

Floristic survey of the mosses of the Estação Biológica de Santa Lúcia, Santa Teresa, Espírito Santo, Brazil

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RESUMO: (Levantamento florístico dos musgos da Estação Biológica de Santa Lúcia, Santa Teresa, Espírito Santo, Brasil). A Estação Biológica de Santa Lúcia (EBSL) localizada no Município de Santa Teresa no Estado do Espírito Santo, Brasil, possui uma área de 440 ha de Mata Atlântica, um bioma com uma alta diversidade de organismos e um sério risco de sobrevivência, pois possui atualmente apenas 12,5% da sua área original espalhada em fragmentos acima de 3 ha. O objetivo deste trabalho foi identificar as espécies de musgos (Divisão Bryophyta) localizados dentro da área da EBSL. Foram identificadas 56 espécies de musgos (22,5% do total de musgos do Estado), das quais 9 são novas ocorrências para o Estado do Espírito Santo.

Palavras-chaves: Taxonomia, Biodiversidade, Briófitas, Floresta Tropical, Riqueza.

ABSTRACT: The Estação Biológica de Santa Lúcia (EBSL) is located in the municipality of Santa Teresa in Espírito Santo state, Brazil, has an area of 440 ha of Atlantic Rainforest, a biome with a high diversity of organisms and a serious risk of survival because it has currently only 12.5% of its original area scattered in fragments over 3 ha. The objective of this study was to identify the species of moss (Division Bryophyta) located within the area of EBSL. Fifty six moss species (22.5% of total of mosses for state) were identified, of which 9 are new records for the state of the Espírito Santo.

Key words: Taxonomy, Biodiversity, Bryophyte, Tropical forest, Richness.

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Introduction

The Estação Biológica de Santa Lúcia (EBSL) is located in the municipality of Santa Teresa in the mountainous region of the state of Espírito Santo. It is a protected area comprising an area covered by the Atlantic Rainforest biome with about 440 ha and with a presence of high biological richness (Mendes & Padovan, 2000).

It is well known that the Atlantic Rainforest biome is one of the most important in the world due to its high degree of biodiversity and vulnerable situation (Campanili & Schaffer, 2010). This biome occupied an area of approximately 15% of Brazil, but today there remain only 12.5% of Atlantic Rainforest distributed in fragments with over 3 ha (Fundação SOS Mata Atlântica & INPE, 2014), and is the biome where 131 million people or 69% of Brazil's population live (IBGE, 2010). For being the first place of colonial settlement of the Portuguese in about 515 years this environment has undergone a population pressure for several centuries.

In this biome, mosses (Division Bryophyta) are abundant and well represented, present in all available substrates, such as rocks, tree trunks, leaves and soil and so they are part of the landscape. The Atlantic Rainforest remnants have great diversity of microhabitats and high humidity, which favors the development of this group of plants (Frahm *et al.* 2003), so this environment becomes a prime target for the collection of bryophytes (Oliveira-e-Silva *et al.* 2002; Costa & Silva 2003; Visnadi 2005; Santos & Costa 2008; Valente *et al.* 2009; Siqueira *et al.* 2011).

Specific studies on bryophytes occurring in the state of Espírito Santo are relatively recent and begins with the work of Schäfer-Verwimp (1991), followed by Behar *et al.* (1992), Visnadi & Vital (1995), Costa & Silva (2003), Yano (2005), Yano & Peralta (2008) and Yano (2012). The last full catalogue that gathers the data available for the state of Espírito Santo was carried out by Yano (2012), which reports on the occurrence of 286 taxa of Division Bryophyta for the state, but this figure was reduced to 248 in compiling of Costa *et al.* (2015). Although research on bryophytes in the state of Espírito Santo have been increasing, gaps in collections in preserved areas of Atlantic Rainforest in the state are still observed. So far there is no work that specifically addresses the mosses of the EBSL.

Floristic inventories are important for supporting preservation actions, and in the case of a biome so intensely occupied by human populations, recording the species occurring in the locality is of great importance because human populations tend to increase while areas of native forests tend to decrease.

So the aim of this study is to conduct a floristic inventory of mosses in the EBSL and contribute to the knowledge of the flora of the state of Espírito Santo and the Atlantic Rainforest biome.

Material and methods

The Estação Biológica de Santa Lúcia (19°58'11" S 40°32'11" W), has a Tropical Altitude climate type according Köppen (1948) classification, with an average annual rainfall of 1,868 mm (Mendes & Padovan, 2000). Temperature means was estimated 19.9 °C with the average maximum at 26.2 °C and the minimum in 14.3 °C (Thomaz & Monteiro, 1997). Its predominant vegetation cover is Tropical Rainforest (Velooso & Góes-Filho, 1982), in most primary and well preserved, distributed over a highly undulating soil, with altitudes ranging between 650 m and 900 m (Thomaz & Monteiro, 1997).

