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Environment

Briology studies in the northern region

Estudos da briologia na região norte

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ABSTRACT

This article is a literature review aimed at answering the following question: Over the past 30 years, research on bryophytes in northern states has intensified, allowing the identification and conservation of the biological diversity of bryophytes in this region. region? For data collection, we used the databases SCIELO, Google Scholar and sucupira platform. The inclusion criteria were defined as articles published between 1988 and 2018, and the exclusion criteria were articles from those 30 years old that were not located. States outside the northern region were excluded. Over the last 30 years, there were 186 scientific works, of which 58 articles were analyzed. Advances in Bryophyta research in the northern region are linked only to Brioflora's urban centers and surveys, so knowledge of the entire region is required for use in different areas of science.

Keywords: Biodiversity; Bryophytes; Conservation

RESUMO

Este artigo trata-se de uma revisão de literatura que teve como objetivo obter uma resposta à seguinte questão: Ao decorrer dos últimos 30 anos as pesquisas sobre briófitas nos estados da região norte se intensificaram, permitindo a identificação e conservação da diversidade biológica das briófitas nessa região? Para a coleta de dados foram utilizadas as bases SCIELO, Google acadêmico e Plataforma Sucupira, definiu-se como critério de inclusão: artigos publicados entre os anos de 1988 a 2018, e o critério de exclusão, artigos desses 30 anos que não tinham como localização estados fora da região norte, eram excluídos. No período compreendido dos últimos 30 anos, verificaram-se 186 obras cientificas, dos quais foram analisados 58 artigos. Os avanços das pesquisas sobre Bryophyta na região norte, está atrelada apenas aos centros urbanos e levantamentos da Brioflora dessa forma, se faz necessário o conhecimento de toda região para utilizar em diferentes áreas da ciência.

Palavras-chave: Biodiversidade; Briófitas; Conservação

1 INTRODUCTION

Throughout history, great efforts have been made to understand the systematics and diversity of bryophytes, the most important of which is undoubtedly the work of Richard Spruce (1884), the result of his trip to the Amazon in the nineteenth century. The work entitled “Hepaticae Amazonicae et Andinae” published in 1884 and 1885 contains a description of over seven hundred species, about five hundred collected by himself, four hundred of which are new to science, to date this book is the largest work on bryology South American. In addition, some specific inventories and various studies focused on the taxonomy and systematics of some groups were made, but information from these studies was dispersed.

Currently in Brazil, work on the diversity and ecology of bryophytes is carried out in major capitals, such as Recife, Brasilia, Belem, Manaus, Porto Alegre, São Paulo, in the Brazilian Amazon, is also no different, being centralized near the capital of the state. Climate change can become the biggest threat to biodiversity and many ecological systems are already showing their effects (GARCIA *et al*., 2012). Thus, the maintenance of bryological diversity can suffer losses from anthropic phenomena, because the reduction of species richness and density of individuals is a result of the reduction of soil moisture (MEDEIROS *et al*., 2014).

The Amazon Forest has a great floristic diversity, but it is currently undergoing intense growth process, caused by anthropic actions such as burning, deforestation, deforestation that destroy areas and can extinguish species that have not yet been studied. Habitat loss and fragmentation, overexploitation of natural resources, biological invasion and climate change are leading many species to extinction (LEMES; LOYOLA, 2014).

This group of plants have relevance to the Brazilian flora, cooperating for the biodiversity of planet Earth. Responsible for the dynamics of most terrestrial ecosystems, as they contribute to the maintenance of atmospheric humidity,

prevent water loss, retain soil moisture in ecological interactions (BORDIN, 2009; PEREIRA, 2019).

The biodiversity of Brioflora in the northern region is very diverse, but the issues of botanical identification and ecological importance are still poorly understood. The bryofloristic survey is a pioneering work necessary, in addition, to verify the component species of this region, which has been exposed to different anthropic actions, resulting in loss of biodiversity, is important to support conservation programs, management, environmental education, etc.

In the state of Amazonas, most studies conducted on this subject are restricted to the metropolitan region of Manaus, specifically the Adolfo Ducke Forest Reserve. In addition, bryophyte biogeography is marked by a very high endemic rate in a very large area, since Amazonas is located in a tropical forest with an equatorial climate according to the Köppen classification (ALMEIDA *et al*., 2015). A favorable environment is created for the propagation of these bryophytes, since the forest is closed, dense and humid, offering all the requirements for the proliferation of these species.

Thus, the progress of the study on bryophytes in the Amazon should be evaluated, given the high concentration of biological diversity of this flora that has relevance in the areas of Ecology (ecological succession), Medicine (ethnobotany), Paleontological (fossil record), Economic (drug production).

Thus, the progress of the study on bryophyte in the northern region should be evaluated, given the high concentration of biological diversity of this flora that has diverse functions in nature (eg water retention, indicator of atmospheric pollution, allelopathic functions, etc.). In this sense, this paper aims to answer the following question: over the past 30 years has research on bryophytes in the northern states intensified, allowing the identification and conservation of the biological diversity of bryophytes in this region?

