

Biodiversity survey, ecology and new distribution records of *Marchantiophyta* in a remnant of Brazilian Atlantic Forest¹

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Recebido em 04.III.2016

Aceito em 29.IV.2017

DOI: 10.21826/2446-8231201772112

ABSTRACT – We present the results of a survey of the liverwort species occurring in a fragment of dense montane ombrophilous forest in Parque Nacional de Boa Nova, located in a transition zone between Caatinga and Atlantic Forest in southwestern Bahia State, Brazil. A total of 126 species distributed among 41 genera and 14 families were found. Sixteen species are reported for the first time from the state of Bahia, while ten species represent new records for the Northeast Region of Brazil. The family *Acrobolbaceae* E.A. Hodgs and the genus *Dicranolejeunea* (Spruce) Schiffn. are also reported for the first time from Bahia. *Cololejeunea winkleri* (Morales & Benecker) Bernecker & Pócs, is cited for the first time from the Brazilian Atlantic Forest. The results obtained in this study demonstrate the importance of Parque Nacional de Boa Nova for the conservation of bryophyte biodiversity in Brazil.

Keywords: Bahia, bryophytes, phytogeography, liverworts

RESUMO – Florística, ecologia e novos registros de *Marchantiophyta* em um remanescente da Floresta Atlântica Brasileira. São apresentados os resultados de um levantamento de espécies de hepáticas que ocorrem em um fragmento de floresta ombrófila densa montana no Parque Nacional de Boa Nova, localizado numa zona de transição entre Caatinga e Mata Atlântica no sudoeste da Bahia. Foram encontradas 126 espécies distribuídas entre 41 gêneros e 14 famílias. Dezesesseis espécies são relatadas pela primeira para o estado da Bahia, enquanto dez espécies representam novos registros para a região Nordeste do Brasil. A família *Acrobolbaceae* E.A. Hodgs e o gênero *Dicranolejeunea* (Spruce) Schiffn. São também relatados pela primeira vez na Bahia. *Cololejeunea winkleri* (Morales & Benecker) Bernecker & Pócs, é citada pela primeira vez para a Mata Atlântica brasileira. Os resultados obtidos neste estudo demonstram a importância do Parque Nacional de Boa Nova para a conservação da biodiversidade de briófitas no Brasil.

Palavras-chave: Bahia, briófitas, fitogeografia, hepáticas

INTRODUCTION

The Atlantic Forest is considered a global conservation priority, and is an important center of bryophyte diversity (Gradstein *et al.* 2001, Mittermeier *et al.* 2006, Silva & Pôrto 2014). Despite high endemism and biodiversity, this biome has been subjected to extensive destruction that has dramatically reduced its coverage to approximately 11% to 16% of its original extent (Ribeiro *et al.* 2009).

The few remnants of Atlantic Forest that remain in the Northeast Region of Brazil are estimated to cover only 2% of its original area in the region (Tabarelli *et al.* 2002). These remnants occupy a thin coastal strip from the state of Rio Grande do Norte to extreme southern Bahia, where it extends inland (Silva & Pôrto 2014). Several studies have emphasized the importance of the Atlantic Forest in southern Bahia as one of the main sites of plant endemism in the World (Gentry 1992, Martini *et al.* 2007).

Studies on bryophyte diversity in the Brazilian Atlantic Forest have historically been concentrated in the South and Southeast regions of the country (e.g. Bordin & Yano 2009,

Costa 1995, Costa & Yano 1995, 1998, Costa *et al.* 2015, Santos & Costa 2008, Schäfer-Verwimp 1991, Visnadi & Vital 1989, 2000, Yano & Colletes 2000, Visnadi 2002, 2005, 2006, 2015, Yano & Peralta 2008, 2009, 2011). However, the Northeast Region has recently received increasing attention, which has resulted in a better comprehension of the bryophyte flora of the Atlantic Forest (Silva & Pôrto 2014). It is estimated that approximately 1,524 bryophyte species occur in this biome (Costa & Peralta 2016), with 788 in the Atlantic Forest of the Northeast Region (Silva & Pôrto 2014). Research in the state of Bahia has contributed significantly to this increased knowledge, accounting for more than 50% of the scientific production in the region (Silva & Pôrto 2014).

Several studies on liverwort flora have been carried out in Bahia over the last two decades, most of which have provided new species records from a variety of localities in the state (Bastos *et al.* 1998a, Bastos & Vilas Bôas-Bastos 2000a; b, Bastos 2011, 2012, Bastos & Yano 2002, 2004, 2005, Bastos & Gradstein 2006, Valente & Pôrto 2006a). Data on the bryophyte flora of rupestrian

grasslands (campos rupestres) of Chapada Diamantina were provided by Bastos *et al.* (2000), for various areas of Chapada Diamantina by Valente *et al.* (2011) and for the Caatinga by Bastos *et al.* (1998b). Specific floristic data on liverworts were provided by Bastos & Valente (2009) for the Michelin Ecological Reserve, by Valente & Pôrto (2006b) for Serra da Jibóia. Valente *et al.* (2011, 2013a; b) and Oliveira & Bastos (2014) reported on ecological studies undertaken in Chapada Diamantina and the Michelin Ecological Reserve, respectively.

The aim of the present study was to present the results of a survey of liverwort species in a fragment of dense montane ombrophilous forest located in Parque Nacional de Boa Nova. Floristic and ecological information, specifically with regard to Brazilian and global phytogeographical patterns, and the distribution of species on different substrates in the study area, was also gathered. The data obtained contribute to a better understanding of the bryophyte flora of ecotonal vegetation within the state of Bahia.

MATERIAL AND METHODS

Study site

Parque Nacional de Boa Nova is located in the municipality of Boa Nova, northeast of the Plateau of Vitória da Conquista and south of the Rio de Contas (Bencke *et al.* 2006) (Fig. 1). The park encompasses approximately 120 km², and was established as a Protected Area in 2010 by Decree No. 12642, of June 11, 2010. The park is located in a transition zone between Atlantic Forest and Caatinga (Brasil 2010) and includes a variety of phytophysionomies, such as dense montane ombrophilous forest, deciduous and semi-deciduous seasonal forests, and open and arboreal caatinga. This region is considered a priority area for conservation of flora, and bird and invertebrate fauna in Brazil (Gonzaga *et al.* 1995, MMA 2000, Bencke *et al.* 2006, Develey & Goerck 2009).

The fragment studied is located in the eastern portion of the park (14°24'53"S, 40°07'55.6"W) in an area classified as dense montane ombrophilous forest at 764–1043 m a.s.l., where forest remnants are confined to hilltops and hillsides (Bencke *et al.* 2006, Develey & Goerck 2009). Dense ombrophilous forests typically occur in tropical climates with high temperatures (above 25°C), heavy rainfall and few dry days, and contain high densities of epiphytes (IBGE 2012).