Random sampling was performed during the month of September 2013 in the damp environments such as margin of waterfalls and streams, and trails through the forests. The methodology follow Frahm *et al.* (2003) and identified using an optical microscope and stereomicroscope with the aid of specialized literature, then incorporated into the collections of the Brasilia University herbarium (UB) and duplicates of surplus material were sent to the herbarium of Museu de Biologia Prof. Mello Leitão (MBML). When necessary, permanent slides were prepared with Hoyer solution (Anderson, 1954).

Substrate classification followed Robbins (1952) with modifications: (1) corticolous - on trunk living tree, (2) epiphyllous - on living leaves, (3) epixylic - on dead or decaying trunk, (4) rupicolous - on stones and (5) terrestrial - on the ground. The 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 based on the position of perichaetium follows that proposed by La Farge-England (1996). The information regarding the geographical distribution were taken mainly from List of Species of Flora of Brazil (Costa *et al.*, 2015) and for verification of the new occurrences for the state and biome Yano & Peralta (2008), Yano (2011, 2012) and Costa *et al.* (2011) were consulted. The Tropicos® database (Tropicos 2015) was used for correction of names of taxa. The biome distribution was chosen because it is more natural than the distribution by states because they have artificial limits.

Table 1. Species of mosses occurring in the Estação Biológica de Santa Lúcia, ES, Brazil, with data on phytogeographical distribution and substrate found. 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 Espírito Santo.

SPECIES	SUB.	PHYT. DOM.	VOUCHERS
ACROCARPOUS			
BARTRAMIACEAE (1/2)			
* <i>Philonotis elongata</i> (Dism.) H.A. Crum & Steere	RU	AM, AT, SA	Faria, A.L.A. 1016
<i>Philonotis uncinata</i> (Schwäger.) Brid.	RU	AM, AT, CA, PA, PL, SA	Sousa, R.V. 717, 723, 732, 745, 768, 786
BRYACEAE (1/3)			
<i>Rosulabryum billardieri</i> (Schwäger.) J.R. Spence	RU	AM, AT, PA, PL, SA	Faria, A.L.A. 1026
<i>Rosulabryum capillare</i> (Hedw.) J.R. Spence	TE	AM, AT, PA, PL, SA	Sousa, R.V. 733
<i>Rosulabryum densifolium</i> (Brid.) Ochyra	RU	AT, SA	Faria, A.L.A. 1033
CALYMPERACEAE (2/4)			
<i>Octoblepharum albidum</i> Hedw.	CO, EX	AM, AT, CA, PA, PL, SA	Faria, A.L.A. 1049; Sousa, R.V. 779
<i>Octoblepharum pubinatum</i> (Dozy & Molke) Mitt.	CO	AM, AT, CA, PL, SA	Faria, A.L.A. 1048
<i>Syrhobodan graminicola</i> R.S. Willians	EX, RU	AM, AT	Sousa, R.V. 787, 819
<i>Syrhobodan prolifer</i> Schwäger.	EX, RU, TE	AM, AT, CA, SA	Faria, A.L.A. 998, 1016, 1030, 1044, 1045; Sousa, R.V. 746, 748, 754, 757, 766, 770, 788, 789, 790, 791, 792
DICRANACEAE (1/1)			
<i>Leucoloma trifforme</i> (Mitt.) A. Jaeger	RU	AT	Faria, A.L.A. 1037, 1044; Sousa, R.V. 769, 788, 794, 796, 812
LEUCOBRYACEAE (2/8)			
<i>Campylopus aretocarpus</i> (Hornsch.) Mitt.	CO, RU	AT, CA, PA, SA	Sousa, R.V. 771, 813, 816, 1016
<i>Campylopus dichrostis</i> (Müll. Hal.) Paris	RU	AT, SA	Sousa, R.V. 746

Table 1 (cont.)

