



Checklist of ferns and lycophytes from the highlands of Pico Paraná State Park, Paraná, Brazil

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Abstract

We present a checklist for the ferns and lycophytes from Pico Paraná State Park, in Southern Brazil. The Park is entirely located at the Serra do Mar mountains, and represents an important remnant of the Atlantic Rain Forest with altitude achieving 1,887 m. In this locality is the Pico Paraná, the highest mountain in Southern Brazil. This study was focused on the altitudes above 1,000 m, which are mainly represented by dwarf forests and altitudinal fields. A total of 142 species were recorded, three of them (*Ceradenia maackii*, *Diplazium tamandarei*, and *Stenogrammitis wittigiana*) are only found in the park in Southern Brazil. Besides of the checklist of the species, we highlight some important aspects related to endangered species, geographic distribution, and life forms. The high level of endemism, the presence of endangered species, and the phylogenetic diversity as represented by distinct families of ferns and lycophytes show the biogeographic importance of this area for the conservation of these groups of plants.

Key words: Atlantic Rain Forest, endemism, highlands, richness, Southern Brazil.

Resumo

Nós apresentamos uma compilação das espécies de samambaias e licófitas coletadas no Parque Estadual Pico Paraná, sul do Brasil. O Parque está localizando dentro da Serra do Mar paranaense, e representa um importante remanescente de Floresta Atlântica com altitude atingindo 1.887 m. Nesta localidade está o Pico Paraná, a montanha mais alta do sul do Brasil. Neste estudo foi investigado as áreas acima de 1.000 m, justamente nos pontos onde ocorrem floresta nebulosa e campos de altitude. No total foram registradas 142 espécies. *Ceradenia maackii*, *Diplazium tamandarei*, and *Stenogrammitis wittigiana* são encontradas apenas na área do parque no sul do Brasil. Além de apresentar a lista de espécies, este estudo destaca as espécies ameaçadas, distribuições geográficas e formas de vida das plantas. O alto nível de endemismo, a presença de espécies ameaçadas, a diversidade filogenética representada por várias famílias de samambaias e licófitas mostram a importância biogeográfica do Pico Paraná para a conservação destes grupos de plantas.

Palavras-chave: Floresta Atlântica, endemismo, ambiente de altitude, riqueza, Sul do Brasil.

Introduction

The mountain regions of the Neotropics present a high rate of diversity, richness and endemism for ferns and lycophytes (Tryon 1972, 1986; Moran 1995). Particularly, this richness is in part influenced by different degrees of temperature, luminosity and humidity, which vary accordingly to the different altitudinal gradients. Likewise, these different environmental conditions require specific morphological and physiological adaptations of the species (Lieberman *et al.* 1996; Kessler 2000; Safford 2007). As a result, the upper-montane

forests and the highland fields frequently harbors a high levels of endemism (Martinelli 2007), and many species are also exclusive of these environments (Martinelli 2007).

Among the mountain ranges of the Serra do Mar in coastal Brazil, the Pico Paraná State Park is placed in an interesting biogeographic position. It is located in a confluence of different vegetation types, such as the *Araucaria* forests, grassland fields, and the Atlantic Rain Forest (Maack 2012; Labiak 2014). The Park is also a borderline region for the geographic distribution of many plant

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species (Labiak 2014). Additionally, the Pico Paraná is the highest point in Southern Brazil and presents few botanically explored environments and peculiar geographical-climatical conformations (Maack 2012). This prompted us to carry out a more detailed botanical survey of its environments, focusing on those areas above 1.000 meters that are the less explored botanically.

Here, we present a checklist of the species of ferns and lycophytes from Pico Paraná State Park, highlighting the most important records for Southern Brazil, reporting the endangered species, and showing the data of the geographic distribution and life forms, as a contribution to the knowledge of the diversity presented in high montane forests in the Brazilian Atlantic Rain Forest.

Materials and Methods

Study site

The Pico Paraná State Park (PEPP) is located in the cities of Campina Grande do Sul and Antonina, in Paraná state, Southern Brazil. The park comprises an area of 4.334 hectares in the Serra do Ibitiraquire, a mountain chain that is part of the main range called Serra do Mar mountains. The Park is located between the coordinates 25°12'51.68"–25°17'52.91"S and 48°46'20.46"–48°52'58.71"W (Figs. 1, 2). Within the limits of the

Park is located the Pico Paraná, which is the highest mountain in Southern Brazil, reaching 1,887 m in altitude (Figs. 1, 2). The current study was carried out in the areas between 1,000–1,887 m.