Data sampling and analysis

Botanical material was collected during four expeditions, totaling 10 sampling days, in 2013 and 2014. Plants were collected along trails and in the forest interior, with the substrates on which they were growing being recorded for later assessment of their ecological spectrum (i.e., the diversity of substrates colonized by the communities Fudali 2000). The substrates considered were based on Richards (1984) and Fudali (2001), and included: live trunks (corticicolous), decomposing trunks

(epixilous), soil (terricolous), leaves (epiphyllous) and rocks (saxicolous). Collected samples were placed in paper bags and herborized according to the methodology proposed by Frahm (2003). Vouchers were deposited in the herbarium of the Universidade Estadual de Feira de Santana, Bahia (HUEFS).

Specimens were identified to species with the aid of specialized literature (eg. Bastos & Yano 2006, 2008, 2009, Fulford 1963, 1966, 1968, 1976, Gradstein *et al.* 2001, Gradstein & Costa 2003, Hell 1969, Heinrichs *et al.* 1998, 1999, 2000, 2001, Reiner-Drehwald 1993, 1994, 1995 a, b, 1998, 2000), and classified according to the system proposed by Crandall-Stotler *et al.* (2009).

The geographical distributions in Brazil of the species collected were analyzed in consultation with Brazilian Flora 2020 (FBO 2016), published reports from floristic surveys and new records reported for species in different states of Brazil. Nationwide distribution patterns of species were classified according to frequency of occurrence across Brazilian states as: narrow (1–4 Brazilian states), moderate (5–9 Brazilian states), and wide (more than 10 Brazilian states). Phytogeographical patterns were based on Gradstein & Costa (2003), Valente & Pôrto (2006b), Campelo & Pôrto (2007), Alvarenga *et al.* (2008), Santos & Costa (2008), Bastos & Valente (2009), Oliveira & Bastos (2009), Valente *et al.* (2013a, b) and Oliveira & Bastos (2014).

Floristic surveys from other areas of the Atlantic Forest of Brazil where consulted for comparisons with the data from the present survey (Tab. 1). For this, a presence/absence spreadsheet was created with rare species (i.e., present in only one area) being excluded.

The Jaccard index was used to determine the floristic similarity between different areas. This index is based on the correlation between the species that are present in two areas and the number of species unique to each area (Muller-Dombois & Ellenberg 1974). The results of this analysis were used to construct a dendrogram using the unweighted pair group method with arithmetic mean (UPGMA) in FITOPAC 2.0. (Shepherd 2007).

RESULTS AND DISCUSSION

Species richness and new records

A total of 918 specimens were analyzed and 126 species were identified, belonging to 41 genera and 14 families (Tab. 2). Of the total number of species, 16 were reported for the first time from Bahia, 10 of which were also new records for the Northeast Region of Brazil.

The family *Acrobolbaceae* E.A. Hodgs. is reported for the first time in the Northeast Region. According to Costa (2015), three genera of *Acrobolbaceae* have been reported from Brazil, namely *Lethocolea* Mitt., *Marsupidium* Mitt. and *Tylimanthus* Mitt. The genus *Tylimanthus* has been recorded in the Brazilian states of Mato Grosso, Mato Grosso do Sul, Paraná, São Paulo, Rio de Janeiro and Espírito Santo, in areas of Cerrado, Pantanal and Atlantic

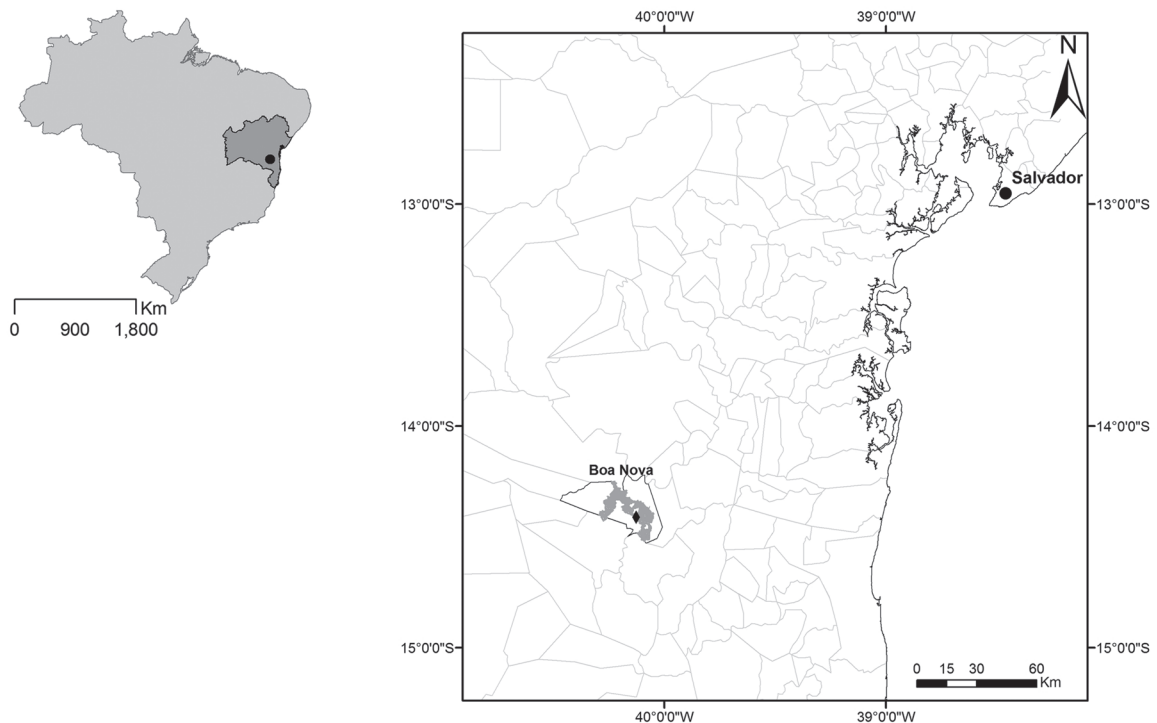


Fig. 1. Location of Parque Nacional de Boa Nova. The municipality of Boa Nova in the state of Bahia is circumscribed, and the location of the study site is indicated by the dot.

Table 1. Floristic surveys used for analysis of floristic similarity.