SPECIES	SUB.	PHYT. DOM.	VOUCHERS
* <i>Campylopus fragilis</i> (Brid.) Bruch & Schimp.	CO, EX	AT	Faria, A.L.A. 1017; Sousa, R.V. 790
<i>Campylopus heterostachys</i> (Hampe) A. Jaeger	EX, RU	AM, AT, CA, SA	Sousa, R.V. 760, 775
<i>Campylopus occultus</i> Mitt.	CO, EX, RU, TE	AM, AT, PA, PL, SA	Faria, A.L.A. 1007, 1008; Sousa, R.V. 739, 747, 753, 763, 778, 780, 802, 822,
<i>Campylopus pilifer</i> Brid.	RU, TE	AM, AT, CA, PA, SA	Faria, A.L.A. 1056; Sousa, R.V. 737, 739, 773
<i>Campylopus thwaitesii</i> (Mitt.) A. Jaeger	RU	AM, AT, CA, PA, SA	Faria, A.L.A. 1018
<i>Ochrobryum gardneri</i> (Müll. Hal.) Mitt.	CO, EX, RU	AM, AT, PL, SA	Sousa, R.V. 746, 789, 789-A, 818,
POTTIACEAE (4/4)			
* <i>Barbula arcuata</i> Griff.	TE	AM, AT, SA	Sousa, R.V. 758
<i>Hypophila involuta</i> (Hook.) A. Jaeger	RU	AM, AT, CA, PA, PL, SA	Faria, A.L.A. 1023; Sousa, R.V. 715, 721, 743
* <i>Timmiaella barbulooides</i> (Brid.) Mönk.	RU	AT	Sousa, R.V. 804
<i>Weissia controversa</i> Hedw.	RU	AM, AT, SA	Faria, A.L.A. 1055
CLADOCARPOUS			
ORTHOTRICHACEAE (2/3)			
<i>Macromitrium richardii</i> Schwägr.	EX	AM, AT	Sousa, R.V. 764
<i>Schlotheimia jamesonii</i> (Arn.) Brid.	RU	AM, AT, PA, SA	Faria, A.L.A. 1006
<i>Schlotheimia rugifolia</i> (Hook.) Schwägr.	CO, EX, RU, TE	AM, AT, SA	Faria, A.L.A. 986, 987, 993, 1053; Sousa, R.V. 736, 740, 787, 799, 815
PLEUROCARPOUS			
BRACHYTHECIACEAE (1/1)			
<i>Zelometeorium patulum</i> (Hedw.) Manuel	CO, EX, EF	AM, AT, PL, SA	Faria, A.L.A. 988, 1047, 1050, 1057; Sousa, R.V. 731, 744, 808
DALTONIACEAE (1/1)			
* <i>Leskeodon auratus</i> (Müll. Hal.) Broth.	TE	AM, AT	Sousa, R.V. 823

Table 1 (cont.)

SPECIES	SUB.	PHYT. DOM.	VOUCHERS
HYPNACEAE (2/3)			
<i>Chryso-hypnum diminutivum</i> (Hampe) W.R. Buck	EX	AM, AT, PA, PL, SA	Sousa, R.V. 785-A, 801
<i>Chryso-hypnum elegantulum</i> (Hook.) Hampe	RU	AM, AT, PL, SA	Faria, A.L.A. 1025
<i>Mittenothamnium reptans</i> (Hedw.) Cardot	CO, EX	AT, PA, SA	Faria, A.L.A. 1038; Sousa, R.V. 787, 814
LEUCOMIACEAE (1/1)			
<i>Leucomium strumosum</i> (Hornsch.) Mitt.	RU	AM, AT	Sousa, R.V. 810
METEORACEAE (2/2)			
<i>Floribundaria flaccida</i> (Mitt.) Broth.	CO	AM, AT, PL, SA	Faria, A.L.A. 999
<i>Meteorium nigrescens</i> (Sw. ex Hedw.) Dozy & Molk.	CO, EX	AM, AT, PL, SA	Faria, A.L.A. 1009, 1013; Sousa, R.V. 734, 756
NECKERACEAE (3/3)			
* <i>Homalioidendron piniforme</i> (Brid.) Enroth	RU	AT	Faria, A.L.A. 1056
<i>Neckeropsis disticha</i> (Hedw.) Kindb.	CO	AM, AT, PL, SA	Sousa, R.V. 750
<i>Thamnobryum fasciculatum</i> (Sw. ex Hedw.) I. Sastre	RU	AT	Sousa, R.V. 809
PHYLLOGONIACEAE (1/1)			
<i>Phyllogonium viride</i> Brid.	CO	AM, AT	Faria, A.L.A. 1005; Sousa, R.V. 738
PILOTRICHACEAE (2/3)			
<i>Callitostella pallida</i> (Hornsch.) Ångström	EX, RU, TE	AM, AT, CA, PA, PL, SA	Faria, A.L.A. 990, 1028, 1031, 1034; Sousa, R.V. 714, 716, 735, 757, 770, 772, 781-A, 782-A, 788-A, 796, 796-A, 812, 818
<i>Thamniopsis incurva</i> (Hornsch.) W.R. Buck	RU	AM, AT	Sousa, R.V. 800, 812-A, 822
* <i>Thamniopsis purpureophylla</i> (Müll. Hal. ex E. Britton) W.R. Buck	TE	AT	Faria, A.L.A. 997
PTEROBRYACEAE (4/4)			
<i>Henicodium geniculatum</i> (Mitt.) W.R. Buck	CO	AM, AT, PL, SA	Faria, A.L.A. 1004
<i>Jaegerina scariosa</i> (Lorentz) Arzeni	CO, EX	AM, AT, PL, SA	Sousa, R.V. 761, 776

Table 1 (cont.)

