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Survey of the bryophytes of a gallery forest in the National Park of Serra do Cipó, Minas Gerais, Brazil¹

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Abstract: Serra do Cipó has attracted the interest of many researchers over the years because of its unique characteristics, particularly the fact that the site represents the transition between Cerrado and Atlantic Forest. The study area of Serra do Cipó is located along a gallery forest “córrego Três Pontinhas,” at 19°16'00" S and 43°32'49" W and an altitude of 1,188 m. The objective of this study was to survey the Division Bryophyta in a gallery forest within the National Park of Serra do Cipo, Minas Gerais. Collections were made during the months of November 2009 and July 2011. We found 15 families, 26 genera, 43 species, and 4 varieties of mosses. The families with the largest number of species were Leucobryaceae (10), Sematophyllaceae (9), and Calymperaceae (6). Other families included Fissidentaceae (3), Bryaceae, Pylaisiadelphaceae, Pottiaceae, and Orthotrichaceae (2 spp. each); Brachytheciaceae, Cryphaeaceae, Fabroniaceae, Helicophyllaceae, Hypnaceae, Polytrichaceae, and Sphagnaceae had only 1 sp. each. Three new records for the state of Minas Gerais were found: *Acroporium caespitosum*, *A. longirostre*, and *Colobodontium vulpinum*.

Keywords: Acrocarpous, Bryophyta, conservation, mosses, new records, pleurocarpous, taxonomy

Introduction

With approximately 13,000 described species, the division Bryophyta is the second richest in species among the land plants (Goffinet *et al.* 2009). In Brazil, there are approximately 883 species (Forzza *et al.* 2012), but there is still no taxonomic work with a national coverage.

The area of the Serra do Cipó has aroused the interest of researchers over the years due to its unique characteristics, particularly the fact that this region contains the transition between two very important biomes: the Cerrado and Atlantic Forest. The region is also famous for its richness and endemism of rocky grassland (Ribeiro *et al.* 2009). Further, due to its high importance as a watershed between the basins of the Rio Doce to the east and the San Francisco River to the west, the National Park of Serra do Cipó (PARNA-Cipó) was established by Decree no. 90 223, of September 25, 1984 (Brasil 1984).

PARNA-Cipó is located entirely within the state of Minas Gerais, Brazil, (19°13' to 19°32' S and 43°27' to 43°27' W) and covers an area of 31,617.8 ha with a perimeter of 119,978.5 m, of which 20,764 ha or 65.6% is in the Jaboticatubas municipality. The other municipalities are Santana do Riacho with 2,615 ha (8.3%), Morro do Pilar with 5,934 ha (18.8%), and Itambé do Mato Dentro with 2,304 ha (7.3%). The administrative headquarters of PARNA-Cipó

are located just 100 km from the state capital of Minas Gerais, Belo Horizonte (Ribeiro *et al.* 2009). This city has more than five million inhabitants and is currently the 3rd largest metropolitan area in the country (IBGE 2012). Thus, studies on the biodiversity of this region are urgent as it is known that the city is expanding toward this area, threatening the large number of endemic species of both flora (89 spp.) and fauna as (18 spp.) (Madeira *et al.* 2008).

Although there is a high a degree of endemism of flowering plants in the Serra do Cipó (Madeira *et al.* 2008; Santos *et al.* 2011), nothing is known regarding its bryophyte endemism. The first moss inventories in the Serra do Cipó started with Giulietti *et al.* (1987), in which 18 species of mosses and 1 liverwort are listed. However, the author fails to mention the habitat of the listed species or the sampling methodology. This number is very low compared to collection reports of other groups of plants in the same locality that may have involved a greater sampling effort, particularly flowering plants (Madeira *et al.* 2008; Santos *et al.* 2011). After 24 years, a new, much more comprehensive study on bryophytes was conducted in Serra do Cipó produced by Yano & Peralta (2011) containing illustrations, identification keys, and descriptions of 142 species of mosses, 93 species of liverworts, and 2 species of hornworts. The present work is part of the project Flora of Serra do Cipó outlined by Giulietti *et al.* (1987), which has a goal of producing monographs of

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all plant families of the Serra do Cipó. The work of Yano & Peralta (2011) features a total of 237 species of bryophytes (mosses, liverworts, and hornworts) in the Serra do Cipó against 19 species initially identified, indicating that collection efforts can greatly increase our knowledge of biodiversity in a particular region. This number of 142 species of mosses represents 30% of the total species within only 0.05% of area of the State of Minas Gerais (Forzza *et al.* 2012).