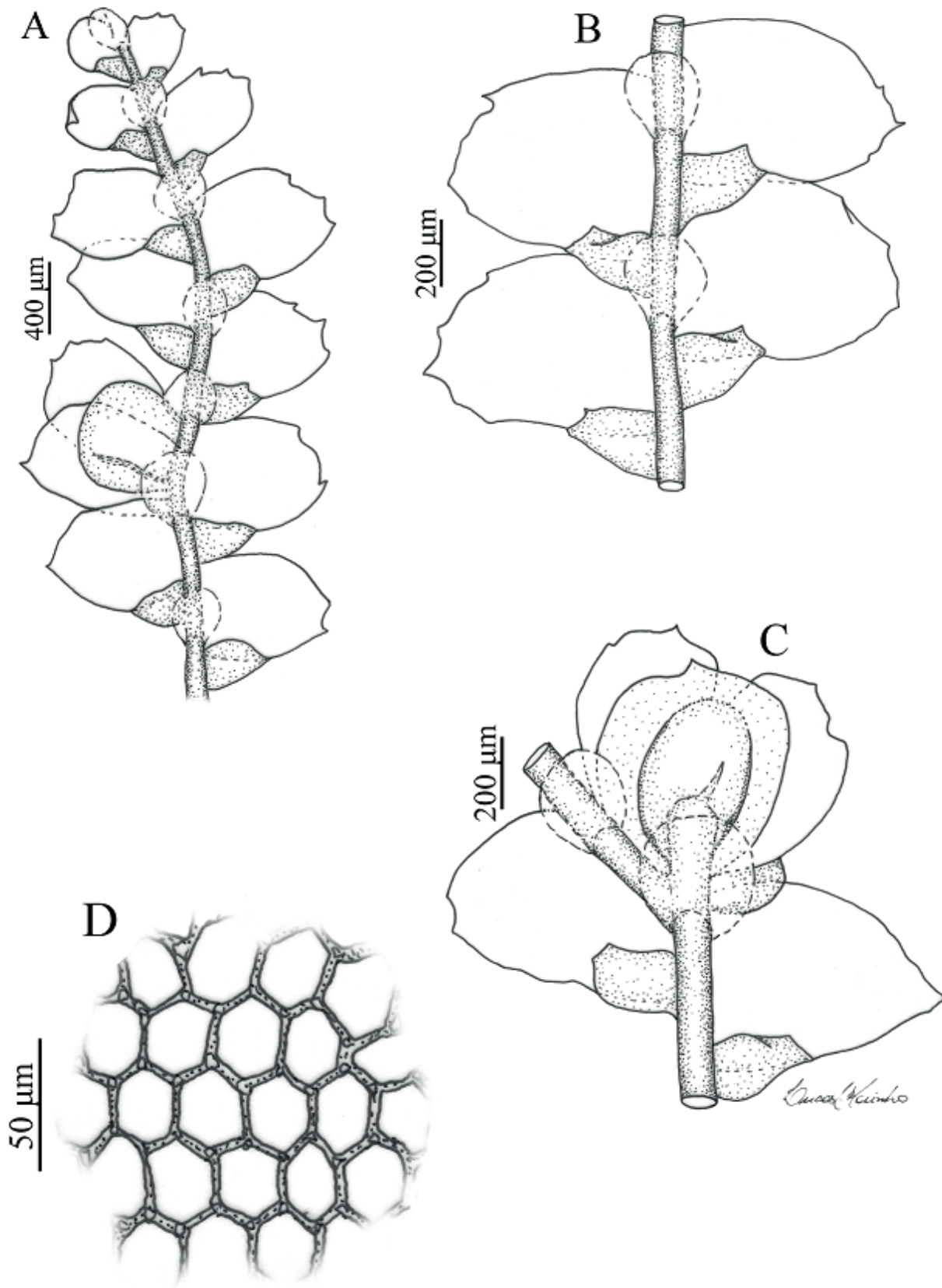
Area	References
Parque Nacional de Boa Nova	This study
Serra da Jibóia	Valente <i>et al.</i> (2009)
Montane Forests of Chapada Diamantina	Valente <i>et al.</i> (2013 b)
Reserva do Poço Escuro	Souza <i>et al.</i> 2016 (in press)
Reserva Ecológica da Michelin	Bastos & Valente (2009); Oliveira & Bastos (2014)
Montane Forest of Ubajara (CE)	Siqueira <i>et al.</i> (2011)
Parque Estadual de Ubajara	Silva (2011 – unpublished data)
Serra Negra	Amorim (2011 – unpublished data)
Parque Nacional Itatiaia	Costa <i>et al.</i> 2015
RPPN El Nagual	Santos & Costa (2008)
Brejos de Altitude	Pôrto <i>et al.</i> (2004)
Parque Estadual Ilha da Anchieta	Peralta & Yano (2008)
Parque Estadual Intervales	Vísnađi (2015)

Forest. The genus *Tylimanthus* is recognized by its glossy whitish-green to bluish gametophytes, which form dense tufts. The leaves are oblique and succubous, with a truncated to emarginated apex, cells with trigons and numerous oil bodies, and a papillose cuticle (Gradstein & Costa 2003). In Brazil this genus is represented by the species *Tylimanthus laxus* (Lehm. & Lindenb.) Spruce (Gradstein & Costa 2003, Costa 2015), and, in the present study was found growing on live trunks. This species is rare in Brazil and has been found in rainforests, riparian forests, high altitude fields (campos de altitude) and cerrado (Costa 2015).

The genus *Dicranolejeunea* (Spruce) Schiffn. (Fig. 2) is also reported for the first time from the Northeast Region. This genus is widely distributed throughout tropical America where it is represented by a single species,

Dicranolejeunea axilaris (Nees & Mont.) Schiffn.. In Brazil this species, which has been found in the states of Paraná, Rio de Janeiro and Espírito Santo (Costa *et al.* 2015), occurs in dense and mixed ombrophilous forest. Its diagnostic characteristics are a glossy brownish-green gametophyte with a predominantly *Frullania*-type branching pattern, stems with protruding cortical cells and medullar cells with thickened walls, oblique and dentate leaves that are convoluted when dehydrated and have small lobes, dentate female bracteoles and a flat ciliate-laciniate perianth that lacks a peduncle (Kruijtt 1988; Gradstein 1994; Gradstein & Costa 2003).

Cololejeunea winkleri (Morales & Benecker) Bernecker & Pócs, is a new record for the Northeast Region of Brazil, formerly known only from the Amazon in the states of



Figs. 2. A-D. *Dicranolejeunea axilaris* (Nees & Mont.) Schiffn. **A.** Ventral view of the gametophyte. **B.** Detail of leaves and underleaves. **C.** Gynoecium with perianth. **D.** Lobe cells.

Amazonas and Pará (Gradstein & Costa 2003, Ilkiu-Borges & Lisboa 2004; Costa *et al.* 2015). The species is easily recognized by the rounded opening in the apex lobe formed by the apical tooth and a protuberance of approximately two cells long on the margin of the ventral lobe (Ilkiu-Borges & Lisboa 2004).

Riccardia schwaneckeii (Steph.) Pagán, *Calypogeia uncinulatula* Herzog, *Drepanolejeunea biocellata* A. Evans, *Lejeunea raddiana* Lindenb., *Plagiochila macrostachya* Lindenb., *Plagiochila stricta* Lindenb. and *Radula nudicaulis* Steph. are also new records for the Northeast Region of Brazil. *Aneura pinguis* (L.) Dumort, *Kymatocalyx dominicensis* (Spruce) Vána, *Frullania serrata* Gottsche, *Frullanoides liebmanniana* (Lindenb. & Gottsche) van Slageren, *Leptolejeunea obfusata* (Spruce) Steph. and *Metzgeria conjugata* Lindenb. are all new records for the state of Bahia. All these species occur in Atlantic Forest, and especially in dense and mixed ombrophilous forest, but also gallery forests. Some species are known to also occur in Cerrado (*T. laxus*, *C. uncinulatula*, *F. liebmanniana* and *L. obfusata*), the Amazon (*P. macrostachya*, *C. winkleri*, *F. liebmanniana*, *L. obfusata*), the Pantanal (*T. laxus*, *A. pinguis*) and the Pampas (*R. schwaneckeii*). The remaining species occur only in Atlantic Forest.