2 MATERIAL AND METHODS

This study constitutes an analytical bibliographical review about the survey of bryophytes.

Data collection was performed from August 2018 to 2019, and the databases used were the Scientific Electronic Library Online (SCIELO), Google Scholar, Google Scholar, Capes, Wiley online library and sucupira platform databases. The following inclusion criteria were defined: articles published between 1989 and 2019.

We included in this study articles that presented descriptors in the abstract such as: survey, collection, bryophytes, referral, plots, Brioflora, Amazonas and variants in English. For Google academic and SCIELO searches, no language was limited in an attempt to obtain a relevant amount of theoretical framework. As an exclusion criterion, articles from those 30 years that were not located in states outside the northern region were excluded.

After selecting the articles according to the previously defined inclusion criteria, the following steps were followed in this order: exploratory reading; selective reading and choice of material that fit the objectives and theme of this study; analytical reading and analysis of the texts, ending with the performance of interpretative reading and writing.

3 RESULTS AND DISCUSSION

Over the last 30 years there were 186 scientific works (articles, dissertations, theses, monographs), of which 60 scientific works were analyzed. The analysis of the data obtained for the selection of the journals in the three research bases indicated that seven journals published scientific articles on botany / bryophyte, from 1989 to 2019. The data also indicated that all have ISSN and are classified by Qualis Capes updated (Table 1).

Table 1 - Seven selected journals, and the bases where they are found whose publications involve the theme of this research, number of publications / year, the source where they are found and Qualis Capes

Periodical	**NPA**	**Source**	**QC-CA***
Acta Amazonica	15	Scielo	B1
Acta Botânica Brasílica	7	Scielo	B1
Bol. Mus. Para. Emilio Goeldi – CN	1	CAPES	B3
Rodriguésia	25	Scielo	B1
Biota Amazônia	3	GA	B4
Hoehnea	3	Scielo	B1
Iheringia	1	Scielo	B1

Bulletin Museu Paraense Emílio Goeldi - Natural Sciences; NPA - Number of Publications / year; GA - Google Scholar; QC-Qualis Capes- Environmental Sciences (*2013 - 2016)
Source: sucupira platform (2019).

In a study by Figueiredo Filho *et al*. (2014), the authors concluded that the higher the Qualis, it is understood that the better the publication, or at least the greater the degree of demand and competition for this article to be subject. In this review, it was noted that the highest concentration of scientific articles were published in journals with Qualis B1 in the area of Environmental Sciences, which increases its analysis, as the evolution of research of bryophytes and their contribution to conservation of this vegetable.

Regarding the volume of publications, in each of the seven journals analyzed, the data obtained indicated that the values for absolute frequencies (fi) were between one and twenty-four publications, whose averages ranged from 0.14 to 3, respectively (Table 2).

Table 2 - Number of publications by journal between 1989 and 2019

Periodical	**1989-1999**	**2000-2010**	**2011-2019**	***Fi***	$\bar{x}$
Acta Amazonica	6	9	0	15	2,14
Acta Botânica Brasílica	0	5	2	7	1
Bol. Mus. Para. Emilio Goeldi – CN	0	1	0	1	0,14
Rodriguésia	0	1	24	25	3,57
Biota Amazônia	0	0	3	3	0,42
Hoehnea	0	0	3	3	0,42
Iheringia	0	0	1	1	0,14
Total	6	16	32	55	

Source: Authors 2019

As for the statistical analysis of the three periods, it indicated that the values for the averages of publications in the three periods were between 0.9 and 3.4, the lowest values were between 1989 and 1999, and the highest between 2011. By 2019, it is noteworthy that this decade is not yet complete, so this number is likely to increase (Table 3).

Table 3 - Values obtained in the statistical analysis of data from scientific publications between 1989 and 2019 in seven journals analyzed

	1989-1999	**2000-2010**	**2011-2019**
Sample size	7	7	7
Minimum	0	0	0
Maximum	6	9	24
Average	0,9	1,3	3,4

Source: Authors 2019

Related to the most prolific journal, the data showed that the “Rodriguésia” magazine, with twenty-four publications was more effective. It is noteworthy that such a journal publishes original scientific, review, opinion and scientific papers in various areas of Plant Biology (taxonomy, systematics and evolution, physiology,

phytochemistry, ultrastructure, cytology, anatomy, palynology, development, genetics, reproductive biology, ecology, ethnobotany and phylogeography), as well as in the history of botany and activities related to botanical gardens; this justifies the higher value for the relative frequency of publications for this journal, as well as the value found, on average ($\bar{x}$=3,57).

In a study by Fonseca (2015) at the Faculty of Medicine of Porto, Portugal, this author states that the exponential growth of scientific articles is due to factors such as increased research, technological advances or even the reinforcement of the article's importance scientific. In about two decades, the difficulty of accessing scientific information has changed from being imperative to choosing from the immense amount of scientific articles produced. As the stage of research and publications that took place between 1989 and 2019, already has high average (3,4) the selection for the preparation about the conservation of bryophytes increases.

