



## Ferns and Lycophytes from fragments of semideciduous forest in central Espírito Santo, Brazil

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### Abstract

This study presents a checklist of lycophytes and ferns from secondary semideciduous forests in São João de Petrópolis, Santa Teresa, Espírito Santo, Brazil. We recorded 37 species (four lycophytes and 33 ferns) belonging to nine families and 17 genera. *Selaginella* is the only genus representing lycophytes whereas *Adiantum*, *Anemia* and *Asplenium* are the main representative genera for ferns. Most species are lithophytes (48.6%) or terrestrial (21.6%). Epiphytes are scarce (8.2%), and we did not record any arborescent, hemiepiphyte or scandent species. Climate seasonality, reduced size of forest fragments, and disturbance history may explain the low richness in the site. We recorded the occurrence of a regionally threatened fern species, namely, *Asplenium austrobrasilense*, and revealed the first record of *Asplenium otites* in Espírito Santo. This demonstrates the biological relevance of semideciduous forest remnants in Espírito Santo and reinforces arguments for their effective protection.

**Key words:** Atlantic Forest, floristics, pteridophytes, secondary forest.

### Resumo

Este estudo apresenta uma lista de licófitas e samambaias de florestas semidecíduas secundárias em São João de Petrópolis, Santa Teresa, Espírito Santo, Brasil. Registramos 37 espécies (quatro licófitas e 33 samambaias) pertencentes a nove famílias e 17 gêneros. *Selaginella* é o único gênero representando as licófitas, enquanto *Adiantum*, *Anemia* e *Asplenium* são os principais gêneros representativos de samambaias. A maioria das espécies são litófitas (48,6%) ou terrestres (21,6%). Epífitas são escassas (8,2%) e não registramos nenhuma espécie arborescente, hemiepífita ou escandente. A sazonalidade climática, o tamanho reduzido dos fragmentos florestais e o histórico de perturbações podem explicar a baixa riqueza no local. Registramos a ocorrência de uma espécie de samambaia ameaçada regionalmente, a saber, *Asplenium austrobrasilense*, e revelamos o primeiro registro de *Asplenium otites* no Espírito Santo. Isso demonstra a relevância biológica de remanescentes de floresta semidecídua no Espírito Santo e reforça os argumentos para a sua proteção efetiva.

**Palavras-chave:** Mata Atlântica, florística, pteridófitas, floresta secundária.

### Introduction

Lycophytes and ferns are distinct clades of vascular plants, which account for around 12,000 species in the world (PPG I 2016). Most of these species are endemic to the Neotropics, a recognized diversity hotspot for both clades (Almeida & Salino 2016). In Brazil, such clades comprise together more than 1,200 species, ca. 70% of them occurring in the Atlantic Forest domain (Prado *et al.* 2015). The Atlantic Forest has been recognized as a global biodiversity hotspot (Myers *et al.* 2000).

It is currently represented by forest fragments with reduced size (mostly < 100 ha, according to Ribeiro *et al.* 2009), suffering further biological pauperization.

Despite the ever increasing amount of inventories of lycophytes and ferns in the Atlantic Forest over the last two decades, some regions of this phytogeographic domain remain poorly known. For instance, the inventories are relatively scarce in Espírito Santo, a region that is recognized by a high diversity of lycophytes and ferns (Prado

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*et al.* 2015). There, inventories have been carried out in just a few well preserved areas, such as parks and reserves (*e.g.*, Behar & Viégas 1992; Behar & Viégas 1993; Viégas-Aquije & Flausino 2007; Andrade *et al.* 2016; Sylvestre *et al.* 2016; Schwartzburd *et al.* 2017). However, it is known that the Atlantic Forest is mostly represented by secondary forests that can host an important fraction of the original flora and reveal useful pieces of information for taxonomic, ecologic and biogeographic studies (Ribeiro *et al.* 2009).

