunea*, and *Radula* (seven species each), and according to Gradstein & Pócs (1989) and Gradstein *et al.* (2001) those are the principal genera found in most floristic surveys in the tropics. Other well-represented genera in our survey were *Metzgeria* and *Riccardia*, which have their known centers of diversity in southeastern Brazil (Costa 2008; Santos 2008).

The high species richness found in the genera *Riccardia, Lejeunea*, *Metzgeria*, and *Plagiochila* demonstrated the importance of that Atlantic Rainforest remnant in São Paulo state for liverworts conservation - as more than 40% of the liverworts species known to São Paulo state, and more than 30% for the Atlantic Rainforest species, have been recorded here.

The present study demonstrated that new collection efforts in many areas of São Paulo state can still evidence other novelties similar to those presented below.

Prionolejeunea scaberula (Spruce) Steph. was cited by Costa & Peralta (2015) for the São Paulo state, but without a voucher, in the present study was encountered in lowland forests.

Rectolejeunea truncatilobula C. Bastos is cited here for only the second time in 35 years for São Paulo state (Ilha do Cardoso), it was encountered in submontane forest.

Plagiochila aerea Taylor is a montane Atlantic Rainforest species, recorded here for the first time to São Paulo state.

Vitalianthus bischlerianus (Pôrto & Grolle) R.M.Schust. & Giancotti is endemic to the Brazilian Atlantic Rainforest. It was found here for the first time growing on living leaves, but is more typical of tree trunks, and is considered here a facultative epiphyllous species.

Substrate colonization

Regarding substrate colonization, 100 species were found to be corticolous, 54 rupiculous, 48 were epiphyllous; 38 were epixylous, 24 terricolous, and two on artificial substrate (iron ducts) (Fig. 1).

The high number of epiphyllous species encountered (26% of the total number) was remarkable, and represents fully 39% of the total number of the epiphyllous liverworts species recognized for Brazil (Bryophytes in Flora do Brasil 2020 under construction). They were found

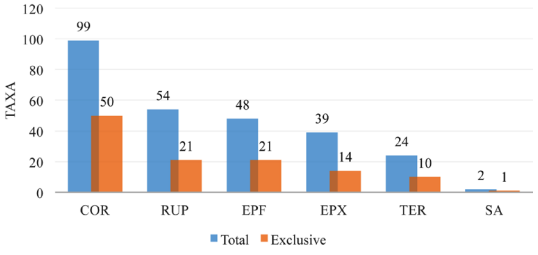

Figure 1 – Total number of species per substrate. COR = corticicolous; RUP = rupicolous; EPF = epiphyllous; EPX = epixilous; TER = terricolous; SA = artificial substrate.

in the three vegetation formations, and according to Gradstein (1992), epiphyllous bryophytes comprise a threatened category in anthropogenically impacted environments due to their sensitivity to disturbances and their preference for preserved areas, with species richness in plantations and secondary forests being much lower than in primary forests. Epiphyllous species require low solar radiation levels, high water retention by the epibiont leaf surfaces, and well preserved environments. We therefore consider the NIP forests as well preserved.

Phytogeographic patterns

Eight phytogeographic patterns were recognized among the liverworts sampled (Tab. 2), the majority of taxa demonstrated Neotropical distributions (102 spp. - 57%.), followed by taxa endemic to Brazil (16 spp. - 9%), Pantropical taxa (14 spp. - 7.9%), Afro-American taxa (13 spp. - 7.3%), together representing 80% of the total taxa encountered.

The predominance of the Neotropical species is common in floristic surveys undertaken in Brazil (Costa & Silva 2003; Santos & Costa 2010; Visnadi 2012; Carmo *et al.* 2016; Carmo & Peralta 2016).