Marchesinia bongardiana (Lehm. and Lindenb.) Trevis., is not considered a new record for Brazil in this work. This species was long treated as a synonym of *Marchesinia brachiata* (Sw.) Schiffn. However, molecular studies performed by Heinrichs *et al.* (2009) demonstrated that these are indeed two distinct species. The authors indicate that this species differs from *M. brachiata* by having loosely-arranged amphigastria on the caulidium and not moderately decurrent, as in *M. brachiata*. *Marchesinia brachiata* is widely distributed in Brazil, and additional research on these two species is needed.

Lejeuneaceae had the highest generic and specific richness, accounting for 53% of the total number of species in the area, followed by *Plagiochilaceae* and *Frullaniaceae*, with 17 and 7 species, respectively. *Plagiochila* (Dumort) Dumort was the most represented genus with 17 species, followed by *Lejeunea* Lib. with 13 species. Gradstein & Pócs (1989) point out that 90% of the entire diversity of bryophytes in tropical rainforests belongs to 15 families, among them *Lejeuneaceae*, *Frullaniaceae*, *Lepidoziaceae*, *Plagiochilaceae*, and *Radulaceae*. The results obtained here corroborate previously studies, which found high prevalences of *Lejeuneaceae* in tropical forests, which, according to Gradstein (1995), represents about 70% of the diversity of bryophytes in lowland ombrophilous forests. *Lejeuneaceae* also stood out as the most abundant family in the present study, with almost 420 samples being collected. *Ceratolejeunea cornuta* (Lindenb.) Schiffn. was the most abundant species in the area, being found in 53 samples, followed by *Lejeunea flava* (Sw.) Nees and *Omphalanthus filiformis* (Sw.) Nees, found in 51 and 31 samples, respectively.

Ecological spectrum

Regarding the ecological spectrum of substrates, corticolous species (82 species) were most prevalent, followed by epixilous (69), terricolous (39), saxicolous (30), and epiphyllous (28) species (Fig. 3). Approximately 45% (58) of the species exhibited substrate specialization, most of which were corticolous (24), epiphyllous (11) or epixilous (10). Sixty-six species colonized two to four substrates. Among the species that were found on multiple types of substrates, *Cheilolejeunea oncophylla* (Aongström) Grolle & E. Reiner, *Lejeunea flava* (Sw.) Nees, and *Plagiochila patentissima* Lindenb. stood out because they colonized all substrate types considered. The predominance of corticolous bryophyte communities is expected in tropical forests, where there is great availability of live-trunks. Gradstein & Pócs (1989) indicated that live trunks and leaves are the preferred substrates of liverwort species. The high number of epixilous species in the present study can be attributed to large tree-falls in the forest, which destroys smaller trees and leads to an increase in the availability of this substrate (personal observation).

Epiphyllous communities develop under specific conditions of humidity and shade, which are typically present only in rainforests (Richards 1954, 1984). In the studied area, 28 species were found in the phyllosphere, with 11 of them being specific to this substrate type. More than 80% of the 28 species belong to the family *Lejeuneaceae* were epiphyllous, which is, according to Gradstein (1994; 1997), one of the families with the greatest evolutionary success in colonizing this substrate. As epiphyllous are extremely sensitive to microclimatic conditions (Gradstein *et al.* 2001), they can be indicative of environment quality. Although the studied forest area has been anthropized and used for eco-tourism, a significant number of epiphyllous species was still found, probably due to the high humidity of the site throughout the entire year (personal observations of the first author). *Leptolejeunea exocellata* (Spruce) A. Evans, *Cololejeunea papilliloba* (Steph.) Steph. and *Diplasiolejeunea brunnea* Steph. were all well represented in the epiphyllous community; they were found in seven, six, and five samples, respectively.

Geographic distribution

Regarding the distribution of the species in Brazil, 43.3% were widely distributed, occurring in more than nine Brazilian states, 19.9% were narrowly distributed, found in less than five states, and 36.2% were moderately distributed. As for global distribution, the following patterns were observed: Neotropical (68.3%); Pantropical (13.5%); American (North, Central and South American: 5.5%); Disjunct (American and African, Neotropical and African, Neotropical and Asian, Neotropical and Madagascan and West Indian and Brazilian: 6.4%); Cosmopolitan and Subcosmopolitan (3.9%); and Brazilian endemic (2.4%). The high number of Neotropical species was expected, because, in general, they are more abundant than Pantropical

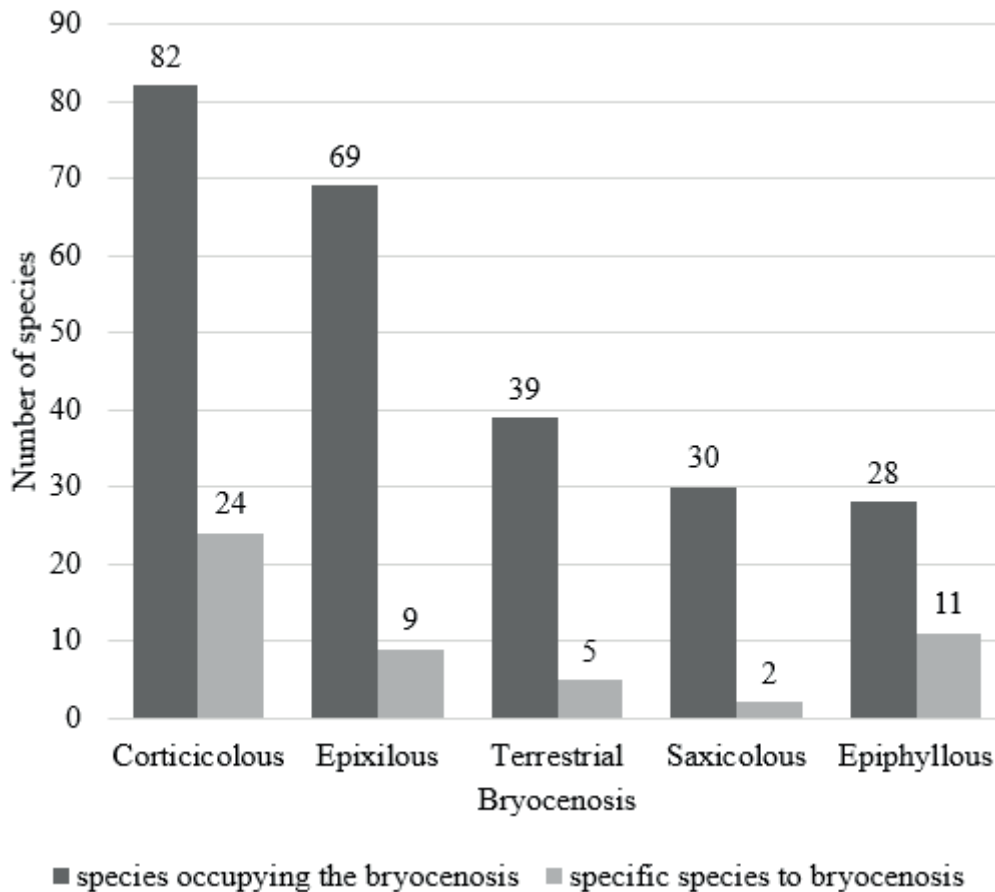


Fig.3. Graphical representation of substrates colonized by liverwort species in the fragment of dense montane ombrophilous forest studied in the National Park of Boa Nova, Bahia, Brazil.

species (Tan & Pócs 2000). These data corroborate other studies in the state of Bahia, such as Valente *et al.* (2009), Bastos & Valente (2009), Valente *et al.* (2013b) and Oliveira & Bastos (2014).