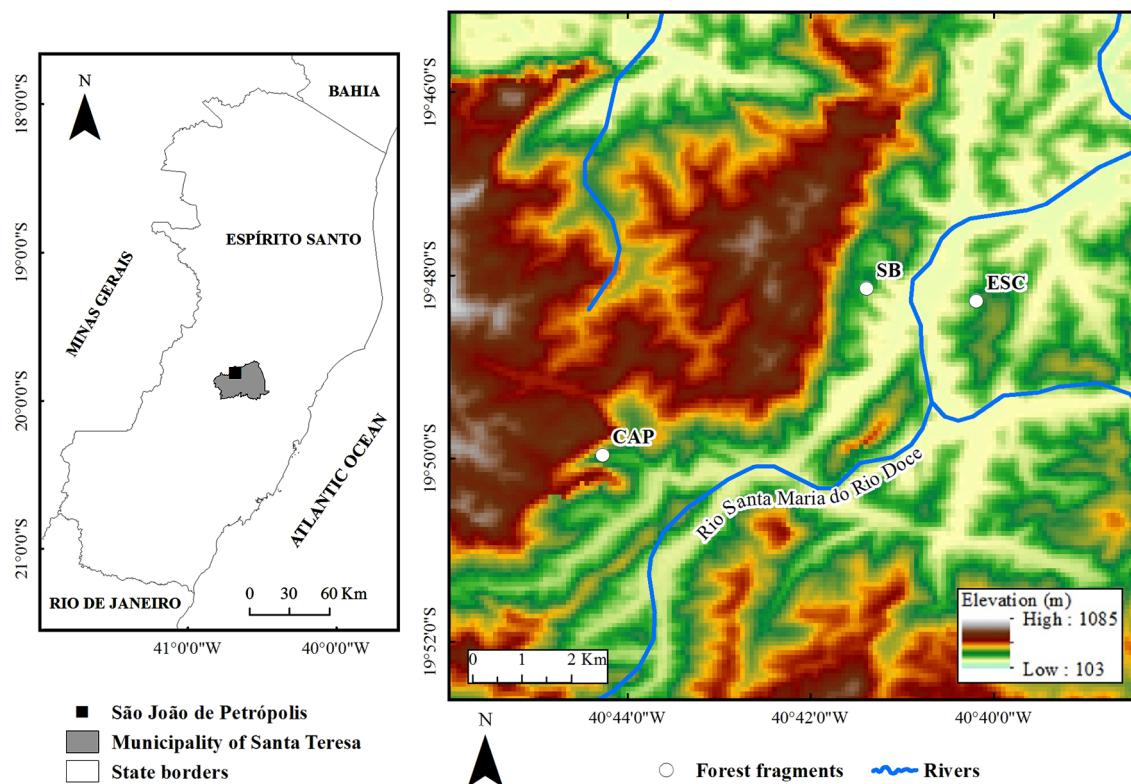
In this paper, we present a checklist of lycophytes and ferns that occur in secondary forests in São João de Petrópolis, Santa Teresa, Espírito Santo. This study is the first report of these plant groups in semideciduous forests in Espírito Santo and takes part in the efforts for inventorying the flora in the lower Rio Santa Maria do Doce basin, a highly disturbed region where several new, endemic angiosperm species have been surprisingly recorded in the last 20 years (*e.g.*, Assis 2003; Coelho *et al.* 2006; Leme *et al.* 2010; Pirani *et al.* 2011). We not only expect to improve

the knowledge about lycophytes and ferns in such an important region, but also support studies on plant diversity and conservation decisions in the Atlantic Forest hotspot.

## Material and Methods

### Study area

São João de Petrópolis (SJP) is a district of the municipality of Santa Teresa, located in the central area of the state of Espírito Santo, Brazil (Fig. 1). According to Climate-Data's database (<<https://pt.climate-data.org/>>), the climate is typically warm and seasonally humid, with a dry season occurring from May to September. The average annual temperature is 24.4°C and the average annual precipitation is 1161 mm. The relief is hilly and the elevation varies from 150 to 500 m. The lower areas comprise a flat, wide valley, which is crossed by the Rio Santa Maria do Doce. This valley is occupied by agricultural fields, houses, roads, and the buildings and facilities of the Instituto Federal do Espírito Santo. The hills around the valley are commonly covered by interspersed



**Figure 1** – Location map of São João de Petrópolis in Santa Teresa, central Espírito Santo, Brazil. Forest fragments included in this study are represented by white circles. (CAP = Fazenda Capeletti; SB = Mata do São Brás; ESC = Mata da Escola).

secondary forests with rocky outcrops (Fig. 2a,b). In some of these hills there are narrow, rocky streams, usually intermittent during the dry season (Fig. 2c). The vegetation is composed of broadleaved seasonal semideciduous forests of lower or upper plains, according to Oliveira-Filho (2009).