Sixteen encountered taxa are known to be endemic to Brazil, of which 11 species are endemic to Brazilian Atlantic Rainforest (ca. 20% of the total number of endemic liverworts recognized for that biome) (Bryophytes in Flora do Brasil 2020 under construction). They were found colonizing living trunks (10 spp.), leaves (four spp.), rocks (four spp.), soil (three spp.), and dead trunk (one spp.). Those results also demonstrate the importance of the NIP for the conservation of the endemic species from the Atlantic Rainforest, which is considered a center of endemism for liverworts in Brazil (Gradstein & Costa 2003).

Floristic similarities

Analyzes of the similarities between the liverworts compositions of six different areas, demonstrated that the floristic affinity between the six areas varied from 31% to 63% (Tab. 3). The highest similarities were observed among areas of Serra do Mar State Park, while the lowest similarity was between PESM-NSV (Santa Virginia Nucleus) and RBASP (Alto da Serra de Paranapiacaba Biological Reserve) (the areas with highest and lowest species richness respectively).

The areas PEI (Intervales State Park) and RBASP were considered to be poorly sampled in light of the low numbers of species found (83 and 68 spp. respectively), so that the results of the cluster analysis could be different if new surveys were carried out.

Clustering analysis revealed the existence of a group with similarity values varying between 52% and 63% [three areas in the PESM (NSV, NPC and NIP) and one area in the EEJI (Juréia-Itatins Ecological Station) (Fig. 2). Probably those four areas belong to the same Atlantic Rainforest continuum.

Table 2 – Phytogeographic patterns of the liverworts species found in the NIP. Percentages, in relation to the total number of species, are indicated in parentheses.

Distribution patterns	Abbreviation	Total spp.
Neotropical (distributed in the tropical America region)	Neo	102 (57%)
Endemic of Brazil	Bra	16 (9%)
Pantropical (widely distributed in tropical regions of America, Africa and Asia)	Pan	14 (7,9%)
Afro-American (disjoint distribution between the tropical regions of America and Africa)	Afr-Am	13 (7,3%)
Wide (found in three continents at least)	Amp	11 (5,6%)
Tropical and subtropical America (distributed in tropical and subtropical America in regions)	Am-TS	8 (4%)
Tropical South America (distributed in tropical region of South America)	AST	6 (3,4%)
Holartic (widely distributed in temperate regions in the northern hemisphere)	Holo	2 (1,1%)
Others (unidentified pattern)	Out	8 (4,5%)

Table 3 – Comparison of richness, similarity and shared taxa among the different Atlantic Rainforest areas of São Paulo state. Underline = similarity index (Sörensen); *Italic* = shared taxa; **bold** = area richness; A = PESM-NIP; B = PESM-NPC; C = PESM-NSV; D = RBASP; E = EEJI; F = PEI.

	A	B	C	D	E	F
A	**180**	*111*	*122*	*50*	*93*	*53*
B	0.62535211	**176**	*124*	*47*	*102*	*60*
C	0.59512195	0.60933661	**231**	*46*	*100*	*64*
D	0.4048583	0.3852459	0.30769231	**68**	*35*	*28*
E	0.56363636	0.62385321	0.52356021	0.3196347	**151**	*48*
F	0.40458015	0.46332046	0.40764331	0.37086093	0.41025641	**83**

The two areas with the highest similarity were NIP and NPC (63%). According to IF (2008), arriving cold fronts tend to retreat and stagnate before dissipating, resulting in a very high rainfall rates and similar climates in both areas. Additionally, we observed that those two nuclei have the same vegetation types and elevational ranges - which probably contributed to the grouping of these areas.

Conclusion

The liverworts flora found in NIP demonstrates the importance of the nucleus for the conservation of hepatic diversity in the Atlantic Rainforest of the state of São Paulo and Brazil, since in NIP occurs 42% of the known liverworts species to São Paulo and 32% to Atlantic Rain Forest of Brazil.