The analysis of the data regarding the geographical distribution of the research and selected publications indicated that seven are related to the state of Amazonas, forty-eight in Pará, two in Rondônia, two in Amapá, two in Roraima and one in Acre (Frame 1), it is also observed that in some articles data were collected in two different states. It is visible from these data that the state of Pará was the most studied over these 30 years, due to the creation of the project “Flora of the Serra dos Carajás, Pará, Brazil”, started in 2014, through the cooperation between the Museu Paraense Emílio Goeldi (MPEG) and the Vale Technological Institute of Sustainable Development (ITVDS), especially aiming at the elaboration of FLONA Carajás yeast flora, in view of the need to deepen and systematize the knowledge about this region (VIANA *et al*., 2016).

Therefore comes the state of Amazonas, though Yano; Câmara (2004) state that the bryophytic flora of the state of Amazonas is relatively well studied, but there is no way to agree with this statement, because when analyzing the publications over the last years, it is observed that the geographical location of

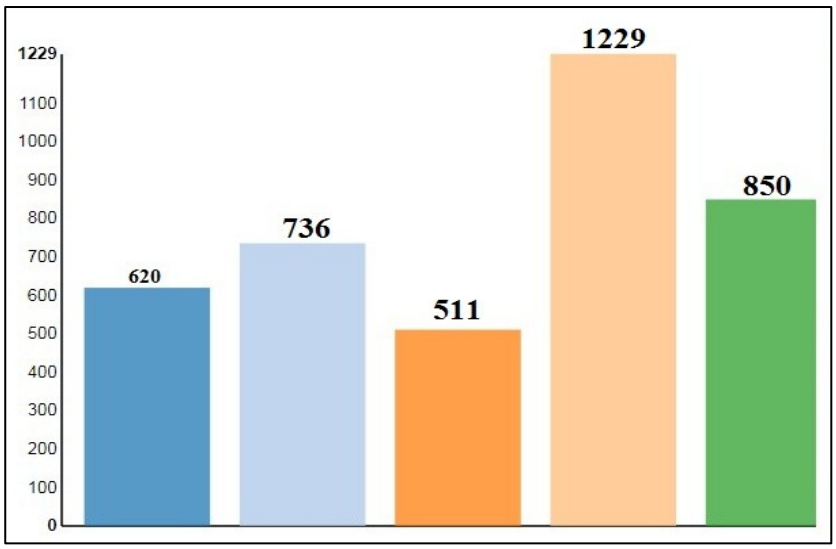
the research is concentrated in the Adolpho Duck Reserve and in the vicinity of the capital, it is noteworthy that the Amazon is one of the largest states in territorial extension of Brazil (1.571,000 km²), which presents a difference in relation to the relief, type of forest, forests, rivers, etc., which will provide diverse environments in which they provide the diversity and richness of this Brioflora, emphasizing here the importance of exploration to the interiors of states.

And this same discussion must also be taken into consideration in other states such as Pará, which is also concentrated in the Ferreira Penna Scientific Station, belonging to the Paraense Emílio Goeldi Museum, located in the Caxiuanã National Forest. Roraima, Rondônia, Acre, Tocantins and Amapá, the latter are only published works in the capitals (Frame 1).

Second Gentle; Menezes (2011) studies of bryophytes for some regions of Brazil are still scarce or cover restricted areas, as is the case of the northern region. It still covers most of the Brazilian Amazon, which due to its length, difficulty of access and history of relatively recent scientific research, the flora of the Amazon is the least known among the Brazilian phytogeographic domains (BFG, 2015). It is noteworthy the presence of wide gaps of floristic knowledge throughout the Brazilian Amazon, which is reflected by the low collection density, with less than 0.18 specimens collected per square kilometer in the predominantly northern Amazon region (BFG, 2015; MORIM; NIC LUGHADHA, 2015).

In the flora of Brazil 2020, there is a graph showing the Brazilian phytogeographic domain with the largest number of bryophytes species is the Atlantic Forest, with 1.344, followed by the Amazon, with 575, Cerrado with 482, Pantanal with 163, Pampa with 119 and Caatinga with 111 (Figure 1). The Southeast Region is the most diverse, with 1.229 species, followed by the South with 850, Northeast with 736, North with 620 and Midwest with 511.

Figure 1 - Number of bryophyte species by region



Source: Flora do Brasil 2020, 2019.

It is observed that the northern region is in 4th place in number of species, which corroborates the data (Table 1), in relation to studies in this region. These data conjecture the current knowledge of this group of plants in the northern region and some states with fewer taxa such as Amapá (87 ssp), Rondônia (169 ssp), Acre (166 ssp), Roraima (194 ssp) and Tocantins (67 ssp)), this data is from Flora do Brasil 2020 updated to date.