#### Data collection and analysis

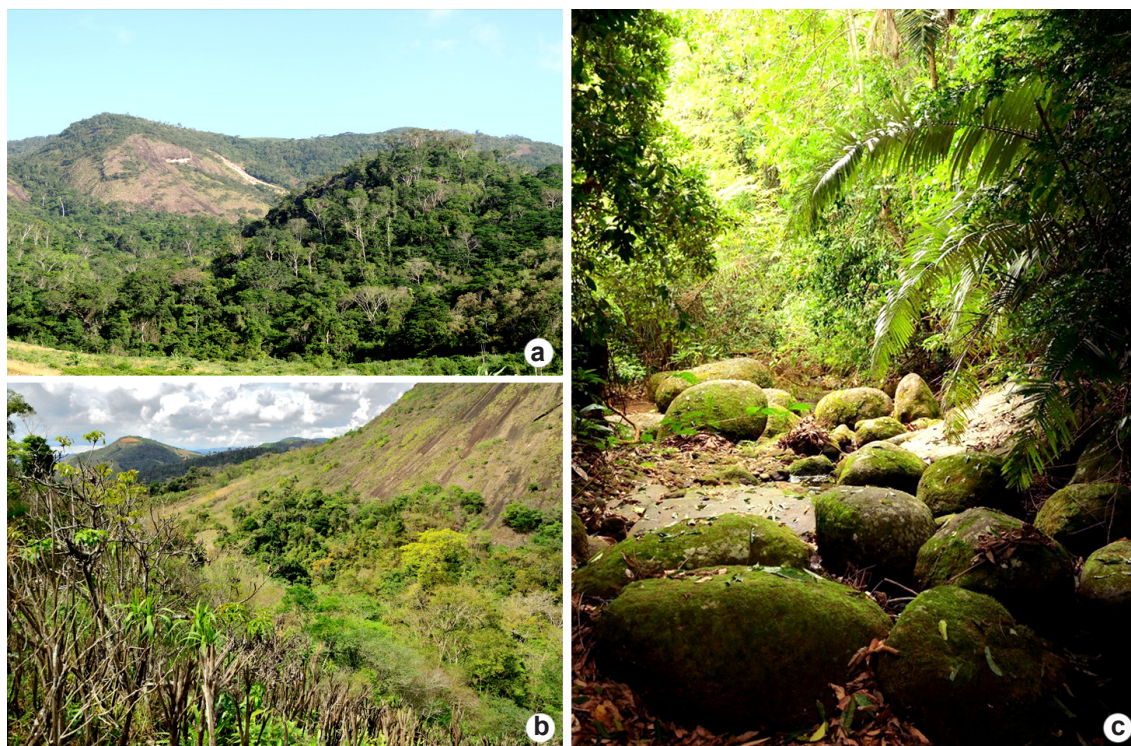
We collected vouchers of lycophytes and ferns bi-monthly in three forest fragments (Fig. 1) from March 2012 to May 2013. Two of these fragments, named Mata do São Brás (SB; ca. 50 ha; 19°48'09"S, 40°41'23"W) and Mata da Escola (ESC; ca. 170 ha; 19°48'17"S, 40°40'11"W), occupy opposite sides of the Rio Santa Maria do Doce valley, within the farm of the Instituto Federal do Espírito Santo. The third fragment is located in the Fazenda Capeletti (CAP; ca. 20 ha; 19°49'58"S, 40°44'16"W). All specimens were prepared according to methods for the botanical collection, which were proposed by Windisch (1992), and then incorporated into the herbarium of the Instituto Nacional da Mata Atlântica (MBML). We consulted

taxonomic monographs and the collections of the Herbarium MBML, as well as the herbarium of the Universidade Federal do Espírito Santo (VIES), for the determination of specimens.