Bryophytes generally thrive best in moist environments (Goffinet *et al.* 2009), such as gallery forests and forest formations around small rivers (Rezende 1998; MMA 2007). Thus, these environments become prime targets for collection. Indeed, surveys conducted in gallery forests have shown that this environment has a great diversity of bryophytes (Genevro *et al.* 2006; Câmara 2008a; 2008b; Dias-Neto 2011). Thus, the aim of this study was to conduct a moss survey (Division Bryophyta) in a gallery forest associated with Três Pontinhas creek, (19°16'00" S and 43°32'49" W), altitude 1,188 meters above sea level located within the National Park of Serra do Cipó. This creek is a tributary of the Indequicé River, which flows into the Parauninha River, a tributary of the Velhas River that is part of the São Francisco River basin, one of the major drainage basins in Brazil.

Material and methods

Two collecting fieldtrips were undertaken, one day in November 2009 and other day in July 2011.

Sampling followed the methodology of Frahm (2003). Collections were made with the aid of a knife or manually. Species were classified according to the substrate on which they were found with the information obtained from the material examined following Robbins (1952) with modifications: 1) corticolous, on living tree trunk; 2) epiphyllous, on living leaves; 3) epixylic, on dead or decaying trunk; 4) rupicolous, on stones and; 5) terrestrial, on the ground.

Identification was performed using keys and literature available and when necessary, by sending the material to specialists. All specimens are stored at the Herbarium of the University of Brasília (UB).

Taxa are presented in Table 1 in alphabetical order of family, genus, and species following the classification system proposed by Goffinet *et al.* (2009). The concept of acrocarpous, cladocarpous, and pleurocarpous follows La Farge-England (1996) and is applied to mosses of Superclass V (Goffinet *et al.* 2009). The information regarding the geographical distribution and biogeographical domains were taken from Costa *et al.* (2011) and Forzza *et al.* (2012).

Results and discussion

A total of 176 herbarium specimens were examined: 120 were collected while 56 were already archived in the herbarium UB.

A total of 43 species were found (Tab. 1), representing about 30% of the number of species of mosses studied by Yano & Peralta (2011). In addition, three new species were recorded for the state of Minas Gerais and 12 more species were identified that have not been cited by Yano & Peralta (2011), but while the latter listed the moss flora of the Serra do Cipó, this paper lists the mosses collected in just one single gallery forest located within the PARNA-Cipó.

The species studied were collected in four different substrates with corticolous accounting for 49% and terrestrial substrate accounting for 30%. This result was expected, since the corticolous substrate is widely available in an area of forest vegetation (Santos & Costa 2008).

Mosses and gallery forests

Studies focusing solely on bryophytes in gallery forests of the Cerrado are rare, the first being Genevro *et al.* (2006) that lists 33 species in a gallery forest in a park in Mato Grosso state, Câmara (2008a, 2008b) with 41 species in the gallery forest of a nature reserve in the Federal District and the as yet unpublished dissertation of Dias-Neto (2011) listing 53 species within a protected area also in the Federal District. With the exception of the work done by Genevro *et al.* (2006) that was based on a collection in a single gallery forest, others were based on collecting in multiple gallery forests and, although the work presented here has also been made based on a double collection in the same gallery forest, the number of species identified was higher than those collected by Câmara (2008a, 2008b) in multiple gallery forests in a given locality. This value of 43 species indicates a high diversity of mosses in this region as the collection was made in a single gallery forest, and still managed to cover about 4.9% of total species, 10% of the genera, and 21% of families of mosses occurring in Brazil.

The most common species collected was *Sematophyllum subpinnatum* with 38 samples, more than double the second most collected which was *Schlotheimia rugifolia* with 15 samples. Genevro *et al.* (2006) found that these species are represented by one or two samples. Câmara (2008a, 2008b) also collected more *S. subpinnatum* with 16 samples, but the second most collected was *Octoblepharum albidum* with 15 samples. In the study by Dias-Neto (2011), it was not possible to determine which was the most collected species because he describes species collected in his dissertation only as pleurocarpous mosses.