Frame 1 - Authors, Year of publication, journals, title, Thematic, Place of collection and Conclusion - about Bryophytes in the northern region of the country between 1989 and 2019

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Maria de Fátima da Silva Pinheiro; Regina Célia Lobato Lisboa; Ruth de Vasconcelos Brazão	1989	Acta Amazonica	Contribution to the study of bryophytes as sources of antibiotics	Medicinal	Adolpho Duck Reserve, Manaus (Amazonas); Reserva Mocambo, Belem (Pará)	—
Olga Yano	1992	Acta Amazonica	Bryophytes from Maracá, Roraima, Brazil	Survey	Maracá Island (Roraima)	—
Olga Yano; Zélia R. de Mello	1992	Acta Amazonica	New bryophytes for the state of Roraima, Brazil	Taxonomy	Herbarium Collections of the National Institute for Research in the Amazon (INPA), during the expeditions of the Amazonian Flora Program (Roraima)	—
Denise Pinheiro da Costa	1993	Acta Amazonica	New occurrence of Pleuroziaceae, *Eupleurozia paradoxa* (Hepaticopsida)	New species occurrence for Brazil	Peak of the fog National Park (Amazonas)	—

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Regina Célia Lobato Lisboa; Anna Luíza Ilkiu-Borges	1995	Bol. Mus. Para. Emilio Goeldi - Série botânica	Diversity of Belém Bryophytes (PA) and their potential as indicators of urban pollution	Ecology	Belém urban area; Belem's forest reserves are Utinga Guamá Ecological Research Area; Zoobotanical Park of the Museu Paraense Emílio Goeldi. (Pará)	—
Regina Célia Lobato Lisboa; Anna Luíza Ilkiu-Borges	1997	Acta Amazonica	New Occurrences of Bryophyta (Mosses) for the State of Pará, Brazil	New occurrences	Belém urban area; Ferreira Penna Scientific Station (ECFPn), belonging to the Emílio Goeldi Paraense Museum, located in the Caxiuanã National Forest, Melgaço municipality; Serra Pelada (municipality of Parauapebas); Iriri River (Altamira municipality) (Pará)	The work aimed to broaden the knowledge of bryoflora and the geographical distribution of bryophytes in Brazil, in which 11 species of mosses were presented as new occurrences for the state of Pará. Two species *Fissidens allenianus* e *Taxithelium portoricence*, are first references to Brazil

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Regina Célia Lobato Lisboa; Maria Josiane L. Lia; Ubijara N. Maciel	1999	Acta Amazonica	Mosses from Marajó Island - Municipality of Anajás, Pará, Brazil	Moss diversity	Marajó Island in the municipality of Anajás (Pará)	The data found are quite satisfactory, considering the number of samples analyzed. However, we cannot consider that the species found in this work correspond to the total number of Anajás mosses. New collections will certainly lead to an increase in the number of species and possibly even families.

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Anna Luíza Ilkiu-Borges; Regina Célia Lobato Lisboa	2002	Acta Amazonica	*Leptolejeunea* e *Rhaphidolejeunea* (Lejeuneaceae) at Ferreira Penna Scientific Station, Pará, Brazil	Gender diversity *Leptolejeunea* and *Rhaphidolejeunea*	Ferreira Penna Scientific Station (ECFPn), belonging to the Emílio Goeldi Paraense Museum, located in the Caxiuanã National Forest, Melgaço (Pará)	The species *Leptolejeunea tredentata* is first mentioned to Brazil. The species found in ECFPn are generally epiphiles, preferring primary environments.
Anna Luíza Ilkiu-Borges; Regina Célia Lobato Lisboa	2002	Acta Amazonica	The genera *Lejeunea* and *Microlejeunea* (Lejeuneaceae) in Ferreira Penna Scientific Station, State of Pará, Brazil, and new occurrences.	Gender diversity *Lejeunea* e *Microlejeunea*	Ferreira Penna Scientific Station (ECFPn), belonging to the Emílio Goeldi Paraense Museum, located in the Caxiuanã National Forest, Melgaço (Pará)	The *Microlejeunea epiphylla* species is mentioned for the first time in the state of Pará and the *Microlejeunea acutifolia* species is a new occurrence for Brazil. In ECFPn *Microlejeunea* species are rare.