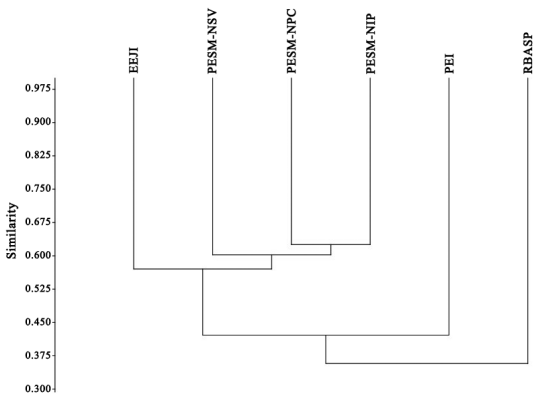

Figure 2 – Similarity dendrogram (Sörensen index) obtained by UPGMA of the six areas compared in this study. The acronyms of the areas correspond to those in Table 1.

We consider the studied area is in good state of conservation, since some of the main liverworts families of Atlantic Rain Forest are well represented, such as Metzgeriaceae, Plagiochillaceae, and Aneuraceae. In addition, a large number of epiphyllous species were found in the study area, a group threatened in disturbed environments due to high sensitivity to environmental disturbances (changes in humidity, luminosity and temperature) and with preference for preserved, humid and shaded sites.

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References

BFG - The Brazil Flora Group (2018) Brazilian Flora 2020: innovation and collaboration to meet Target 1 of the Global Strategy for Plant Conservation (GSPC). Rodriguésia 69: 1513-1527.

Carmo DM, Lima JS, Amélio LA & Peralta DF (2016) Briófitas do Parque Estadual da Serra do Mar, Núcleo Santa Virgínia, estado de São Paulo, Brasil. Hoehnea 43: 265-287.

Carmo DM & Peralta DF (2016) Survey of bryophytes in Serra da Canastra National Park, Minas Gerais, Brazil. Acta Botanica Brasilica 30: 254-265.

Costa DP (2008) Metzgeriaceae (Hepaticae). Flora Neotropica 102: 1-169.

Costa DP (2009) Briófitas. *In*: Stehmann JR, Forzza RC, Salino A, Sobral M, Costa DP & Kamino LHY (eds.) Plantas da Floresta Atlântica. Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, Rio de Janeiro. Pp. 13-17.

Costa DP & Lima FM (2005) Moss diversity in the tropical rainforests of Rio de Janeiro, southeastern Brazil. Revista Brasileira de Botânica 28: 671-685.

Costa DP & Peralta DF (2015) Bryophytes diversity in Brazil. Rodriguésia 66: 1063-1071.

Costa DP, Santos ND, Rezende MA, Buck WR & Schäfer-Verwimp A (2015) Bryoflora of the Itatiaia National Park along an elevation gradient: diversity and conservation. Biodiversity and Conservation 24: 2199-2212.

Costa DP & Silva AG (2003) Briófitas da Reserva Natural da Vale do Rio Doce, Linhares, Espírito Santo, Brasil. Boletim do Museu Biológico Melo Leitão 16: 21-38.

Crandall-Stotler B, Stotler RE & Long DG (2009) Morphology and classification of the Marchantiophyta. *In*: Goffinet B & Shaw AJ (eds.) Bryophyte Biology. 2nd ed. Cambridge University Press, New York. Pp. 1-54.

Dauphin G (2003) *Ceratolejeunea*. Flora Neotropica 90: 1-86.

Flora do Brasil 2020 under construction [continuously updated]. Available at <http://reflora.jbrj.gov.br/reflora/floradobrasil/FB128472>. Acess on 12 April 2017.

Giancotti C & Vital DM (1989) Flora briofítica da Reserva Biológica do Alto da Serra de Paranapiacaba, São Paulo: 1 - Lejeuneaceae (Hepaticopsida) (1). Acta Botanica Brasilica 3: 169-177.

Gradstein SR (1992) The Vanishing Tropical rain forest as environment for bryophytes and lichens. *In*: Bates JW & Farmer AM (eds.) Bryophytes and Lichens in a Changing Enviroment. Clarendon Press, Oxford. Pp. 234-258.

Gradstein SR (2015) Annotated key to the species of *Plagiochila* (Marchantiophyta) from Brazil. Pesquisas, Botânica 67: 23-36.