Floristic similarity

As for floristic similarity (Fig. 4), the dendrogram showed that the areas of Serra Negra (MG), Reserva do Poço (BA), Ubajara Montane Forest (CE) and Serra da Jibóia (BA) formed branches isolated from other areas reflecting low floristic similarity (> 25%). According to Muller-Dombois & Ellenberg (1974), two areas can be considered similar if they share about 25% of their floral components. In general, higher floristic similarities are found between neighboring areas and between those belonging to the same river basin. The formation of two groups was also observed; the first group consisted of the areas of PRNP El Nagual (RJ), Brejos de Altitude (PE/PB), Reserva Ecológica da Michelin (BA) and Parque Estadual Ilha da Anchieta (SP); and the second group consisted of Parque Estadual Intervalas (SP), Parque Estadual Pedra Azul (ES), Chapada Diamantina Montane Forests (BA), Parque Nacional de Boa Nova (BA), Parque Estadual Serra do Mar (SP) Parque Nacional Itatiaia (RJ).

Parque Estadual Boa Nova was clustered with Parque Estadual Serra do Mar and Parque Nacional Itatiaia, with 38% of floristic similarity; the similarity was greater between the last two areas, with 47% floristic similarity. These two areas are geographically distant from Parque Nacional de Boa Nova, but they are close to each other. In this case, the observed similarity may be associated with environmental factors such as climate, rainfall, and edaphic characteristics (Oliveira-Filho *et al.* 2001). The three areas consist of dense montane and dense high montane ombrophilous forests with a humid tropical climate. It is important to emphasize that these areas have a high number of species of liverworts (Parque Nacional de Boa Nova – 126 spp.; Parque Nacional Itatiaia – 230 spp.; Parque Estadual Serra do Mar – 196 spp.), which demonstrates the importance of Protected Areas for the conservation of bryophyte diversity in Brazil.

In this study, high floristic richness was observed in the forest fragment inventoried in Parque Nacional de Boa Nova. The species recorded correspond to nearly 54% of the total number of liverworts reported for Bahia and 20% of those occurring in Brazil. Eighteen taxa of *Marchantiophyta* are reported for the first time from Bahia. Despite the intense ongoing research on bryophytes in

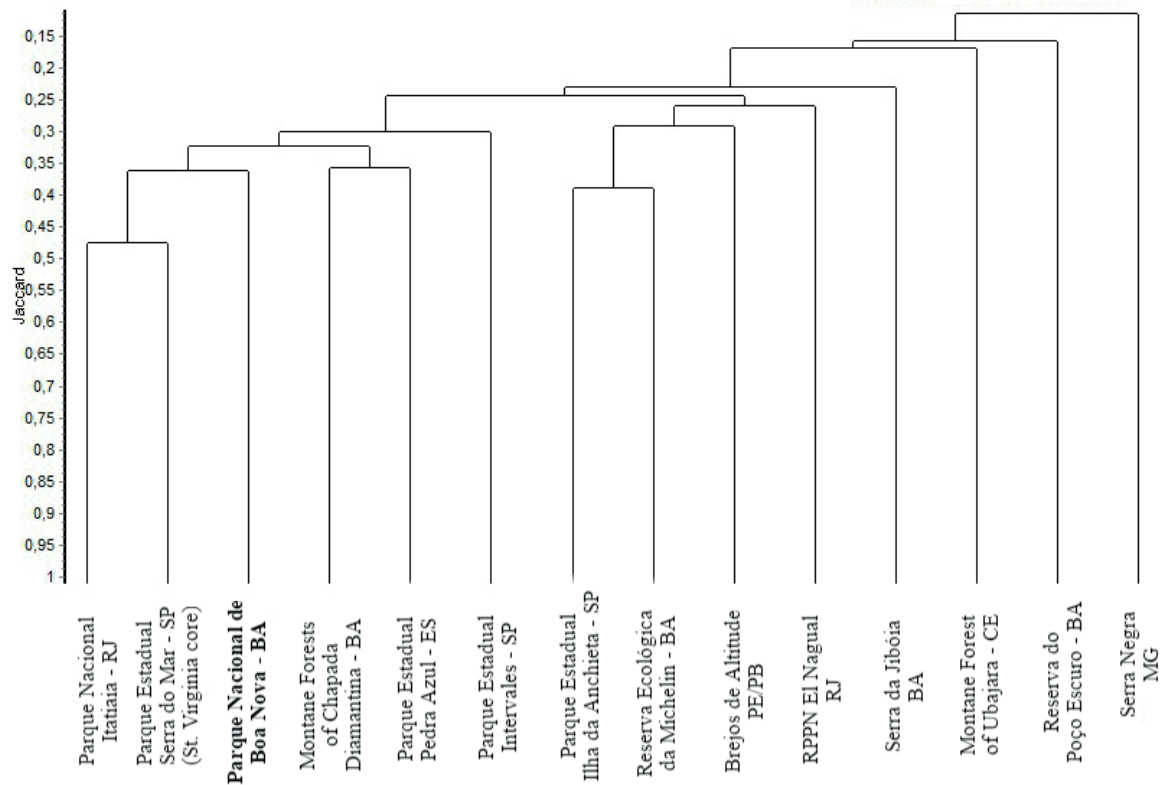


Fig. 4. Dendrogram based on UPGMA of the species composition of liverworts in the study fragment of dense montane ombrophilous forest in Parque Nacional de Boa Nova and other areas of Atlantic Forest in Brazil.

Bahia, surveys in other regions of the state are still likely to recover additional species, and thus are necessary.

The results of the present study emphasize the importance of Parque Nacional de Boa Nova for the conservation of bryophyte biodiversity in Brazil.

ACKNOWLEDGMENTS

We owe a special thanks to the Chico Mendes Institute for granting us the license to collect, and also to the Coordination for the Improvement of Higher Education Personnel (CAPES) for the grant given to the first author, which made it possible for us to complete this study.