When compared with published data for the Atlantic Forest, Oliveira *et al.* (2002) found the most abundant species were *S. subpinnatum*, *Vesicularia vesicularis*, and *Isopterygium tenerifolium*. In the study by Siqueira *et al.* (2011), the most abundant species were *S. subpinnatum*, *Orthostichopsis praetermissa*, and *Henicodium geniculatum*. In the other works consulted (Costa & Silva 2003; Visnadi 2005; Santos & Costa 2008; Valente *et al.* 2009), it was not possible to ascertain the most collected species.

Table 1: Species of mosses occurring in the gallery forest stream Três Pontinhas, National Park of Serra do Cipó, MG, Brazil, with data on geographical distribution and substrate. Substrates (Sub.): CO = corticolous, EX = epixylic, EF = epiphyllous, RU = rupicolous, TE = terrestrial. Phytogeographic domains (Phyt. dom.): Amazon Rainforest = AM, Atlantic Rainforest = AT, Central Brazilian Savanna = SA, Caatinga = CA, Pampa = PA, Pantanal = PL. In parentheses next to each family represents the number of genera and species. * new record for the state of Minas Gerais, ** new occurrence for the National Park of Serra do Cipó.

Species	Sub.	Phyt. dom.	World distr.	Vouchers
ACROCARPOUS				
BRYACEAE Schwägr. (2/2)				
<i>Bryum caespiticium</i> Hedw. **	RU	AT	Cosmopolitan	Sousa, R.V.178, 188
<i>Rosulabryum billarderi</i> (Schwägr.) J.R. Spence	TE	AM, AT, PA, PL, SA	Cosmopolitan	Sousa, R.V. 201
CALYMPERACEAE Kindb. (2/6)				
<i>Octoblepharum albidum</i> Hedw.	CO	AM, AT, CA, PA, PL, SA	Pantropical	Câmara, P.E.A.S. 2118-a
<i>Syrrhopodon gaudichaudii</i> Mont.	CO	AM, AT, CA, PL, SA	Pantropical	Câmara, P.E.A.S. 2102
<i>Syrrhopodon lycopodioides</i> (Sw. ex Brid.) Müll. Hal. **	RU	AT	Neotropical	Câmara, P.E.A.S. 2085
<i>Syrrhopodon parasiticus</i> (Sw. ex Brid.) Paris	CO, EX	AM, AT, PL, SA	Pantropical	Duarte-Silva, A.G. 72, Gonzaga, R.M.O. 93; Sousa, R.V. 150, 168
<i>Syrrhopodon prolifer</i> Schwägr. var. <i>prolifer</i>	CO, RU, TE	AM, AT, CA, AS	Pantropical	Duarte-Silva, A.G. 77; Câmara, P.E.A.S. 2141, 2149; Sousa, R.V. 155, 156, 165, 171, 275