Gradstein SR (2017) *Bazzania* (Marchantiophyta) in South America. Nova Hedwigia 105: 1-24.

Gradstein SR, Churchill SP & Salazar-Allen N (2001) Guide to the Bryophytes of tropical America. Memoirs of the New York Botanical Garden 86: 1-577.

Gradstein SR & Costa DP (2003) The Hepaticae and Anthocerotae of Brazil. Memoirs of the New York Botanical Garden 87: 1-318.

Gradstein SR & Pócs T (1989) Bryophytes. *In*: Lieth H & Werger MJA (eds.) Tropical rain forest ecosystems. Elsevier Science Publishhers B.V., Amsterdan. Pp. 311-325.

Hammer Ø, Harper DAT & Ryan PD (2001) PAST: Paleontological statistics software package for education and data analysis. Palaeontologia Electronica 4: 9.

Hell KG (1969) Briófitas talosas dos arredores da cidade de São Paulo (Brasil). Boletim da Faculdade de Filosofia, Ciências e Letras, Universidade de São Paulo. Botânica 25: 3-187.

IF - Instituto Florestal do Estado de São Paulo (2008) Parque Estadual da Serra do Mar – Plano de Manejo. Instituto Ekos Brasil, São Paulo. 483p.

Ilkiu-Borges AL (2005) A taxonomic monograph of the genus *Prionolejeunea* (Lejeuneaceae, Jungermanniopsida). Tese de Doutorado. Georg-August-University, Göttingen. 191p.

Ilkiu-Borges AL (2016) *Prionolejeunea* (Lejeuneaceae, Jungermanniopsida). Flora Neotropica 116: 1-131.

Loefgren A (1896) Índice das plantas do herbário da Comissão Geographica e Geológica de S. Paulo. Boletim da Comissão Geographica e Geologica de São Paulo 11: 208-215.

Peralta DF & Yano O (2008) Briófitas do Parque Estadual da Ilha Anchieta, Ubatuba, estado de São Paulo, Brasil. Iheringia, Série Botânica 63: 101-127.

Pócs T, Bernecker A & Tixier P (2014) Synopsis and key to species of Neotropical *Cololejeunea* (Lejeuneaceae). Acta Botanica Hungarica 56: 185-226.

Puiggari DJI (1881) Notícia sobre algumas criptógamas nuevas halladas em Apiahy, Provincia de San Pablo en el Brasil. Anales de la Sociedad Cientifica Argentina 11: 201-216.

Rebelo CF, Struffaldi-De-Vuono Y & Domingos M (1995) Estudo ecológico de comunidades de briófitas epífitas na Reserva Biológica de Paranapiacaba, SP, em trechos de floresta sujeitos à influência da poluição aérea. Revista Brasileira de Botânica 18: 1-15.

Reiner-Drehwald ME (2007) Preliminary key to the genus *Lejeunea* in Brazil. Available at <http://www.drehwald.info/Lejeunea/Key_Lejeunea_Brazil_30_Apr.pdf>. Acess on 23 May 2017.

Santos ND (2008) Hepáticas da Mata Atlântica do estado do Rio de Janeiro: diversidade, fitogeografia e conservação. Dissertação de Mestrado. Instituto de Pesquisas Jardim Botânico do Rio de Janeiro/ Escola Nacional de Botânica Tropical, Rio de Janeiro. 143p.

Santos ND (2011) Distribuição espacial de briófitas na Floresta Atlântica, Sudeste do Brasil. Tese de Doutorado. Universidade Estadual de Campinas, São Paulo. 136p.

Santos ND & Costa DP (2010) Phytogeography of the liverwort flora of the Atlantic Forest of southeastern Brazil. Journal of Bryology 32: 9-22

Santos ND, Costa DP, Kinoshita LS & Shepherd GJ (2011) Bryophytic and phytogeographical aspects of two types of forest of the Serra do Mar State Park, Ubatuba/SP, Brazil. Biota Neotropica 11: 425-438.