REFERENCES

- Alvarenga, L.D.P., Oliveira, J.R.P.M., Silva, M.P.P., Costa, S.O. & Pôrto, K.C. 2008. Liverworts of Alagoas State, Brazil. *Acta Botanica Brasilica* 22: 878-890.
- Amorim, E.T. 2011. Estudo florístico e ecológico das briófitas da Serra Negra (Minas Gerais) e sua relação com outras áreas do sudeste do Brasil. Tese 110 f., Universidade Federal de Juiz de Fora, Minas Gerais.
- Bastos, C.J.P. 2011. *Cheilolejeunea ornata* (Lejeuneaceae), a new species from Brazilian Atlantic Forest. *Journal of Bryology* 33: 86-88.
- _____. 2012. Synonym and notes on the occurrence of *Cheilolejeunea intertexta* (Lindenb.) Steph. (Lejeuneaceae, Marchantiophyta) in Neotropics. *Journal of Bryology* 34: 66-67.
- Bastos, C.J.P., Albertos, B. & Vilas Bôas-Bastos, S.B. 1998b. Bryophytes from some Caatinga áreas in the state of Bahia (Brazil). *Tropical Bryology* 14: 69-75.
- Bastos, C.J.P. & Gradstein S.R. 2006. Two new species of *Cheilolejeunea* (Spruce) Schiffn. (Lejeuneaceae) from Brazil: *C. lacerata* sp. nov. and *C. rupestris* sp. nov. *Journal of Bryology* 28: 133-138.
- Bastos, C.J.P., Stradmann, M.T.S. & Vilas Bôas-Bastos, S.B. 1998a. Additional contribution to the bryophyte flora of Chapada Diamantina National Park, state of Bahia, Brazil. *Tropical Bryology* 15: 15-20.
- Bastos, C.J.P. & Vilas Bôas-Bastos S.B. 2000a. Some new additions to the hepatic flora (Jungermanniophyta) for the state of Bahia, Brazil. *Tropical Bryology* 18: 1-11.
- _____. 2000b. Occurrence of some Lejeuneaceae (Jungermanniophyta) in Bahia, Brazil. *Tropical Bryology* 20: 45-54.
- Bastos, C.J.P. & Valente, E.B. 2009. Hepáticas (Marchantiophyta) da Reserva Ecológica Da Michelin, Igrapiúna, Bahia, Brasil. *Sitientibus Série Ciências Biológicas* 8: 280-293.
- Bastos, C.J.P., Yano, O. & Vilas Bôas-Bastos, S.B. 2000. Briófitas de campos rupestres da Chapada Diamantina, Estado da Bahia, Brasil. *Revista Brasileira de Botânica* 23: 357-368.
- Bastos, C.J.P. & Yano, O. 2002. *Pycnolejeunea porrectiloba* (Lejeuneaceae) a new species from Brazil. *Nova Hedwigia* 74: 439-443.
- _____. 2004. New records of Lejeuneaceae (Marchantiophyta) for the Brazil. *Acta Botanica Malacitana* 29: 13-21.
- _____. 2005. Notes on the occurrence of *Cheilolejeunea paroica* Mizut. (Lejeuneaceae, Marchantiophyta) in Neotropic. *Acta Botanica Malacitana* 30: 7-10.
- _____. 2006. Lejeuneaceae holostipas (Marchantiophyta) no Estado da Bahia, Brasil. *Acta Botanica Brasilica* 20: 687-700.
- _____. 2008. O gênero *Ceratolejeunea* Jack & Steph (Lejeuneaceae,