The PEPP is located within the Atlantic Rain Forest, and presents mainly elements of the Upper-montane and Campos de Altitude flora (*sensu* Veloso *et al.* 1992) (Fig. 2). This part of the Serra do Mar mountains is mainly composed by igneous and metamorphic rocks of pre-Cambrian origins (Bigarella 1978).

The climate in this area is considered as subtropical (Köppen 1948), with an average of annual temperature below 18 °C in the winter, and 22 °C in the summer (IAPAR 1994). Frost is common during the winter, and the average annual rainfall varies from 2,000–2,500 mm, depending on the altitude (Ferretti & Brites 2006).

Data collection

Fieldworks were carried out from April 2007 to March 2009, usually each two months (collection permit IAP 37/07, 2007). The specimens were deposited in the herbaria UPCB and MBM, and duplicates were also sent to other herbaria, when available. Also, collections of the herbaria MBM, an RB were consulted to search for potential collections from PEPP. The plants were

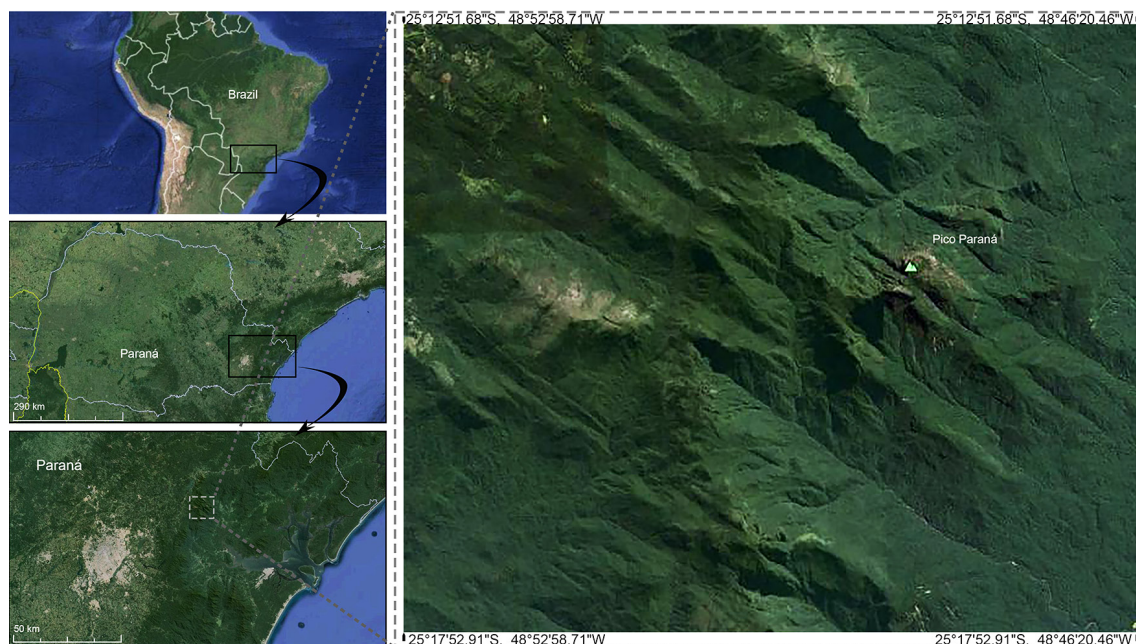


Figure 1 – Location of the Pico Paraná State Park, Paraná, Brazil (figure adapted from Google Earth).



Figure 2 – Habitats in the Pico Paraná State Park – a. stream inside of the forest; b. cloud forest with the trunks of the tree covering by moss; c. upper montane forest; d. continuous fog in the highest latitudinal of the park; e. rocky outcrops; f. Pico Paraná; g. detail of the Pico Paraná; h. Campo de Altitude. (Photos: a. by Fernando B. Matos; b-e. by Jovani B.S. Pereira; f-h. by Paulo H. Labiak)

identified using the literature, by comparison to the collections in UPCB, MBM and RB, as well as by consulting specialists (see acknowledge). The geographic distributions of the species are established using available data in the literature. This study followed the classification system of PPG I (2016).