<i>Syrrhopodon tortilis</i> Hampe	CO	AT	Neotropical	Câmara, P.E.A.S. 2096
FISSIDENTACEAE Schimp. (1/3)				
<i>Fissidens lagenarius</i> Mitt. var. <i>lagenarius</i> **	CO	AT, CA, PL, SA	Neotropical	Sousa, R.V. 191
<i>Fissidens pellucidus</i> Hornsch. var. <i>pellucidus</i> **	EX	AM, AT, CA, PA, PL, SA	Neotropical	Duarte-Silva, A.G. 71
<i>Fissidens serratus</i> Müll. Hal. **	TE	AM, AT, CA, AS	Neotropical	Sousa, R.V. 280
LEUCOBRYACEAE Schimp. (3/10)				
<i>Campylopus dichrostris</i> (Müll. Hal.) Paris	CO, EX	AT, SA	Endemic of Brazil	Sousa, R.V. 198, 266, 279
<i>Campylopus occultus</i> Mitt.	CO	AM, AT, PA, PL, SA	Neotropical	Sousa, R.V. 162
<i>Campylopus pilifer</i> Brid.	RU	AM, AT, CA, PA, SA	Neotropical	Câmara, P.E.A.S. 2155; Sousa, R.V. 148, 169
<i>Campylopus richardii</i> Brid.	RU	AM, AT	Neotropical	Câmara, P.E.A.S. 2155
<i>Campylopus savannarum</i> (Müll. Hal.) Mitt.	CO	AM, AT, CA, PL, SA	Pantropical	Câmara, P.E.A.S. 2034-b; Sousa, R.V. 189
<i>Campylopus thwaitesii</i> (Mitt.) A. Jaeger	CO, EX	AT	Endemic of Brazil	Câmara, P.E.A.S. 2036-a, 2070; Sousa, R.V. 193
<i>Leucobryum clavatum</i> Hampe	TE	AT, SA	Endemic of Brazil	Sousa, R.V. 176
<i>Leucobryum crispum</i> Müll. Hal.	TE	AM, AT, SA	Neotropical	Câmara, P.E.A.S. 2045, 2056; Duarte-Silva, A.G. 88; Gonzaga, R.M.O. 112, 118; Sousa, R.V. 194, 203, 268
<i>Leucobryum martianum</i> (Hornsch.) Hampe ex Müll. Hal.	RU, TE	AM, AT, CA, PL, SA	Neotropical	Duarte-Silva, A.G. 88; Câmara, P.E.A.S. 2062, 2083, 2113, 2114, 2125, 2131, 2132, 2149
<i>Ochrobryum gardneri</i> (Müll. Hal.) Mitt.	EX	AM, AT, PL, SA	Neotropical and Africa	Câmara, P.E.A.S. 2099-b
POLYTRICHACEAE Schwägr. (1/1)				
<i>Polytrichum commune</i> Hedw.	TE	AM, AT, SA	Cosmopolitan	Sousa, R.V. 267
POTTIACEAE Schimp. (2/2)				
<i>Barbula indica</i> (Hook.) Spreng.	TE	AM, AT, CA, PL, SA	Pantropical	Câmara, P.E.A.S. 2115
<i>Hymenostylium recurvirostrum</i> (Hedw.) Dixon **	RU	AT, SA	Cosmopolitan	Câmara, P.E.A.S. 2145
CLADOCARPOUS				
HELICOPHYLLACEAE Broth. (1/1)				
<i>Helicophyllum torquatum</i> (Hook.) Brid.	CO	AM, AT, CA, PA, PL, SA	Neotropical	Câmara, P.E.A.S. 2043, 2135, 2136