- Marchantiophyta) no Estado da Bahia, Brasil. *Hoehnea* 35: 69-74.
- _____. 2009. O gênero *Lejeunea* Libert (Lejeuneaceae) no Estado da Bahia, Brasil. *Hoehnea* 36: 303-320.
- Bencke, G.A., Maurício, G.N., Develley, P.F. & Goerck, J.M. 2006. Áreas Importantes para a Conservação das Aves no Brasil. Parte I - Estados do Domínio da Mata Atlântica SAVE Brasil, São Paulo. Available at: http://www.savebrasil.org.br/wp-content/uploads/2013/11/Areas-Importantes-para-Conservacao-das-Aves_Parte_1.pdf. Accessed on 04 March. 2016.
- Bordin, J. & Yano O. 2009. Briófitas do centro urbano de Caxias do Sul, Rio Grande do Sul, Brasil. *Hoehnea* 36: 1-71.
- Brasil. 2010. Decreto-lei de 11 de junho de 2010. Cria o Parque Nacional e o Refúgio de Vida Silvestre de Boa Nova, no Estado da Bahia, e dá outras providências. Brasília, Diário Oficial da União 14 jun 2010.
- Campelo, M.J.A. & Pôrto, K.C. 2007. Brioflora epífita e epífila da RPPN Frei Caneca, Jaqueira, PE, Brasil. *Acta Botanica brasílica* 21: 185-192.
- Carmo, D.M., Lima, J.S., Amélio, L.A. & Peralta, D.F. 2016. Briófitas do Parque Estadual da Serra do mar, núcleo de Santa Virgínia, Estado de São Paulo, Brasil. *Hoehnea* 43 (2): 265-287.
- Costa, D.P. 1995. Musgos do Pico da Caledônia, Município de Nova Friburgo, Rio de Janeiro, Brasil. *Acta Botanica Brasílica* 8: 141-191.
- _____. 2015. Acrobolbaceae. In Lista de Espécies da Flora do Brasil. Jardim Botânico do Rio de Janeiro, Rio de Janeiro. Available at: <http://floradobrasil.jbrj.gov.br/jabot/floradobrasil/FB97171>. Accessed on 12 Nov. 2015
- Costa, D.P., Bastos, C.J.P. & Schäfer-Verwimp, A. 2015. Lejeuneaceae. In Lista de Espécies da Flora do Brasil. Jardim Botânico do Rio de Janeiro, Rio de Janeiro. Available at: <http://floradobrasil.jbrj.gov.br/jabot/floradobrasil/FB126801>. Accessed on 12 Nov. 2015.
- Costa, D.P. & Peralta, D.F. 2016. Briófitas. In Lista de Espécies da Flora do Brasil. Jardim Botânico do Rio de Janeiro, Rio de Janeiro. Available at: <http://floradobrasil.jbrj.gov.br/jabot/floradobrasil/FB128472>. Accessed on 14 Jan. 2015.
- Costa, D.P., Santos, N.D., Rezende, M.A., Buck, W.R. & Schäfer-Verwimp, A. 2015. Bryoflora of the Itatiaia national Park along an elevation gradient: diversity and conservation. *Biodiversity Conservation* 24: 2199-2212.
- Costa, D.P. & Yano, O. 1995. Musgos do município de Nova Friburgo, Rio de Janeiro, Brasil. *Arquivos da Universidade Federal Rural do Rio de Janeiro* 33: 99-118.
- _____. 1998. Briófitas da restinga de Macaé, Rio de Janeiro, Brasil. *Hoehnea* 25: 99-119.
- Crandall-Stotler, B., Stotler, R.E. & Long D.G. 2009. Phylogeny and classification of the Marchantiophyta. *Edinburgh Journal of Botany* 66: 155-198.
- Develley, P.F. & Goerck, J.M. 2009. Brazil. In Important Bird Areas Americas - Priority sites for biodiversity conservation. (C. Devenish, D.F. Díaz Fernández, R.P. Clay, I. Davidson & Z.I. Yépez, eds.). BirdLife International, Ecuador. (BirdLife Conservation Series No. 16), p. 99-112.
- FBO. 2016. Flora do Brasil 2020 em construção. Jardim Botânico do Rio de Janeiro. Available at: <http://floradobrasil.jbrj.gov.br/> Accessed on 19 May. 2017.
- Frahm, J.P. 2003. Manual of tropical Bryology. *Tropical Bryology* 23: 1-196.
- Fudali, E. 2000. Some open questions of the bryophytes of urban areas and their response to urbanization's impact. *Perspectives in Environmental Sciences* 2: 14-18.
- _____. 2001. The ecological structure of the bryoflora of Wrocław's parks and cemeteries in relation to their localization and origin. *Acta Societatis Botanicorum Poloniae* 70: 229-235.
- Fulford, M.H. 1963. Manual of the leafy Hepaticae of Latin America - Part I. *Memoirs of The New York Botanical Garden* 11: 1-172.
- _____. 1966. Manual of the leafy Hepaticae of Latin America - Part II. *Memoirs of The New York Botanical Garden* 11: 173-276.
- _____. 1968. Manual of the leafy Hepaticae of Latin America - Part III. *Memoirs of The New York Botanical Garden* 11: 277-392.
- _____. 1976. Manual of the leafy Hepaticae of Latin America - Part IV. *Memoirs of The New York Botanical Garden* 11: 393-535.
- Gentry, A.H. 1992. Tropical forest biodiversity: distributional patterns and their conservational significance. *Oikos* 63:19-28
- Gonzaga, L.P., Pacheco, J.F., Bauer, C. & Castiglioni G.D.A. 1995. Na avifaunal survey of the vanishing montane Atlantic Forest of southern Bahia, Brazil. *Bird Conservation International* 5: 279-290.
- Gradstein, R.M. 1994. Lejeuneaceae: Ptychanteae and Brachiolejeuneae. *Flora Neotropica* 62: 1-216
- _____. 1995. Bryophyte diversity of the tropical rainforest. *Archives des Sciences (Geneva)* 48: 91-96.
- _____. 1997. The taxonomic diversity of epiphyllous bryophytes. *Abstracta Botanica* 21: 15-19.
- Gradstein, S.R., Churchil, S.P. & Salazar-Allen, N. 2001. Guide to the Bryophytes of Tropical America. *Memoirs of the New York Botanical Garden* 86: 1-577.
- Gradstein, S.R. & Costa, D.P. 2003. The Hepaticae and Anthocerotae of Brazil. *Memoirs of the New York Botanical Garden* 87: 1-318.
- Gradstein, S.R. & Pócs, T. 1989. Bryophytes. In *Tropical Rain Forest Ecosystems* (H. Lieth, M.J.A. Werger, eds.). Elsevier Science Publishers B.V, Amsterdam. p. 311-325.
- Heinrichs, J., Anton, H., Gradstein, S.R. & Mues, R. 2000. Systematics of *Plagiochila* sect. *Glaucoscentes* Carl (Hepaticae) from tropical America: a morphological and chemotaxonomical approach. *Plant Systematic and Evolution* 220: 115-138.
- Heinrichs, J., Gradstein, S.R. & Grolle, R. 1998. A revision of the neotropical species of *Plagiochila* (Dumort.) Dumort. (Hepaticae) described by Olof Swartz. *The Journal of the Hattori Botanical Laboratory* 85: 1-32.
- Heinrichs, J., Groth, H., Gradstein, S.R., Rycroft, D.S., Cole, W.J. & Anton, H. 2001. *Plagiochila rutilans* (Hepaticae): a poorly known species from tropical America. *Bryologist* 104: 350 - 361.
- Heinrichs, J., Klugmann, F.A., Hentschel, J. & Schneider, H. 2009. DNA taxonomy, cryptic speciation and diversification of the Neotropical-African liverwort, *Marchesinia brachiata* (Lejeuneaceae, Porellales). *Molecular Phylogenetics Evolution* 53: 113-121
- Heinrichs, J., Renker, C. & Gradstein, S.R. 1999. A taxonomic revision of *Plagiochila subplana* Lindenb., a widespread liverwort of tropical America. *Haussknechtia Beiheft* 9: 171 - 181.
- Hell, K.G. 1969. Briófitas talosas dos arredores da cidade de São Paulo (Brasil). *Boletim da Faculdade de Filosofia e Ciências de São Paulo* 25: 1-190.
- Instituto Brasileiro de Geografia e Estatística. IBGE. 2012. Manual técnico da vegetação Brasileira. Instituto Brasileiro de Geografia e Estatística, Departamento de Recursos Naturais e Estudos Ambientais, Rio de Janeiro, p. 1-275.
- Ilkiu-Borges, A.L. & Lisboa, R.C.L. 2004. *Cololejeunea* (Lejeuneaceae, Hepaticae) na Estação Científica Ferreira Penna, Melgaço, PA, Brasil. *Acta Botanica Brasílica* 18(4): 887-902.
- Kruijt, R.C.H. 1988. A monograph of the genera *Dicranolejeunea* and *Acanthocoleus*. *Bryophytorum Bibliotheca* 36: 1-136.
- Martini, A.M.Z., Fiaschi, P., Amorim, A.M. & Paixão, J.L. 2007. A hot-point within a hot-spot: a high diversity site in Brazil's Atlantic Forest. *Biodiversity Conservation* 16: 3111-3128
- Mittermeier, R.A., Gil, P.R., Hoffman, M., Pilgrim, J., Brooks, T., Mittermeier, C.G., Lamoureux, J. & Fonseca, G.A.B. 2006. Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions. *Conservation International*. 392 p.
- Ministério do Meio Ambiente. MMA 2000. Avaliação e ações prioritárias para a conservação da biodiversidade da Mata Atlântica e Campos Sulinos. *Conservation International do Brasil, Fundação SOS Mata Atlântica e Fundação Biodiversitas, Brasília*, p. 4 - 26.
- Mueller-Dombois, D. & Ellenberg, H. 1974. Aims and methods of vegetation ecology. New York, Wiley. 547 p.
- Oliveira, H.C. & Bastos, C.J.P. 2009. Jungermanniales (Marchantiophyta) da Chapada da Ibiapaba, Ceará, Brasil. *Acta Botanica brasílica* 23: 1202 - 1209.
- _____. 2014. Briófitas epífitas de fragmentos de Floresta Atlântica da Reserva Ecológica da Michelin, estado da Bahia, Brasil. *Hoehnea* 41: 631-646.
- Oliveira-Filho, A.T., Curi, N., Vilela, E.A. & Carvalho, D.A. 2001. Variation in tree community composition and structure with changes in soil properties within a fragment of semideciduous forest in south-eastern Brazil. *Edinburgh Journal of Botany* 58: 139-158