Results

A total of 142 species were recorded, corresponding to 64 genera and 19 families (see Table available in <<https://dx.doi.org/10.6084/m9.figshare.5899600>>). The ferns comprised 128 species in 58 genera and 17 families, whereas the lycophytes were represented by 14 species in six genera and two families. The families with the highest number of species were Polypodiaceae (29 spp.), Hymenophyllaceae (21 spp.), Dryopteridaceae (16 spp.), Aspleniaceae and Lycopodiaceae (12 spp., respectively), and Pteridaceae (11 spp.). The most representative genera in number of species were *Hymenophyllum* (13 spp.), *Asplenium* (11 spp.), *Elaphoglossum* (8 spp.), and *Phlegmariurus* (7 spp.).

Special mention is given to *Ceradenia maackii* (Fig. 3a), an endemic species from PEPP, which was described from recent collections in the studied area (Labiak & Pereira 2016). Besides *C. maackii*, other two species are exclusively found in the PEPP in Southern Brazil: *Diplazium tamandarei*, and *Stenogrammitis wittigiana* (Fig. 3b).

As for endangered species, we found that *Doryopteris paradoxa* (Fig. 3c), *Dicksonia sellowiana* (Fig. 3d), *Jamesonia insignis* (Fig. 3e), *Grammitis fluminensis* (Fig. 3f), *Phlegmariurus nudus* and *P. christii* are currently considered endangered species in Brazil (Martinelli & Moraes 2013). Furthermore, the poorly known species *Doryopteris crenulans* (Fig. 3g), *Hymenophyllum magelanicum* (Fig. 3h), *H. peltatum*, and *Trichomanes lucas* are species considered as having priority in taxonomic studies, in order to access their actual conservation status (IBAMA 2008; Martinelli & Moraes 2013).

As for the species distribution ranges (Fig. 4a), we found that 40 species (28%) are endemic to the Brazilian Atlantic Rain Forest (*sensu* Oliveira-Filho & Fontes 2000), whereas 10% (14 spp.) are Pantropical, 60% (85 spp.) are Neotropical, and 1% (2 spp.) are widely distributed in Brazil.

Concerning the life forms (Fig. 4b), 24% (34 spp.) were epiphytes (*sensu* Benzing 1990; including one terrestrial climber species, *Lomaridium*

acutum), 18% (26 spp.) were rupicolous, 39% (55 spp.) of the species were exclusively terrestrials, and 19% (27 spp.) were found in more than one type of habitat.

Discussion

The PEPP has shown a high taxonomic diversity of ferns and lycophytes. This diversity is similar to more species-rich environments such as montane forests, as recorded by Matos *et al.* (2010), and Schwartsburd & Labiak (2007).

The richness of the Polypodiaceae species found in PEPP can be related to the presence of grammitid ferns such as *Ceradenia* (Fig. 3a), *Cochlidium*, *Grammitis* (Fig. 3f), *Melpomene* (Fig. 3i), *Stenogrammitis* (Fig. 3b), *Lellingeria*, *Terpsichore*, *Leucotrichum* and *Moranopteris*, which are particularly well distributed at high elevations in the New World (Parris 2009). Moreover, the richness of the Hymenophyllaceae, especially of *Hymenophyllum* (Fig. 3h,j), appears to be related to the cloud forests at higher altitudes where the genus is well diverse (Morton 1968).

The Paraná State is a borderline region for the geographic distribution of many plant species. Particularly, the PEPP seems to be the southern borderline for the geographic distribution of the *Diplazium tamandarei*, and *Stenogrammitis wittigiana* (Fig. 3b). It must also be pointed out the occurrences of *Doryopteris paradoxa* (Fig. 3c), *Phlegmariurus nudus*, *Hypolepis rugosula* (Fig. 3k), and *Amauropelta tamandarei*, which are only known from few collections in Southern Brazil. Another interesting record is *Plagiogyria fialhoi* (Fig. 3l), which is found at high altitudinal environments in Southeastern Brazil, and occurs only in the PEPP within the state of Paraná.

Regarding the percentage of the endemics species finding in the PEPP (28%, see Fig. 4a), it is higher than those recorded in areas at lower altitudes in Southern Brazil, such as 4% (8 spp.) by Gasper & Sevegnami (2010), 9% (14 spp.) by Schwartsburd & Labiak (2007), and 25% (15 spp.) by Labiak & Prado (1998). We attribute the high level of endemism in the PEPP to the varied number of environments, such as highlands fields, cloud forests, and rocky outcrops (Fig. 2a-h), which require of the species specific morphological and physiological adaptations to occur in these habitats (Safford 1999; Porembski 2007).