Continues.

Table 1. Continuation.

Species	Sub.	Phyt. dom.	World distr.	Vouchers
ORTHOTRICHACEAE Arn. (2/2)				
<i>Macromitrium richardii</i> Schwägr.	CO, EX	AM, AT	Neotropical	Gonzaga, R.M.O. 87, 121
<i>Schlotheimia rugifolia</i> (Hook.) Schwägr.	CO	AM, AT, SA	Neotropical and India	Câmara, P.E.A.S. 2027, 2111; Duarte-Silva, A.G. 73, 75, 91; Sousa, R.V. 152, 153, 167, 170, 174, 199, 256, 274, 279, 280
PLEUROCARPOUS				
BRACHYTHECIACEAE Schimp. (1/1)				
<i>Squamidium brasiliense</i> (Hornsch.) Broth.	EX	AT	Africa and Americas	Sousa, R.V. 260
CRYPHAEACEAE Schimp. (1/1)				
<i>Schoenobryum concavifolium</i> (Griff.) Gangulee **	CO, EX	AM, AT, PA, PL, SA	Cosmopolitan	Sousa, R.V. 197, 200
FABRONIACEAE Schimp. (1/1)				
<i>Fabronia ciliaris</i> (Brid.) Brid. var. <i>ciliaris</i>	TE	AT, CA, SA	Bolívia, Chile, Ecuador and EUA	Sousa, R.V. 271
HYPNACEAE Schimp. (1/1)				
<i>Chryso-hypnum diminutivum</i> (Hampe) W.R. Buck	EX	AM, AT, PA, PL, SA	Cosmopolitan	Câmara, P.E.A.S. 2148
PYLAISIADELPHACEAE Goffinet & W.R. Buck (2/2)				
<i>Isopterygium tenerum</i> (Sw.) Mitt.	CO, EX, TE	AM, AT, CA, PA, PL, SA	Cosmopolitan	Câmara, P.E.A.S. 2034-b; Gonzaga, R.M.O. 100; Sousa, R.V. 156
<i>Wijkia flagellifera</i> (Broth.) H.A. Crum	CO	AT	Neotropical	Duarte-Silva, A.G. 75; Gonzaga, R.M.O. 94; Sousa, R.V. 276, 277
SEMATOPHYLLACEAE Broth. (5/9)				
<i>Acroporium caespitosum</i> (Hedw.) W.R. Buck *	TE	AT, SA	Neotropical	Câmara, P.E.A.S. 2112
<i>Acroporium longirostre</i> (Brid.) W.R. Buck *	CO, RU	AM, AT, SA	Neotropical	Câmara, P.E.A.S. 2087, 2107
<i>Aptychopsis subpungifolia</i> (Broth.) Broth. **	CO	AT	Endemic of Brazil	Duarte-Silva, A.G. 87; Gonzaga, R.M.O. 91,95; Sousa, R.V. 160,270
<i>Colobodontium vulpinum</i> (Mont.) S.P. Churchill & W.R. Buck *	RU	AM, AT, SA	Neotropical	Câmara, P.E.A.S. 2110; Duarte-Silva, A.G. 83, 86
<i>Donnellia commutata</i> (Müll. Hal.) W.R. Buck	CO, EX	AM, AT, PL, SA	Neotropical	Câmara, P.E.A.S. 2028, 2041, 2075-a, 2069, 2105, 2129; Gonzaga, R.M.O. 120; Sousa, R.V.146, 154, 157, 180, 192, 273, 278
<i>Sematophyllum adnatum</i> (Michx.) E. Britton	EX, RU	AM, AT, CA, AS	America tropical and subtropical and tropical Africa	Câmara, P.E.A.S. 2037-a, 2140
<i>Sematophyllum galipense</i> (Müll. Hal.) Mitt.	EX, RU	AM, AT, SA	Neotropical	Câmara, P.E.A.S. 2049, 2051-b, 2086, 2095-a, 2103-a; Gonzaga, R.M.O. 120; Sousa, R.V. 183
<i>Sematophyllum subpinnatum</i> (Brid.) E. Britton	CO, EX, RU	AM, AT, CA, PA, PL, SA	Pantropical	Câmara, P.E.A.S. 2040, 2066, 2067, 2104, 2128-a; Duarte-Silva, A.G. 73, 76, 85, 93, 71, 67, 92, G. 86, 90, 101, 104, 106, 107, 108, 109, 115, 119; Sousa, R.V. 145, 151, 154-a, 161, 173, 177, 185, 186, 187, 159, 168, 184, 195, 197, 198, 278
<i>Sematophyllum subsimplex</i> (Hedw.) Mitt.	CO, EX, RU, TE	AM, AT, CA, PL, SA	Neotropical	Câmara, P.E.A.S. 2038-a, 2116; Duarte-Silva, A.G. 69, 82, 80, 89; Gonzaga, R.M.O. 87, 120; Sousa, R.V. 156, 179, 196, 273
WITHOUT CLASSIFICATION				
SPHAGNACEAE Dumort. (1/1)				
<i>Sphagnum submedium</i> Warnst. **	TE	AT	Endemic of Brazil	Sousa, R.V. 201

It can be concluded that *Sematophyllum subpinnatum* is the most collected among mosses during collecting expeditions, whether in gallery forests of the Cerrado biome, or in the Atlantic Forest.

Distribution of acrocarpous and pleurocarpous mosses

Acrocarpous mosses were found more abundantly in open and exposed areas and are known to be more resistant to dehydration than pleurocarpous mosses (Goffinet *et al.* 2009; Govindaparyi *et al.* 2012), and as the collection took place in a gallery forest, it was expected that there would be a predominance of pleurocarpous mosses over the acrocarpous mosses, but our data showed otherwise. The acrocarpous mosses represented 53% of the species found. Câmara (2008a; 2008b) also demonstrated the occurrence of more pleurocarpous than acrocarpous mosses (54%), well as Dias-Neto (2011) with 42%, both in the Federal District, Brazil. Genevro *et al.* (2006) is the only reference that shows the occurrence of more pleurocarpous mosses (53%).

