



A list of land plants of Parque Nacional do Caparaó, Brazil, highlights the presence of sampling gaps within this protected area

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Abstract

Background

Brazilian protected areas are essential for plant conservation in the Atlantic Forest domain, one of the 36 global biodiversity hotspots. A major challenge for improving conservation actions is to know the plant richness, protected by these areas. Online databases offer an accessible way to build plant species lists and to provide relevant information about biodiversity. A list of land plants of “Parque Nacional do Caparaó” (PNC) was previously built using online databases and published on the website “Catálogo de Plantas das Unidades de Conservação do Brasil.” Here, we provide and discuss additional information about plant species richness, endemism and conservation in the PNC that could not be included in the List. We documented 1,791 species of land plants as occurring in PNC, of which 63 are cited as threatened (CR, EN or VU) by the Brazilian National Red List, seven as data deficient (DD) and five as priorities for conservation. Fifty-one species were possible new occurrences for ES and MG states.

New information

"Parque Nacional do Caparaó" houses 8% of the land plant species endemic to the Brazilian Atlantic Forest, including 6% of its angiosperms, 31% of its lycophytes and ferns and 14% of its avascular plants. Twelve percent of the threatened species listed for the State of Espírito Santo and 7% listed for the State of Minas Gerais are also protected by PNC. Surprisingly, 79% of the collections analysed here were carried out in Minas Gerais, which represents just 21% of the total extension of the Park. The compiled data uncover a huge botanical collection gap in this federally-protected area.

Keywords

Atlantic Forest, conservation, endemism, plant richness, threatened species.

Introduction

The Atlantic Forest is recognised worldwide for its high biological diversity, high rates of endemism and great threat (with more than 70% of its original area devastated) and which is considered one of 36 global biodiversity hotspots (Marques and Grelle 2020). It has been estimated that this phytogeographic domain contains 17,776 species of land plants with an endemism rate of 56% (Flora do Brasil under construction 2020). Only 28% of the Atlantic Forest original area remains and its area consists mainly of edge-affected or secondary vegetation disconnected from larger remnants due to the long and intense disturbances it has experienced throughout its history (Rezende et al. 2018). There are 1,437 protected areas (PAs) in the Atlantic Forest, including strictly-protected areas (477) and areas managed for sustainable use (960) (MMA 2020). However, only 30% of the total vegetation cover is located within PAs, of which 9% are strictly protected (Rezende et al. 2018) and little is known about the plant species that are protected within them (Oliveira et al. 2017).

In the past 20 years, virtual tools have become more popular by sharing information from herbaria all over the world to contribute and to facilitate voucher identification, such as the Global Biodiversity Information Facility (GBIF; <http://www.gbif.org>), REFLORA (<http://reflora.jbrj.gov.br>) and INCT-Splink (<http://inct.splink.org.br>). The availability of biodiversity data on the internet has not only increased communication amongst herbaria, it has also provided information for documenting biodiversity and its distribution in space and time and, thus, has served as a backbone for developing environmental policies (Maldonado et al. 2015, Nualart et al. 2017, Oliveira et al. 2017). In addition, as the Atlantic Forest is one of the best-sampled phytogeographic domains in Brazil, the use of online databases can assist in documenting biodiversity and revealing temporal, spatial and taxonomic gaps in knowledge (Oliveira et al. 2017, Oliveira et al. 2019, Colli-Silva et al. 2020).

"Catálogo de Plantas das Unidades de Conservação do Brasil" (<https://catalogo-ucs-brasil.jbrj.gov.br/>) is a digital platform created in 2018 with the aim to host lists of plant

species that occur within Brazilian protected areas. Currently, the catalogue contains plant lists for five PAs from different Brazilian phytogeographic domains, such as the Amazon, Caatinga and Atlantic Forest. The plant list for “Parque Nacional do Itatiaia” (PNI) was the first made available on this platform (Carrizo et al. 2018), while the list for “Parque Nacional do Caparaó” (PNC) was the most recent (Carrizo et al. 2020). In addition to access to lists of species and vouchers, the website also provides the threat category of species, information on the occurrence of non-native and native species and a list of priority species for conservation for each protected area.

“Parque Nacional do Caparaó” (PNC), created in 1961 and effectively implemented in 1979, aims to protect areas of the Atlantic Forest domain (Santos 2004, ICMBio 2015). The first scientific expeditions to the area now occupied by the PNC were carried out by Wilhelm Schwacke in 1880 and by the Belgian-Brazilian Mission in 1922 (Massart et al. 1929). The first floristic inventory, however, was carried out by Alexander Curt Brade in 1942 and this recorded 259 species of plants of 59 families (Brade 1942). Other Botanists who contributed significantly to the knowledge of the local flora were Alexandre Salino, Braz AP Cosenza, Leopoldo Krieger, Lúcio de Souza Leoni and Vinicius Castro Souza (Santos 2004). Despite this intense collection effort, knowledge of the flora of PNC is dispersed in numerous publications on specific groups or families of plants (Aguiar and Marques 2001, Souza and Souza 2002, Romão and Souza 2003, Leoni and Chautems 2004, Mazine and Souza 2008, Leoni 2009a, Leoni 2009b, Forster and Souza 2013, Góes-Neto et al. 2015, Machado et al. 2016, Araújo et al. 2018, Góes-Neto and Salino 2018, Cardoso et al. 2019, Camelo et al. 2020). There remains, however, a lack of a single source providing access to reliable information about plant species protected by this PA. Here, we provide and discuss additional information about species richness, endemism and conservation in PNC that could not be provided in the plant list for PNC previously published in the catalogue (after Carrizo et al. 2020).