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Denise Pinheiro da Costa	2003	Acta Amazonica	Floristic composition and diversity of bryophytes in a forest in Acre State, Brazil	Survey	Tarauacá and Juruá Rivers (Acre)	Bryophyte diversity in Brazilian Amazon high, presently recorded at 514 species. The bryoflora of the state of Acre (158 species) is poorly known, as suggested by comparisions of species-richness among the Amazonian states of Brazil. There is greater diversity in the primary forests, indicating that their replacement by secondary vegetation results in the depletion of species. The results can be expanded with the collection in other municipalities of the existing microregions.
Rita de Cássia Pereira dos Santos; Regina Célia Lobato Lisboa	2003	Acta Amazonica	Mosses (Bryophyta) from northeastern Pará, Brazil. Bragantina Zone, Salgado microregion and municipality of Viseu	Inventory	Bragança, Manatee, Augusto Corrêa, Spring (Zona Bragantina); Salinas and São João de Pirabas (Salgado Microregion); and Viseu (Pará)	

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Anna Luiza Ilkiu-Borges; Ana Cláudia Caldeira Tavares; Regina Célia Lobato Lisboa	2004	Acta Botanica Brasilica	Germoplasma Island Bryophytes, Tucuruí Reservoir, Pará, Brazil	Diversity	Germplasm Island, Tucuruí Reservoir (Pará)	In this work the Brioflora of this island was studied, having been identified 12 species of moss and 13 of liverworts. These results reflect low diversity of bryophytes occurring on this island.
Olga Yano; Paulo Eduardo A.S. Câmara	2004	Acta Amazonica	Bryophytes from Manaus, Amazonas, Brazil	Survey and distribution of bryophytes	Germplasm Island, Tucuruí Reservoir (Pará)	—
Ayumi Osakada, Regina Célia Lobato Lisboa	2004	Acta Amazonica	New occurrences of liverworts (Marchantiophyta) for the state of Pará, Brazil	Bryophytes Inventory	Parauapebas (Pará)	—
Anna Luiza Ilkiu-Borges; Regina Célia Lobato Lisboa	2004	Acta Botanica Brasilica	Cololejeuneae (Lejeuneaceae, Hepaticae) at Ferreira Penna Scientific Station, Melgaço, PA, Brazil	Tribe Diversity Cololejeuneae	Ferreira Penna Scientific Station (ECFPn), belonging to the Emílio Goeldi Paraense Museum, located in the Caxiuanã National Forest, Melgaço (Pará)	—

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Regina Célia Lobato Lisboa; Rita de Cássia P. dos Santos	2005	Acta Amazonica	Helicophyllaceae (Bryophyta), new occurrence for the State of Pará, Brazil	New occurrence for the Brazilian Amazon	Araguaia Forest (Pará)	—
Regina Célia Lobato Lisboa; Ayumi Osakada	2005	Bol. Mus. Para. Emilio Goeldi – CN	The Gender *Vitalianthus* R.M. Schust. & Giancotti (Lejeuneaceae), in the state of Pará	New species occurrence for the state of Pará	Ferreira Penna Scientific Station, belonging to the Emílio Goeldi Paraense Museum, located in the Caxiuanã National Forest, municipality of Melgaço, state of Pará.	—
Adriana Paula da Silva Souza; Regina Célia Lobato Lisboa	2005	Acta Botanica Brasilica	Mosses (Bryophyta) on Trambioca Island, Barcarena, PA, Brazil	Diversity	Trambioca Island, Barcarena Municipality (Pará)	—
Regina Célia Lobato Lisboa; Ana Cláudia Caldeira Tavares; Salustiano Costa Neto	2006	Boletim do Instituto de Botânica	Mosses (Bryophyta) and (Marchantiophyta) from the Coastal Zone of Amapá State, Brazil	Diversity	Lakes Region, between the mouth of the Amapá Grande River and the mouth of the Araguari River (Amapá).	—

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Lisi Dámaris Pereira Alvarenga; Regina Célia Lobato Lisboa; Ana Cláudia Caldeira Tavares	2007	Acta Botanica Brasilica	New references of liverworts (Marchantiophyta) from Caxiuanã National Forest to the State of Pará, Brazil	New hepatic occurrences for the state of the Pará	Ferreira Penna Scientific Station (ECFPn), belonging to the Emílio Goeldi Paraense Museum, located in the Caxiuanã National Forest, Melgaço (Pará)	—
Rita de Cássia Pereira dos Santos; Regina Célia Lobato Lisboa	2008	Rodriguésia	Mosses (Bryophyta) from Salgado Paraense microregion and its use as possible indicators of disturbed environments	Indicators of disturbed environments	Salgado Paraense Microregion, coastal zone, covering for study area the following municipalities: Curuçá, Magalhães Barata, Maracanã, Marapanim, Salinópolis, São Caetano de Odivelas, São João de Pirabas and Vigia (Pará)	—

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Lisi Dámaris Pereira Alvarenga; Regina Célia Lobato Lisboa	2009	Acta Amazonica	Contribution to the knowledge of taxonomy, ecology and phytogeography of Eastern Amazon Bryophytes	Taxonomy and ecology	Ferreira Penna Scientific Station (ECFPn), belonging to the Emílio Goeldi Paraense Museum, located in the Caxiuanã National Forest, municipality of Melgaço (Pará).	Bearing in mind that the present study consisted of a quick inventory (3 months and ca. 400 samples), it is evident that the nFPPC bryoflora has high richness and diversity. The study, furthermore, confirms that the bryoflora of the Amazon harbors a diversity and richness worthy of being better explored.