SPECIES	SUB.	PHYT. DOM.	VOUCHERS
* <i>Orthostichidium quadrangulare</i> (Schwägr.) B.H. Allen & Magill	CO	AT, SA	Faria, A.L.A. 1011; Sousa, R.V. 777
<i>Orthostichopsis tortipilis</i> (Müll. Hal.) Broth.	CO	AM, AT	Sousa, R.V. 755
PYLAISIADELPHACEAE (1/2)			
<i>Isopterygium tenerifolium</i> (Sw.) Mitt.	EX	AM, AT, SA	Faria, A.L.A. 989; Sousa, R.V. 763
<i>Isopterygium tenerum</i> (Sw.) Mitt.	CO, EX	AM, AT, CA, PA, PL, SA	Faria, A.L.A. 985, 995, 1014; Sousa, R.V. 747, 780, 781
RHIZOGONIACEAE (1/1)			
<i>Pyrrhobryum spiniforme</i> (Hedw.) Brid.	CO, RU, TE	AM, AT, PA, SA	Faria, A.L.A. 1020, 1048, 1049, 1051; Sousa, R.V. 754, 798, 805, 807
SEMATOPHYLLACEAE (2/8)			
<i>Donnellia commutata</i> (Müll. Hal.) W.R. Buck	EX	AM, AT, PL, SA	Sousa, R.V. 797
<i>Sematophyllum adnatum</i> (Michx.) E. Britton	CO	AM, AT, CA, SA	Sousa, R.V. 724, 730, 803, 817
<i>Sematophyllum beyrichii</i> (Hornsch.) Broth.	CO	AT, SA	Faria, A.L.A. 992; Sousa, R.V. 806
<i>Sematophyllum cuspidiferum</i> Mitt.	RU	AT, PL, SA	Sousa, R.V. 772
<i>Sematophyllum galpense</i> (Müll. Hal.) Mitt.	RU, TE	AM, AT, SA	Faria, A.L.A. 1003, 1031; Sousa, R.V. 728, 774, 793
* <i>Sematophyllum macrorhynchum</i> (Hornsch.) Mitt.	CO, EX	AT	Faria, A.L.A. 1040, 1041, 1043
<i>Sematophyllum subpinnatum</i> (Brid.) E. Britton	CO, EX, RU	AM, AT, CA, PA, PL, SA	Faria, A.L.A. 996; Sousa, R.V. 722, 742, 759, 764, 783, 792
<i>Sematophyllum subsimplex</i> (Hedw.) Mitt.	CO, TE	AM, AT, CA, PA, PL, SA	Sousa, R.V. 727, 815
THUIDIACEAE (1/1)			
<i>Thuidium tomentosum</i> Schimp.	RU, TE	AM, AT, PL, SA	Faria, A.L.A. 1022, 1025, 1027, 1042; Sousa, R.V. 726, 765, 788-A

Results

The authors collected 190 samples, 153 samples were identified to species level, 37 to genus level and 5 could not be identified.

Fifty six species of the Division Bryophyta were found (Table 1), being 7 families and 22 species of the acrocarpous mosses (approximately 39% of species), 1 family and 3 species of the cladocarpous mosses (approx. 5% of spp.) and 13 families and 31 species of the pleurocarpous mosses (approx. 55% of spp.). The samples identified to the genus level and could not be identified to species level because the samples were insufficient are: *Sphagnum* L. and *Fissidens* Lindb.

The taxa identified were rupicolous (54%), corticolous (43%), epixylic (36%), terrestrial (23%) and epiphyllous (2%). Some species were sampled in more than one substrate.

Nine new records for the state of Espírito Santo were found. Among the total of species of mosses identified, seven are unique to the Atlantic Rainforest biome to date in Brazil.