The checklist was supplemented with a few species whose occurrence in SJP can be attested by previously deposited specimens in the Herbarium MBML. We adopted the PPG I's (2016) classification for ferns and lycophytes. Species names and authors were confirmed through the consultation of the IPNI (<<http://www.ipni.org>>). Furthermore, we indicate the life form (terrestrial, lithophyte, or epiphyte) for each species.

#### Results

The final checklist comprises 37 species, four of which are lycophytes and 33 are ferns (Tab. 1; Figs. 3-5). Mata do São Brás (SB), Mata da Escola (ESC), and Fazenda Capeletti (CAP) show, respectively, 19, 13, and 15 species. All lycophytes are in the genus *Selaginella* P.Beauv. (Selaginellaceae), and they were exclusively collected on either rocks or shallow soils along intermittent streams within SB and CAP. On the



**Figure 2** – Images from São João de Petrópolis forests – a. Mata do São Brás; b. Interspersed secondary forests with rocky outcrops in Fazenda Capeletti; c. Intermittent rocky stream within Mata do São Brás.

**Table 1** – Lycophytes and ferns recorded in three forest fragments in São João de Petrópolis, Santa Teresa, central Espírito Santo, Brazil. Life forms: LT = lithophytes; TR = terrestrial; EP = epiphytes. Forest fragments: SB = Mata do São Brás; ESC = Mata da Escola; CAP = Fazenda Capeletti.

Taxa	Life form	Voucher	Forest fragments		
			SB	ESC	CAP
<b>Selaginellaceae Willk.</b>					
<i>Selaginella flexuosa</i> Spring	LT/TR	N.T.L.Pena 39			X
<i>Selaginella convoluta</i> (Arn.) Spring	LT	N.T.L.Pena 66	X		
<i>Selaginella muscosa</i> Spring	LT	N.T.L.Pena 84	X		
<i>Selaginella sulcata</i> (Desv.) Spring ex Mart.	LT	N.T.L.Pena 65	X		X
<b>Anemiaceae Link</b>					
<i>Anemia collina</i> Raddi	LT	N.T.L.Pena 40			X
<i>Anemia hirsuta</i> (L.) Sw.	TR	N.T.L.Pena 92	X		
<i>Anemia rotundifolia</i> Schrad.	LT/TR	N.T.L.Pena 25		X	
<i>Anemia tomentosa</i> (Sav.) Sw.	LT/TR	N.T.L.Pena 87	X		X
<b>Aspleniaceae Newman</b>					
<i>Asplenium austrobrasiliense</i> (Christ) Maxon	LT	N.T.L.Pena 70	X		
<i>Asplenium otites</i> Link	LT	N.T.L.Pena 60	X		X
<i>Asplenium pulchellum</i> Raddi	LT	N.T.L.Pena 64	X		
<i>Asplenium serratum</i> L.	LT	W.Boone 598		X	
<b>Blechnaceae Newman</b>					
<i>Blechnum lanceola</i> Sw.	LT	N.T.L.Pena 85	X		X
<i>Blechnum occidentale</i> L.	LT/TR	N.T.L.Pena 78	X	X	X
<i>Neoblechnum brasiliense</i> (Desv.) Gasper & V.A.O.Dittrich	LT/TR	N.T.L.Pena 90	X		
<b>Dryopteridaceae Herter</b>					
<i>Ctenitis falciculata</i> (Raddi) Ching	TR	N.T.L.Pena 67	X		
<i>Parapolystichum acutum</i> (Kuntze) Labiak, Sundue & R.C.Moran	LT	N.T.L.Pena 53			X
<b>Lygodiaceae M.Roem.</b>					
<i>Lygodium volubile</i> Sw.	EP	R.P.Oliveira 861		X	
<b>Polypodiaceae J.Presl</b>					
<i>Campyloneurum nitidum</i> (Kaulf.) C. Presl	EP	A.P.Fontana 223		X	
<i>Microgramma vacciniifolia</i> (Langsd. & Fisch.) Copel.	EP	A.P.Fontana 224		X	
<i>Pechuma plumula</i> (Humb. & Bonpl. ex Willd.) M.G. Price	LT	N.T.L.Pena 50			X
<i>Pechuma filicula</i> (Kaulf.) M.G.Price	LT	N.T.L.Pena 57			X
<b>Pteridaceae E.D.M.Kirchn.</b>					
<i>Adiantum rhizophytum</i> Schrad.	TR	N.T.L.Pena 37		X	
<i>Adiantum curvatum</i> Kaulf.	TR	N.T.L.Pena 80	X	X	
<i>Adiantum deflectens</i> Mart.	LT/TR	N.T.L.Pena 33		X	
<i>Adiantum obliquum</i> Willd.	LT	N.T.L.Pena 76	X		
<i>Adiantum pulverulentum</i> L.	TR	N.T.L.Pena 86	X	X	X
<i>Adiantopsis radiata</i> (L.) Fée	LT/TR	N.T.L.Pena 34		X	