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Marta Regina Silva Pereira	2009	Dissertation	Biosystem study of six species of Calymperaceae (Bryophyta) in the Brazilian Amazon	Amazonian Plant Biodiversity, Reproduction and Plant Growth	Iracema Waterfall Ecological Reserve, municipality of Presidente Figueiredo (Amazonas).	This study contributed to a better understanding of the phenological relationships between morphologically similar sympatric species of difficult taxonomic separation, the relationships of biological seasonality and pre-zygotic barriers discussed in this paper may be of great importance to evaluate the maintenance of species in these ecological conditions.

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Eryka de Nazaré Rezende Moraes; Regina Célia Lobato Lisboa	2009	Acta Amazonica	Diversity, taxonomy and distribution by Brazilian states of Bartramiaceae, Brachytheciaceae, Bryaceae, Calymperaceae, Fissidentaceae, Hypnaceae and Leucobryaceae (Bryophyta) families from Ferreira Penna Scientific Station, Caxiuanã, Pará, Brazil	Diversity and taxonomy	Ferreira Penna Scientific Station (ECFPn), belonging to the Emílio Goeldi Paraense Museum (Pará)	—

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Klissia Calina de Souza Gentil; Cristiane Rodrigues Menezes	2011	Biota Amazônia	Survey of bioindicators of environmental disturbance bryophytes from UNIFAP's Ecuador Ground Zero campus	Survey, taxonomic identification and storage; Indication of disturbed environments	Campus of the Federal University of Amapá (UNIFAP), located on the Juscelino Kubitschek de Oliveira highway, km 02, Bairro Zero of Ecuador, in the city of Macapá (Amapá).	Absences of epiphytic plants indicate disturbances in the ecosystem. The taxa that colonize exclusively leaves have this preference confirmed in literature. The same occurs with typical taxa of live trunks. These data suggest that the absence of epiphylls and large amounts of corticiculture in the Zona da Mussurro area is due to the disturbance of the primary ecosystem. The work proves the lack of studies of the Briophyta Division with probable three occurrences for the State of Amapá in only nine hectares studied.

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Cid José Passos Bastos	2012	Acta Botanica Brasilica	Taxonomy and distribution of *Cheilolejeunea aneogyna* (Spruce) A. Evans (Lejeuneaceae, Marchantiophyta)	Taxonomy in the *Cheilolejeunea aneogyna*	Taken from INPA Herbarium collections: São Gabriel; Manaus; Large Tarumã; Humaitá (Amazonas); Porto Velho (Rondônia) and Santarém (Pará).	—
Sylvia Mota de Oliveira; Hans ter Steege	2013	Acta Botanica Brasilica	Floristic overview of the epiphytic bryophytes of terra firme forests across the Amazon basin	Survey of epiphyte bryophytes	Ferreira Penna Scientific Station (ECFPn), belonging to the Emílio Goeldi Paraense Museum, (Pará); Tapajós National Forest (Pará); Adolpho Duck Reserve, Manaus (Amazonas); Urucu Oil Province (Amazonas); Pico da Neblina National Park (Amazonas).	—

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Osvanda Silva de Moura; Anna Luiza Ilkiu-Borges; Eliete da Silva Brito	2013	Hoehnea	Bryoflora (Bryophyta and Marchantiophyta) from Combu Island, Belem, PA, Brazil	Ecology	Combu Island is an Environmental Protection Area (APA) located in the municipality of Belém, on the left bank of the Guamá River, 1.5 km away from the city of Belém by water (Pará).	—
Eline Tainá Garcia; Anna Luiza Ilkiu-Borges; Ana Cláudia Caldeira Tavares-Martins	2014	Hoehnea	Bryoflora from two terra firme forests in the Tucuruí Lake Environmental Protection Area, PA, Brazil	Ecology	Tucuruí Hydroelectric Power Plant Reservoir, located in the southeastern region of the state of Pará.	—

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Gabriela Ramos Cerqueira, Anna Luiza Ilkiu Borges, Ângelo Gilberto Manzatto, Sebastião Maciel	2015	Biota Amazônia	Bryophytes from an open ombrophilous forest fragment in Porto Velho municipality and new occurrences for Rondônia, Brazil	Survey	Forest area, located at the José Ribeiro Filho Campus of the Federal University of Rondônia, in the municipality of Porto Velho (Rondônia).	Currently 167 species are listed for Rondônia and the new occurrences presented represent an increase of about 8% in this list, reinforcing the indications that systematized collections in order to investigate specific substrates are necessary for future inventories.
Daniele Nunes Fagundes, Ana Cláudia Caldeira Tavares-Martins, Anna Luiza Ilkiu-Borges, Eryka de Nazaré Rezende Moraes; Rita de Cássia Pereira dos Santos	2016	Iheringia	Wealth and ecological aspects of bryophyte (Bryophyta and Marchantiophyta) communities from a terra firme forest fragment in Gunma Ecological Park, Pará, Brazil	Ecology	Gunma Ecological Park, located in the municipality of Santa Bárbara, metropolitan region of Belém (Pará).	—