- Peralta, D.F. & Yano, O. 2008. Briófitas do Parque Estadual da Ilha da Anchieta, Ubauba, estado de São Paulo, Brasil. *Iheringia. Série Botânica* 63(1): 101-127.
- Pôrto, K.C., Germano, S.R. & Borges, G.M. 2004. Avaliação dos Brejos de altitude de Pernambuco e Paraíba, quanto à diversidade de Briófitas, para a Conservação. *In* Brejos de Altitude em Pernambuco e Paraíba: história natural, ecologia e conservação (K.C. Pôrto, J.J.P. Cabral & M. Tabarelli, Eds.). Ministério do Meio Ambiente, Brasília. p.79-98.
- Reiner-Drehwald, M.E. 1993. Las Lejeuneaceae (Hepaticae) de Misiones, Argentina. I. Las especies holostipas. *Tropical Bryology* 7: 13-45.
- _____. 1994. Las Lejeuneaceae (Hepaticae) de Misiones, Argentina. II. Cololejeunea. *Tropical Bryology* 9: 79-88.
- _____. 1995a. Las Lejeuneaceae (Hepaticae) de Misiones, Argentina. III. Drepanolejeunea y Leptolejeunea. *Tropical Bryology* 10: 21-27.
- _____. 1995b. Las Lejeuneaceae (Hepaticae) de Misiones, Argentina. IV. Aphanolejeunea. *Tropical Bryology* 10: 29-39.
- _____. 1998. Las Lejeuneaceae (Hepaticae) de Misiones, Argentina. V. Cheilolejeunea y Lepidolejeunea. *Tropical Bryology* 14: 53-68.
- _____. 2000. Las Lejeuneaceae (Hepaticae) de Misiones, Argentina. VI. Lejeunea y Taxilejeunea. *Tropical Bryology* 19: 81-131.
- Ribeiro, M.C., Metzger, J.P., Martensen, A.C., Pozoni, F.G. & Hirota, M.M. 2009. The Brazilian Atlantic Forest: how much is left, and how is the remaining Forest distributed? Implications for conservation. *Biological Conservation* 142: 1141-1153.
- Richards, P.W. 1954. Notes on the bryophyte communities of lowland Tropical Rain Forest, with special reference to Moraballi Creek, British Guiana. *Vegetatio* 5-6: 319-328.
- _____. 1984. The ecology of tropical Forest bryophytes. *In*. *New Manual Bryology*, v.2 (R.M. Schuster, ed.). The Hattori Botanical Laboratory, Nichinan. p.1233-1970.
- Santos, N.D. & Costa, D.P. 2008. A importância de Reservas Particulares do Patrimônio Natural para a conservação da brioflora da Mata Atlântica: um estudo em El Nagual, Magé, RJ, Brasil. *Acta Botanica Brasilica* 22: 359-372.
- Schäfer-Verwimp, A. 1991. Contribution to the knowledge of the bryophyte flora of Espírito Santo, Brazil. *The Journal of the Hattori Botanical Laboratory* 69: 147-170.
- Shepherd, G.J. 2007. FITOPAC 2.0. Departamento de Botânica/ UNICAMP. Available at: <http://pedroisenlohr.webnode.com.br/fitopac/> Accessed on 12 Nov. 2015
- Silva, L.T.P. 2011. Briófitas do Parque Estadual Pedra Azul (pepap), Município de Domingos Martins, Espírito Santo, Brasil. Dissertação 87 f., Universidade Estadual de Feira de Santana, Bahia.
- Silva, M.P.P. & Pôrto, K.C. 2014. Briófitas: estado do conhecimento e vulnerabilidade na Floresta Atlântica Nordestina. *Boletim do Museu de Biologia Mello Leitão* 36: 19-34.
- Siqueira, S.M.C, Costa, P.S., Souza, E.B & Oliveira, H.C. 2011. Briófitas de um remanescente de Mata Atlântica no Município de Ubajara, CE, Brasil. *Hoehnea* 38 (4): 597-608.
- Souza, A.M., Valente, E.B., Bastos, C.J.P. & Azevedo, C.O. 2016 in press. Marchantiophyta of the Poço Escuro Reserve, Vitória Da Conquista, Bahia, Brazil. *Natureza online*.
- Tabarelli, M., Marins, J.F. & Silva J.M.C. 2002. La biodiversidad brasileña amenazada. *Investigación y Ciencia* 308: 42-49.
- Tan, B.C. & Pócs T. 2000. Bryogeography and conservation of bryophytes. *In* *Bryophyte biology* (A.J. Shaw & B. Goffinet, eds.). Cambridge University Press, Cambridge. p. 403-448.
- Valente, E.B. & Pôrto, K.C. 2006a. Novas ocorrências de hepáticas (Marchantiophyta) para o Estado da Bahia, Brasil. *Acta Botanica Brasilica* 20: 195-201.
- _____. 2006b. Hepáticas (Marchantiophyta) de um fragmento de Mata Atlântica na Serra da Jibóia, Município de Santa Teresinha, BA, Brasil. *Acta Botanica Brasilica* 20: 433-441.
- Valente, E.B., Pôrto, K.C., Vilas Bôas-Bastos, S.B. & Bastos, C.J.P. 2009. Musgos (Bryophyta) de um fragmento de Mata Atlântica na Serra da Jibóia, município de Santa Teresinha, BA, Brasil. *Acta Botanica Brasilica* 23: 369-375.
- _____. 2011. Checklist of Bryophytes of Chapada Diamantina, Bahia, Brazil. *Boletim do Instituto de Botânica* 21: 111-124.
- _____. 2013a. Species richness and distribution of bryophytes within different phytogeographies in the Chapada Diamantina region of Brazil. *Acta Botanica Brasilica* 27: 294-310
- Valente, E.B., Pôrto, K.C., Bastos, C.J.P. & Ballejos-Loyola, J. 2013b. Diversity and distribution of the bryophyte flora in montane forests in the Chapada Diamantina region of Brazil. *Acta Botanica Brasilica* 27: 506-518.
- Visnadi, S.R. 2002. Meteoriaceae (Bryophyta) da Mata Atlântica do estado de São Paulo. *Hoehnea* 29: 159-187.
- _____. 2005. Brioflora de Mata Atlântica do Estado de São Paulo: região norte. *Hoehnea* 32: 215-231
- _____. 2006. Sematophyllaceae da Mata Atlântica do Nordeste do estado de São Paulo. *Hoehnea* 33: 455-484.
- _____. 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* 10(1): 105-125.
- Visnadi, S.R. & Vital, D.M. 1989. Briófitas rupícolas de um trecho do Rio Bethary, Iporanga, Estado de São Paulo. *Acta Botanica Brasilica* 3: 179-183.
- _____. 2000. Lista das briófitas ocorrentes no Parque Estadual das Fontes do Ipiranga - PEFI. *Hoehnea* 27: 279-294.
- Yano, O. & Colletes, A.G. 2000. Briófitas do Parque Estadual de Sete Quedas, Guaíra, Paraná, Brasil. *Acta Botanica Brasilica* 14: 215-242
- Yano, O. & Peralta, D.F. 2008. Briófitas da Ilhabela, Estado de São Paulo, Brasil. *Hoehnea* 35: 111-121.
- _____. 2009. Flora de Grão Mogol, Minas Gerais: Briófitas (Bryophyta e Marchantiophyta). *Boletim de Botânica* 27: 1-26.
- _____. 2011. Flora da Serra do Cipó, Minas Gerais: Briófitas (Anthocerotophyta, Bryophyta e Marchantiophyta). *Boletim de Botânica* 29: 135-299.