Taxa	Life form	Voucher	Forest fragments		
			SB	ESC	CAP
<i>Cheilanthes eriophora</i> (Fée) Mett.	LT	H.Q.Boudet Fernandes 1722		X	
<i>Cheilanthes goyazensis</i> (Taub.) Domin	LT	N.T.L.Pena 47			X
<i>Doryopteris collina</i> (Raddi) J.Sm.	LT	N.T.L.Pena 45			X
<i>Doryopteris varians</i> (Raddi) J.Sm.	LT	N.T.L.Pena 51			X
<i>Hemionitis tomentosa</i> (Lam.) Raddi	TR	N.T.L.Pena 75	X		
<i>Pteris denticulata</i> Sw.	TR	N.T.L.Pena 88	X	X	
<i>Pteris leptophylla</i> Sw.	LT	N.T.L.Pena 54			X
<b>Thelypteridaceae Pic.Serm.</b>					
<i>Christella dentata</i> (Forssk.) Brownsey & Jermy	LT/TR	N.T.L.Pena 79	X		
<i>Christella hispidula</i> (Decne.) Holttum	TR	N.T.L.Pena 91	X		

other hand, the fern species belong to eight families and 16 genera. The most representative fern family is Pteridaceae (13 spp.), and the most representative fern genera are *Adiantum* L. (five spp.), *Anemia* Sw., and *Asplenium* L. (four spp. each).

The most common life forms are lithophytes (48.6%) and terrestrial (21.6%). Some species (21.6%) present these two life forms, and only three species are epiphytes (8.2%). We did not record any arborescent, hemiepiphytic or scandent species. The fern species *Asplenium serratum* L., *Campyloneurum nitidum* (Kaulf.) C.Presl, *Cheilanthes eriophora* (Fée) Mett., *Lygodium volubile* Sw. and *Microgramma vacciniifolia* (Langsd. & Fisch.) Copel. were incorporated into the checklist due to the existence of specimens that were previously collected in SJP and deposited in the Herbarium MBML.

The fern species *Asplenium otites* Link (Fig. 4g) was reported for the first time in Espírito Santo. In turn, *Blechnum lanceola* Sw. (Fig. 3g) had only been recorded once in Espírito Santo before our study (in Pontões Capixabas, northwestern of the state, according to Dittrich *et al.* 2015). Among the species recorded here, only *Asplenium austrobrasiliense* (Christ) Maxon (Fig. 5) is considered a threatened fern species in Espírito Santo (Simonelli & Fraga 2007).