With respect to the life forms (Fig. 4b), the percentage of the epiphytic species was higher than the ones found in the *Araucaria* forest (19.7%;

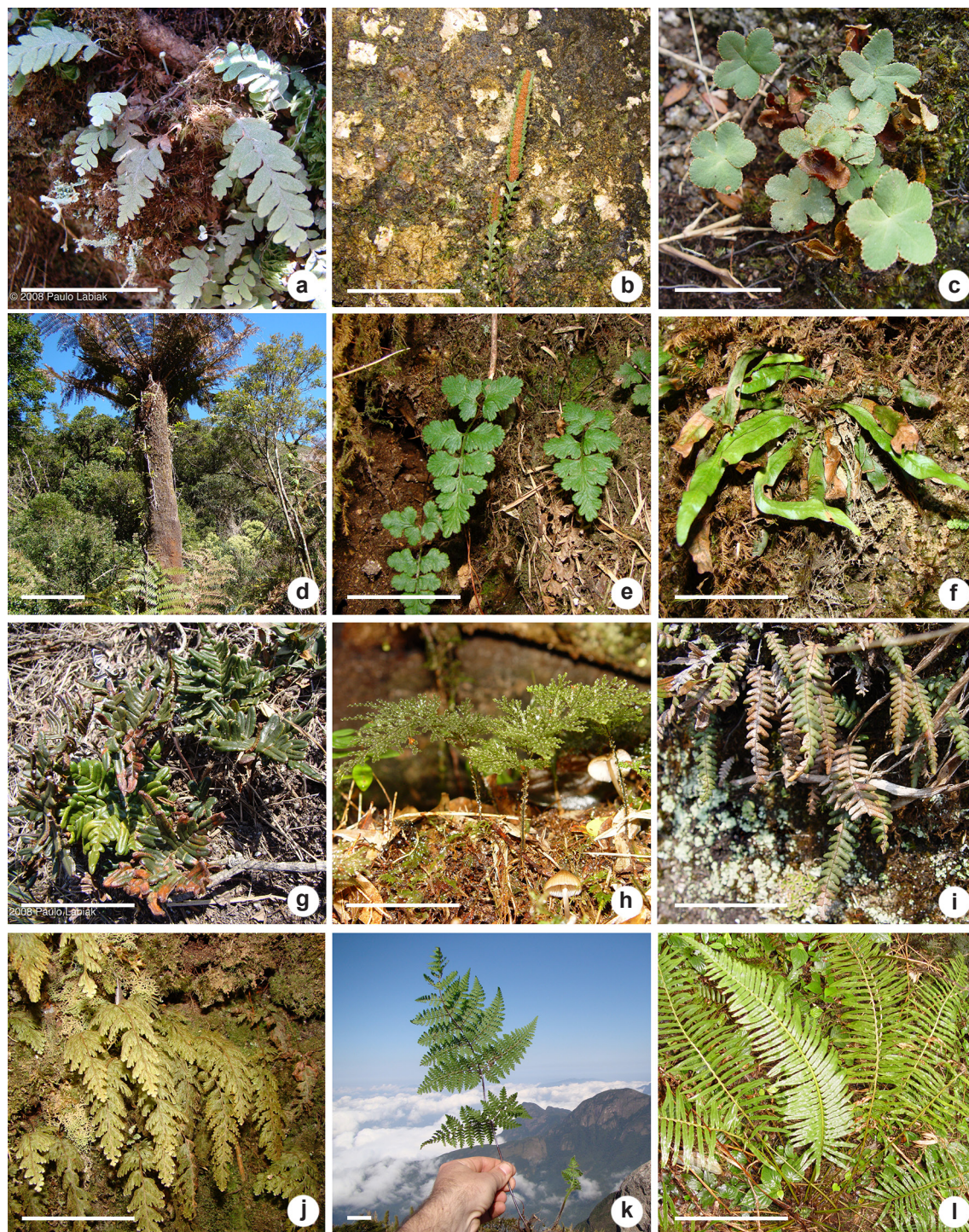


Figure 3 – Ferns species found in the Pico Paraná State Park – a. *Ceradenia maackii*. b. *Stenogrammitis wittigiana*. c. *Doryopteris paradoxa*. d. *Dicksonia sellowiana*. e. *Jamesonia insignis*. f. *Grammitis fluminensis*. g. *Doryopteris crenulans*. h. *Hymenophyllum magellanicum*. i. *Melpomene albicans*. j. *Hymenophyllum rufum*. k. *Hypolepis rugulosa*. l. *Plagyogiria fialhoi*. Scale bars: a,e,g,j = 10 cm; b = 2 cm; c,f,h,i,k = 5 cm; d = 1 m; l = 15 cm. (Photos: a,b,e-g,k. by Paulo H. Labiak; c,d. by Fernando B. Matos; h-j,l. by Jovani B.S. Pereira)