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Fúvio Rubens Oliveira-da-Silva; Anna Luiza Ilkiu-Borges	2016	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Bartramiaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—
Anna Luiza Ilkiu-Borges; Fúvio Rubens Oliveira-da-Silva	2016	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Calypogeiaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—
Anna Luiza Ilkiu-Borges; Fúvio Rubens Oliveira-da-Silva	2016	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Lepidoziaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—
Fúvio Rubens Oliveira-da-Silva; Anna Luiza Ilkiu-Borges	2016	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Stereophyllaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Moisés Oliveira Lopes, Márcio Roberto Pietrobom, Dimas Marchi do Carmo; Denilson Fernandes Peralta	2016	Hoehnea	Estudo comparativo de comunidades de briófitas sujeitas a diferentes graus de inundação no município de São Domingos do Capim, PA, Brasil	Ecology	Heart of Jesus and Nova Aliança Communities, located between the PA-127 highway and the Capim River, 15 to 18 km from the municipality of São Domingos do Capim, in the northeast region of Pará.	—
Fúvio Rubens Oliveira-da-Silva; Anna Luiza Ilkiu-Borges	2017	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Bryaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—
Anna Luiza Ilkiu-Borges; Fúvio Rubens Oliveira-da-Silva	2017	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Cephaloziaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Anna Luiza Ilkiu-Borges; Fúvio Rubens Oliveira-da-Silva	2017	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Cephaloziellaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—
Fúvio Rubens Oliveira-da-Silva; Anna Luiza Ilkiu-Borges	2017	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Bryaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—
Anna Luiza Ilkiu-Borges; Fúvio Rubens Oliveira-da-Silva	2017	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Cephaloziaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—
Fúvio Rubens Oliveira-da-Silva; Anna Luiza Ilkiu-Borges	2017	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Orthotrichaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Anna Luiza Ilkiu-Borges; Fúvio Rubens Oliveira-da-Silva	2017	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Plagiochilaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—
Fúvio Rubens Oliveira-da-Silva; Anna Luiza Ilkiu-Borges	2017	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Pterobryaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—
Paulo Henrique Meller Sobreira	2018	Dissertation	Richness and composition of bryophytes and pteridophytes between campinarana and terra firme in two locations in Central Amazonia, Brazil	Ecology	Adolpho Ducke Forest Reserve, located at km 26 of the AM-010 highway; Cachoeira da Sussuarana Environmental Protection Area (APA), located near the village of Balbina hydroelectric dam, Presidente Figueiredo municipality, about 150 km from Manaus (Amazonas).	The most diverse bryophyte families were Lejeuneaceae and Calymperaceae, while for the pteridophytes were Hymenophyllaceae and Polypodiaceae. It was observed that there was a positive correlation between bryophytes and pteridophytes richness.

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Larissa de Souza Saldanha; Márcia Nascimento Pinto; Renato Abreu Lima; Vandreza Souza dos Santos; Ronaldo de Almeida	2018	Biota Amazônia	Morphological characterization of bryophytes in Benjamin Constant-AM	Morphology	Site located at km 3 of BR 307 Benjamin Constant / Atalaia do Norte (Amazonas).	The most common family of Bryophyta phylum was Calymperaceae with six occurrences; Marchantiophyta was the Plagiochilaceae with two occurrences. It is noteworthy that it was the first bryphloristic survey of the city of Benjamin Constant.
Fúvio Rubens Oliveira-da-Silva; Anna Luiza Ilkiu-Borges	2018	Rodriguésia	Briófitas (Bryophyta e Marchantiophyta) of the Serra dos Carajás sarcas, Pará, Brazil	Taxonomy and ecology	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	The study of bryophytes in the Serra dos Carajás made it possible to know 51 new records for the Carajás cangas, seven for Pará, three for the Northern region and one for Brazil.
Fúvio Rubens Oliveira-da-Silva; Anna Luiza Ilkiu-Borges	2018	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Calymperaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Eliene Lima; Fúvio Rubens Oliveira-da-Silva; Anna Luiza Ilkiu-Borges	2018	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Frullaniaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—
Fúvio Rubens Oliveira-da-Silva; Anna Luiza Ilkiu-Borges	2018	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Hypnaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—
Fúvio Rubens Oliveira-da-Silva; Aline Joseph Ramalho; Anna Luiza Ilkiu-Borges	2018	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Leucobryaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—
Fúvio Rubens Oliveira-da-Silva; Anna Luiza Ilkiu-Borges	2018	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Pilotrichaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—

To be continued...

Frame 1 - continuation

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Fúvio Rubens Oliveira-da-Silva; Anna Luiza Ilkiu-Borges	2018	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Pylaisiadelphaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—
Fúvio Rubens Oliveira-da-Silva; Anna Luiza Ilkiu-Borges	2018	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Sematophyllaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—
Fúvio Rubens Oliveira-da-Silva; Anna Luiza Ilkiu-Borges	2018	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Thuidiaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—
Fúvio Rubens Oliveira-da-Silva; Anna Luiza Ilkiu-Borges	2018	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Dicranaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—

To be continued...