## Discussion

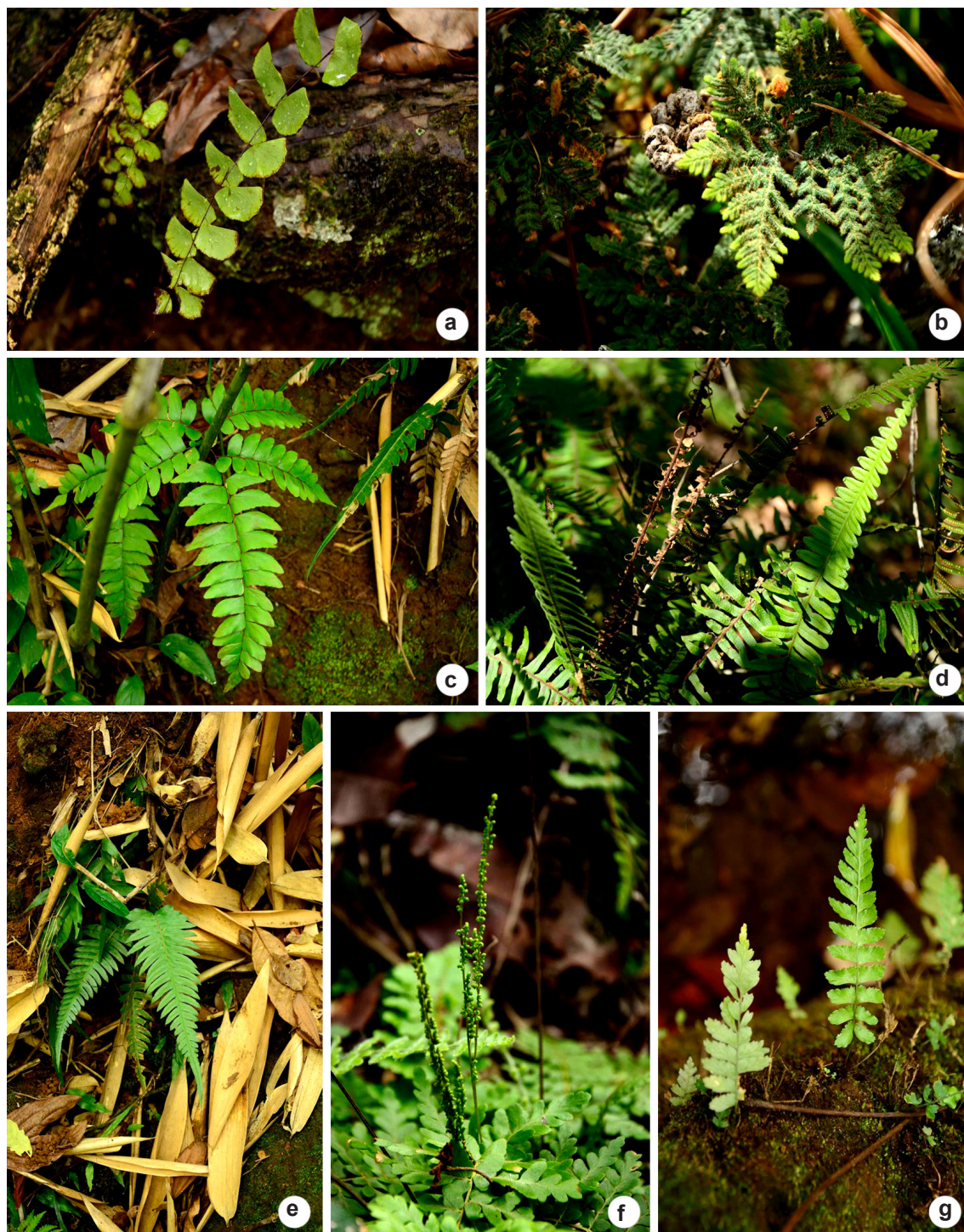
The checklist presented here indicates that SJP forests are not as rich in terms of lycophytes and ferns as some forest sites within the Atlantic Forest domain. For instance, Melo & Salino (2002)

recorded 123 species in a semideciduous forest in the Parque Estadual do Rio Doce, eastern Minas Gerais, Viégas-Aquije & Flausino (2007) found 126 species in an evergreen forest in the Reserva Biológica Augusto Ruschi, central Espírito Santo, Matos *et al.* (2010) collected 182 species in a rain forest in Serra Bonita, eastern Bahia, and Mazziero *et al.* (2015) recorded 235 species in a rain forest in the Parque Estadual Turístico do Alto Ribeira, southern São Paulo.