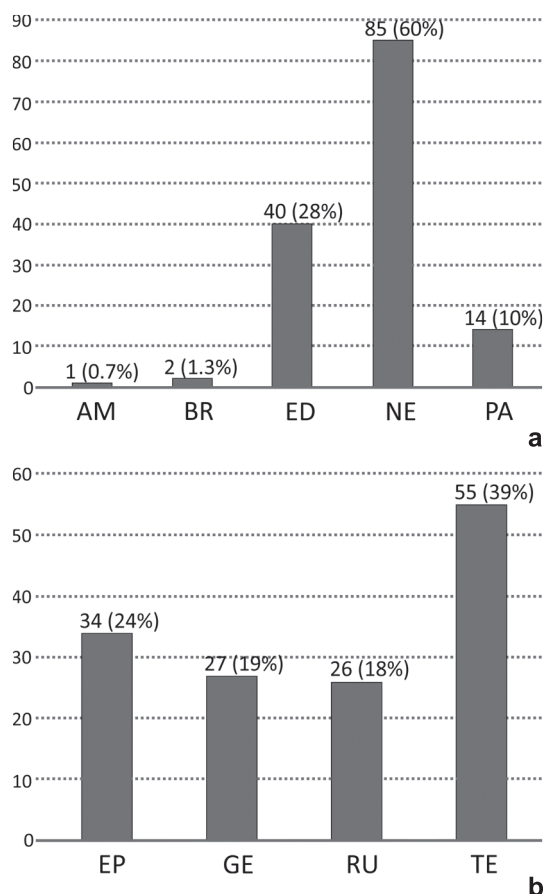


Figure 4 – Number of species of ferns and lycophytes in the Pico Paraná State Park by geographic range and life form (percentage of the species in brackets) – a. geographic ranges; b. life forms. The geographic distributions of the taxa are the following: Pantropical (PA), America (including Nearctical plus Neotropical) (AM), Neotropical (NE), widely distributed in Brazil (BR), endemic from Brazilian Atlantic rain forest (ED). The life forms are classified as terrestrial (TE), epiphyte (EP), rupicolous (RU), and more than one type of habitat (GE).

30 spp.) by Schwartzburd & Labiak (2007), and in the lowlands coastal forests (19.3%; 16 spp.) by Salino *et al.* (2005). This is not an unexpected result, considering the presence of streams and continuous fog in the highest altitudes (Fig. 2a-e), which make the altitudinal environments very humid (as evidenced by trees with trunks covered with moss; see Fig. 2a-c), and provide the necessary humidity for these ferns (Kessler 2000). This factor may explain the amount of epiphytic species that was recorded in the PEPP.

It is also important to note the high percentage of the species which were found exclusively as rupicolous (18%; Fig. 4b). This value is higher than those recorded in other vegetation formations such as in the montane forest in Paraná (2.5%; 2 spp.) and in southern Bahia (5%; 9 spp.) (Dittrich *et al.* 2005; Matos *et al.* 2010; respectively), in the lowland and in the montane forest (4.2%; 8 spp.) (Gasper & Sevegnani 2010), and in the restinga (2.6%; 3 spp.) (Salino *et al.* 2005). The number of rupicolous species may be related to the existence of markedly altitudinal environments such as rocky outcrop and rocky cliffs in the cloud forests as well as streams over rocks within the forest (Fig. 2e-h).

In conclusion, the altitudinal environment of the PEPP appears to offer the ideal conditions for the establishment of the various groups of ferns and lycophytes which results not just in the number of species, but also in the diversity of life forms. Furthermore, the high level of endemism, the presence of endangered species, and the phylogenetic diversity (as represented by distinct families of ferns and lycophytes) highlight the biogeographic importance of this area for the conservation of these groups of plants.

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