Schiffner V & Arnell S (1964) Ergebnisse der botanischen Expedition der kaiserlichen Akademie der

Wissenschaften nach Südbrasilien 1901. II. Hepaticae. Österrichische Akademie der Wissenschaften, Mathematisch-Naturwissenschaftliche Klasse, Denkschriften 111: 1-156

Söderström L, Hagborg A, von Konrat M, Bartholomew-Began S, Bell D, Briscoe L, Brown E, Cargill DC, Costa DP, Crandall-Stotler BJ, Cooper ED, Dauphin G, Engel JJ, Feldberg K, Glenny D, Gradstein SR, He X, Heinrichs J, Hentschel J, Ilkiu-Borges AL, Katagiri T, Konstantinova NA, Larraín J, Long DG, Nebel M, Pócs T, FelisaPuche F, Reiner-Drehwald E, Renner MAM, Sass-Gyarmati A, Schäfer-Verwimp A, Moragues JGS, Stotler RE, Sukkharak P, Thiers BM, Uribe J, Váňa J, Villarreal JC, Wigginton M, Zhang L & Zhu RL (2016) World checklist of hornworts and liverworts. PhytoKeys 59: 1-828.

Veloso HP, Rangel Filho ALR, & Lima JCA (1991) Classificação da vegetação brasileira, adaptada a um sistema universal. Ministério da Economia, Fazenda e Planejamento, Fundação Instituto Brasileiro de Geografia e Estatística, Diretoria de Geociências, Departamento de Recursos Naturais e Estudos Ambientais. 124p.

Visnadi SR (1998) Briófitas em ecossistemas costeiros do Núcleo Picinguaba do Parque Estadual da Serra do Mar, Ubatuba, SP. Tese de Doutorado. Universidade Estadual Paulista, São Paulo. 274p.

Visnadi SR (2005) Brioflora da Mata Atlântica do estado de São Paulo: região norte. Hoehnea 32: 215-231.

Visnadi (2009) Briófitas do caxetal, em Ubatuba, São Paulo, Brasil. Tropical Bryology 30: 8–14.

Visnadi SR (2011) Briófitas dos picos do Cuscuzeiro e do Cardoso, estado de São Paulo, Brasil. Boletim do Museu Paraense Emílio Goeldi Ciências Naturais 6: 307-317.

Visnadi SR (2012) Bryophytes from Jureia-Itatins Ecological Station, São Paulo state, Brazil. Tropical Bryology 34: 17-31.

Visnadi SR (2013a) Briófitas de áreas antrópicas do Parque Estadual da Serra do Mar, Núcleo Picinguaba, Ubatuba, estado de São Paulo, Brasil. Boletim do Museu Paraense Emílio Goeldi Ciências Naturais 8: 49-62.

Visnadi SR (2013b) Bryoflora from the tourist state park of Alto do Ribeira, São Paulo state, Brazil Brioflora do Parque Estadual Turístico do Alto do Ribeira (PETAR), estado de São Paulo, Brasil. Tropical Bryology 35: 52-63.

Visnadi SR (2015) Brioflora do Parque Estadual Intervales, São Paulo, Brasil: uma importante área para conservação da biodiversidade da Mata Atlântica do Sudeste brasileiro. Boletim do Museu Paraense Emílio Goeldi, Ciências Naturais 10: 105-125.

Visnadi SR & Vital DM (1989) Briófitas rupícolas de um trecho do rio Bethary, Iporanga, estado de São Paulo. Acta Botanica Brasilica 3: 179-183.

Vital DM & Visnadi SR (1994) New records and notes on Brazilian Hepaticopsida. The Bryologist 97: 71-72.

Yano O (1984) Briófitas. *In*: Fidalgo O & Bononi VLR (coords.) Técnicas de coleta, preservação e herborização de material botânico. Instituto de Botânica, São Paulo. Pp. 27-30.

Yano O & Peralta DF (2007) Briófitas da Ilha do Bom Abrigo, estado de São Paulo, Brasil. Hoehnea 34: 87-94.

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