Three complementary suppositions help to explain the low richness in SJP forests. First, seasonal forests, such as those in SJP, commonly support less plant species than rain forests in the Atlantic Forest domain due to physiological and reproductive constraints caused by the low water availability during dry periods (Oliveira-Filho & Fontes 2000). Second, larger forest fragments can support more species than smaller ones (Fahrig 2003). In this sense, SJP forest fragments, even accounting together ca. 250 ha, certainly cannot have as many species as those remnants from the aforementioned studies (all of them with 2000 ha or more). Third, disturbance history directly affects the local diversity of plants (Chazdon 2003). In fact, SJP forests were, in part, selectively logged and burned down in the past. As a consequence, some species of lycophytes and ferns from the original flora may have been extinct in those areas. Both the scarcity of epiphyte species and the absence of arborescent, hemiepiphyte and scandent species in our checklist may represent negative effect of disturbances on the local diversity of plants. Usually, such life forms are better represented in



**Figure 3** – Some fern species collected in São João de Petrópolis, Santa Teresa, central Espírito Santo, Brazil – a. *Selaginella flexuosa* (Selaginellaceae). b. *Pteris leptophylla* (Pteridaceae). c. *Adiantum pulverulentum* (Pteridaceae). d. *Anemia collina* (Anemiaceae). e. *Pteris denticulata* (Pteridaceae). f. *Adiantopsis radiata* (Pteridaceae). g. *Blechnum lanceola* (Blechnaceae). h. *Pecluma filicula* (Polypodiaceae).



**Figure 4** – Some fern species collected in São João de Petrópolis, Santa Teresa, central Espírito Santo, Brazil – a. *Adiantum deflectens* (Pteridaceae). b. *Cheilanthes goyazensis* (Pteridaceae). c. *Adiantum obliquum* (Pteridaceae). d. *Pecluma plumula* (Polypodiaceae). e. *Blechnum occidentale* (Blechnaceae). f. *Anemia tomentosa* (Anemiaceae). g. *Asplenium otites* (Aspleniaceae).



**Figure 5** – *Asplenium austrobrasilense* (Aspleniaceae), a threatened fern species in Espírito Santo – a. adaxial surface of laminae; b. abaxial surface of laminae.

well preserved sites across the Atlantic Forest, even in semideciduous forests (e.g., Melo & Salino 2002; Matos *et al.* 2010; Mazziero *et al.* 2015).

In contrast, past disturbances may have led to an increase of the density of the disturbance-tolerant species (*i.e.*, species which tolerate both low humidity and high light intensity). In fact, some species reported here are typically known as being found in disturbed sites, such as *Adiantum pulverulentum* L. (Fig. 3c), *Anemia rotundifolia* Schrad, *Pteris denticulata* Sw. (Fig. 3e), and the alien species *Christella dentata* (Forssk.) Brownsey & Jermy (see Colli *et al.* 2004; Schwartzburd & Labiak 2007; Gasper & Sevegnani 2010 for comments on some of those species).

Considering a regional approach, the SJP forests notably host populations of either threatened fern species (*A. austrobrasilense*) or few collected ones (*A. otites* and *B. lanceola*). This corroborates recent insights about the biological relevance of semideciduous forest in Espírito Santo (for instance, see Abreu *et al.* 2013; Saiter *et al.* 2015), and reinforces arguments for the creation of parks and reserves in such a forest type (Simonelli &

Fraga 2007). Given that there are only four small reserves covered by semideciduous forests across Espírito Santo (Simonelli & Fraga 2007), the Parque Estadual Cachoeira da Fumaça (ca. 160 ha), Parque Estadual Mata das Flores (800 ha), Floresta Nacional de Pacotuba (ca. 450 ha) and Reserva Particular do Patrimônio Natural Cafundó (517 ha), we argue that the protection of such forests is still insufficient. Therefore, the checklist presented here not only enriches the knowledge about ferns and lycophytes in Espírito Santo, but also offers useful information for conservation planning in the Atlantic Forest hotspot.

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