When examining the distribution of acro and pleurocarpous mosses in the Atlantic Forest, the data show a balance, with three studies (Oliveira *et al.* 2002; Costa & Silva 2003; Siqueira *et al.* 2011) showing the occurrence of more acrocarpous than pleurocarpous mosses, and three studies (Visnadi 2005; Santos & Costa 2008; Valente *et al.* 2009) showing the opposite. Note that we used only those studies in which there was a complete list of mosses and families, and those wrongly applied in a category were corrected using the criteria proposed by La Farge-England (1996) and Goffinet *et al.* (2009). Such information becomes more relevant when one takes into consideration that the pleurocarpous mosses form one of the most diverse groups within the Division Bryophyta, with approximately 45% of the genera (Cox *et al.* 2010) and its most common habitat is on trunks and leaves of angiosperms (Shaw *et al.* 2003). It is exactly this type of environment that is common in a gallery forest in the Cerrado biome (Rezende 1998; MMA 2007) and the Atlantic Forest is characterized by a moist environment and the formation of a dense arboreal canopy (Rambaldi *et al.* 2003).

Substratum preference and geographical distribution

From our data, it can be noted that the substrate corticolous was predominant in all mosses, either acro, pleuro, or cladocarpous, but the rupicolous and terrestrial substrates were not observed in cladocarpous mosses. The epiphyllous substrate was not observed in any mosses.

As for the distribution by phytogeographic domains, eight species (19% of the total) are so far considered ex-

clusive to the Atlantic. They are *Aptychopsis subpungifolia*, *Bryum caespiticium*, *Campylopus thwaitesii*, *Sphagnum submedium*, *Squamidium brasiliense*, *Syrrhopodon lycopodioides*, *S. tortilis*, and *Wijkia flagellifera*. No other phytogeographic domain shows exclusive species. All 43 species occur in the Atlantic Forest and 32 of 43 species occur in the Cerrado.

By observing this distribution, it can be inferred that in principle, the moss flora of the gallery forest creek Três Pontinhas, is represented to a greater degree by mosses from the Atlantic Forest than to the Cerrado. However, this can only be concluded after an ecological study to test this hypothesis.

Conservation status

Regarding the conservation status of the species studied, none of the presented species (nor any other in the region), occur in MMA Instruction No. 06 of 2008 (MMA 2008), the official list of endangered species used by the Brazilian government. In addition, the Red List of the International Union for Conservation of Nature and Natural Resources (IUCN) mentions 44 species of mosses with some degree of endangerment, and none are found the National Park of Serra do Cipó.

The moss species identified in this study have a widespread occurrence in Brazil. The only species occurring here that could possibly become more vulnerable would be because they occur in only three of the twenty-seven states of Brazil and the Federal District and are endemic to the country. These are *A. subpungifolia* and *S. submedium*. *A. subpungifolia* was identified with the help of photographs of the type specimen, as this species can be confused with other species of the genus *Acroporium* because both have elongated leaves and inclined alar cells at an angle of ca. 45°. However, *A. subpungifolia* has as distinctive features the straight margin and alar cells with thickened walls. As for *S. submedium* according to Crum (1992), this species is close to *Sphagnum buckianum*, but differs in having larger pores evenly distributed in cells and, unlike *S. buckianum* in which the pores have restricted ends, *S. submedium* presents three groups of fascicles with one pending, while *S. buckianum* presents two, both scattered.

Far from indicating that bryophytes are in a safe situation, the work of Câmara & Carvalho-Silva (2011) demonstrates the gaps existing in the study of bryophytes and that the realization that even apparently common species are endangered can occur when further studies are conducted.

The data discussed in this work along with other literature demonstrates that the National Park of Serra do Cipó has a very diverse flora of bryophytes, in view that an area of a few tens of meters along a gallery forest was sampled, but also demonstrates that more comprehensive studies on the ecology of the species are necessary.

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