Discussion

The results of this study have indicated a high richness of mosses in the EBSL, because while occupying a small area of approximately 0.0089% of state of the Espírito Santo, the number of mosses identified in the EBSL is 22.5% of the total species recorded in the state (Costa *et al.*, 2015). Comparing with other moss surveys in protected areas of the Atlantic Rainforest in the state of Espírito Santo: Costa & Silva (2003) identified 27 mosses in an area of 22,000 ha, the Reserva Natural do Vale do Rio Doce, Yano (2005) 55 mosses in the same locality and Silva & Piassi (2010) 9 mosses an area of 1,500 ha, the Parque Estadual Paulo César Vinha. Approximately 66% (37 species) of the species identified in this study are not present in both protected areas mentioned above: *Barbula arcuata* Griff., *Callicostella pallida* (Hornsch.) Ångström, *Campylopus dichrostis* (Müll. Hal.) Paris, *C. fragilis* (Brid.) Bruch & Schimp., *C. heterostachys* (Hampe) A. Jaeger, *C. thwaitesii* (Mitt.) A. Jaeger, *Chrysohypnum diminutivum* (Hampe) W.R. Buck, *Donnellia commutata* (Müll. Hal.) W.R. Buck, *Floribundaria flaccida* (Mitt.) Broth., *Homaliiodendron piniforme* (Brid.) Enroth, *Hyophila involuta* (Hook.) A. Jaeger, *Jaegerina scariosa* (Lorentz) Arzeni, *Leskeodon auratus* (Müll. Hal.) Broth., *Leucoloma trifforme* (Mitt.) A. Jaeger, *Leucomium strumosum* (Hornsch.) Mitt., *Macromitrium richardii* Schwägr., *Meteorium nigrescens* (Sw. ex Hedw.) Dozy & Molk.,

Mittenothamnium reptans (Hedw.) Cardot, *Orthostichidium quadrangulare* (Schwägr.) B.H. Allen & Magill, *Orthostichopsis tortipilis* (Müll. Hal.) Broth., *Philonotis elongata* (Dism.) H.A. Crum & Steere, *P. uncinata* (Schwägr.) Brid., *Phyllogonium viride* Brid., *Rosulabryum billarderi* (Schwägr.) J.R. Spence, *R. capillare* (Hedw.) J.R. Spence, *R. densifolium* (Brid.) Ochyra, *Sematophyllum adnatum* (Michx.) E. Britton, *S. beyrichii* (Hornsch.) Broth., *S. cuspidiferum* Mitt., *S. macrorhynchum* (Hornsch.) Mitt., *S. subpinnatum* (Brid.) E. Britton, *Syrrhopodon graminicola* R.S. Willlians, *Thamniopsis incurva* (Hornsch.) W.R. Buck, *T. purpureophylla* (Müll. Hal. ex E. Britton) W.R. Buck, *Thamnobryum fasciculatum* (Sw. ex Hedw.) I. Sastre, *Timmiella barbulooides* (Brid.) Mönk. and *Weissia controversa* Hedw. Thus, EBSL has an area of 440 ha and the greatest amount of mosses, 56 species, compared to the researches above cited.

The new records of mosses for the state of Espírito Santo (Table 1) show that there are still gaps in the knowledge of this group of plants in Brazil and particularly in this state. Regarding the amount of samples collected for this study, among the new records: 1 species has 3 samples, 2 spp. has 2 samples and 6 spp. has 1 sample. These 11 combined samples represent approximately 7% of the total collected for this study, which indicates that species are not easily found in collections expeditions. Among the 9 species that are new records, 5 species are unique to the Atlantic Rainforest biome in Brazil to date, thus a decrease in the area of this biome can mean greater rarity of these species or even its extinction.

The point of view of conservation of biological diversity of mosses, keep the preserved forest formation is of great importance, because mosses lack mechanisms developed to conserve water in their tissues, so the diversity is greater in wetter areas and which are not directly exposed to sunlight (Glime, 2007). So it was not unusual that 43% of mosses were found in corticolous substrate. The presence of rupicolous substrate was the largest, present in 54% of the species, almost all damp rock.

Thus it becomes clear that keeping a conserved forest environment is beneficial for smaller organisms that depend on the microclimate generated by the trees, and the removal of trees can cause the disappearance of several other species associated with them. Such an argument is of even greater importance when it comes of the Atlantic Rainforest biome, which has been fragmented and exploited over the centuries.

This study was able to extend the knowledge of the group of plants belonging to Division Bryophyta for the state of Espírito Santo, demonstrating that floristic inventories are still required in parks and small areas of preserved vegetation of the Atlantic Rainforest biome because, in a small area of forest

of about 440 ha, it was possible to get about ¼ of the existing species of mosses in the state of Espírito Santo and still get new occurrences of species to this state.

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