Frame 1 - conclusion

Authors	Year of publication	Journals	Title	Thematic	Place of collection	Conclusion
Anna Luiza Ilkiu-Borges; Fúvio Rubens Oliveira-da-Silva	2018	Rodriguésia	Flora of the Serra dos Carajás sarcas, Pará, Brazil: Lejeuneaceae	Taxonomy	Serra dos Carajás National Forest in the municipalities of Parauapebas and Canaã dos Carajás (Pará)	—
Adriel M. Sierra; Marta R. Pereira; Charles E. Zartman	2019	Rodriguésia	New records for the bryophyte flora of the Brazilian Amazon	New occurrence for the Brazilian Amazon	Youth Mountain - Roraima; Foggy Peak, Serra do Aracá, Hill of the Six Lakes - Amazonas	—
Marta R. Pereira; Alice Ledent; Patrick Mardulyn; Charles E. Zartman; Alain Vanderpoorten	2019	Journal of Systematics and Evolution	Maintenance of genetic and morphological identity in two sibling *Syrrhopodon* species (Calymperaceae, Bryopsida) despite extensive introgression	Phylogeny	Amazonas	—

Source: Authors 2019

Regarding the taxonomy considering the analyzed articles, the most frequent families were Calymperaceae with three genera Octoblepharum (3 spp), Calymperes (4 spp), Syrrhopodon (9 spp); Fissidentaceae with one genus Fissidens (11 spp), Hypnaceae with four genera Chryso-hypnum (2 ssp), Isopterygium (1 ssp), Ectropothecium (1 ssp), Rhacopilopsis (1 ssp) and Lejeuneaceae with 18 Cheilolejeunea (5 spp) genera Ceratolejeunea (3 spp), Cololejeunea (3 spp), Drepanolejeunea (2 spp), Acrolejeunea (2 spp), Lejeunea (2 spp),

Shiffneriolejeunea (2 spp), Odontolejeunea (1 ssp), Bryopteris (Brysp) (1 spp), Harpalejeunea (1 spp), Leptolejeunea (1 spp), Lopholejeunea (1 spp), Mastigolejeunea (1 spp), Taxilejeunea (1 spp), Pycnolejeunea (1 spp), Symphyogyna (1 spp) and Prionolejeunea (1 spp) Amazon region according to the works of Ilkiu-Borges *et al*. (2004), Lisboa *et al*. (1999), Santos; Lisbon (2003), Souza; Lisbon (2005).

It is worth emphasizing that these are among the 10 most diverse families in Brazil, and the genera Lejeunea (42 spp), Cololejeunea (21 spp), Fissidens (61 spp), Syrrhopodon (25 spp.), Calymperes (15 spp.) the 10 most known in the country (COSTA *et al*., 2010).

Flora do Brasil 2020 (2019) shows that when analyzed by phytogeographic domain in the Amazon the most diverse families are: Lejeuneaceae (182 spp.), Calymperaceae (44 spp.), Fissidentaceae (32 spp.), Lepidoziaceae (26 spp., 2) Sematophyllaceae (19 spp.), Pilotrichaceae (21 spp.), Orthotrichaceae (18 spp.), Dicranaceae (18 spp.), Sphagnaceae (14 spp.), and Plagiochilaceae (15 spp.) and Bryaceae (9 spp). These 11 families concentrate 26% of the total species for Brazil and 70% of the domain's diversity in the country (COSTA; LUIZI-PONZO, 2010). This shows the diversity in the northern region, and the importance of taxonomic studies for the region.

Regarding ecology, the articles analyzed are emphasized regarding richness, biodiversity, floristic composition of the studied Brioflora, according to Heidtmann (2012). Brioflora ecology generates knowledge about the diversity and biogeography of the species, contributing to the understanding of its distribution.

Advances in bryophyte research in the northern region have grown, although bryophyte in this region is one of the least understood, as difficulties related to continental size and scarcity of research resources in this region are smaller when compared to the number of other regions (PEREIRA, 2019).

Over the years research on this theme has grown in these states, and in the Amazon this scenario has been updated by recent publications of new

occurrences for the region (CARDOSO *et al*., 2015; BASTOS; ZARTMAN, 2017), were also collected and described new species (MOURA; ILKIU-BORGES, 2012; BASTOS; ZARTMAN, 2016; SIERRA *et al*., 2019), however, it is necessary to produce knowledge about species diversity, habits and negative environmental actions that achieve this vegetable.

Therefore, the study with different applications of this theme should be a factor of research acceleration, although it has allowed the identification of new species, which may or may not play roles as indicators of areas disturbed by presence or absence, and thus contribute more efficiently with the conservation of the biological diversity of bryophyte. Thus, knowledge of the entire region is required for use in different areas of science.

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