Sampling methods

Study extent: A list of all plant specimens from PNC in three databases was compiled from downloads: JABOT (“Jardim Botânico do Rio de Janeiro”, JBRJ, <http://www.jbrj.gov.br/jabot>), REFLORA (“Herbário Virtual Reflora”, <http://reflora.jbrj.gov.br>) and Splink (“INCT Herbário Virtual da Flora e dos Fungos”, <http://inct.splink.org.br>). Searches were performed in each database on 15 April 2019, using the following filters: (1) locality = Caparaó and (2) locality = Caparao (without special characters). These searches led to a total of 24,655 specimens (JABOT = 4,187; REFLORA = 9,405; Splink = 11,063; Fig. 1).

To obtain a list of species with currently-accepted nomenclature, we manually selected all specimens identified to the species level, leading to the following: JABOT determined = 3,113, undetermined = 1,074; REFLORA determined = 6,637, undetermined = 2,768; and Splink determined = 7,922, undetermined = 3,141 (Fig. 1). We also removed specimens that had a locality that did not belong to the area covered by the PNC, as well as duplicates (based on the catalogue code, collector name and number and the year in which the sample was collected) (Fig. 1). We then corrected and updated species names and

determined their threat categories using the function *get.taxa* from the *flora* package (Carvalho 2017) of R software v. 3.5.3 (R Development Core Team 2019). We used this function to compare the names in our list with those in Flora do Brasil under construction (2020) and determined the threat category for each species according to the Red List Authority for plants in Brazil - CNCFLora (<http://www.cncflora.jbrj.gov.br/portal>) (Fig. 1). Introduced species were not recovered by the function *get.taxa* and so these specimens had to be reviewed manually. After these corrections, taxonomists checked the preliminary list of 2,372 species virtually, using images available in the online databases (Fig. 1). When a taxonomist modified a plant species name, at least one specimen of that species was updated in the Herbarium of “Jardim Botânico do Rio de Janeiro” (RB, acronym from Thiers 2020) and its database JABOT, as well as in the REFLORA database, but not in Splink. Intraspecific taxonomic categories were not considered, nor were hybrids.

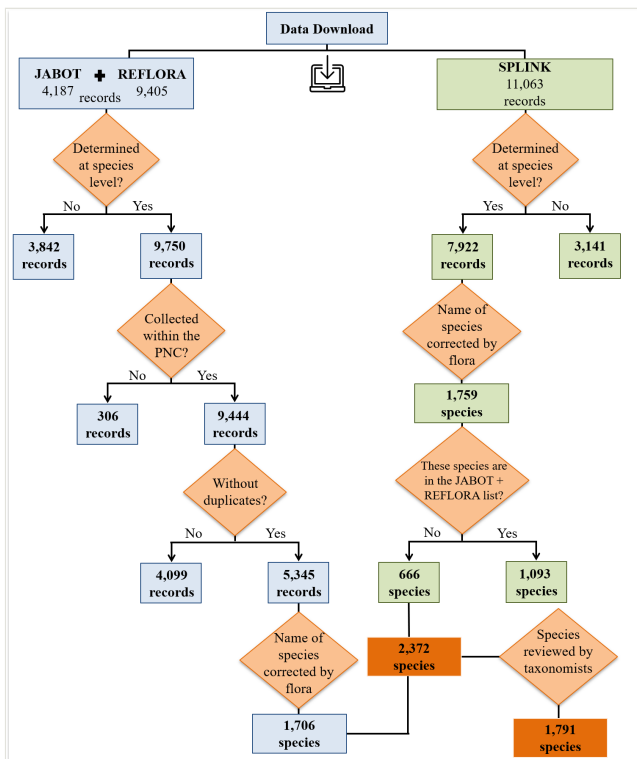


Figure 1. [doi](#)

Stages of data cleaning performed in R software to obtain a list of land plants of “Parque Nacional do Caparaó,” Brazil, from the online databases.

To assess the most collected sites in the Park, we built a word cloud, based on the name of locations where specimens were collected. We did not include broad locations in the word cloud, such as “Serra do Caparaó” and “Parque Nacional do Caparaó”, since they are not informative. We constructed the word cloud using the function *wordcloud* of the *wordcloud* package version 2.6 (Fellows 2018).

To evaluate whether species were native or non-native and endemic or non-endemic to Brazil and to assign a threat category, we used information from Flora do Brasil 2020 (under construction; <http://floradobrasil.jbrj.gov.br>) and the Red List Authority for plants in Brazil - CNCFLora (<http://www.cncflora.jbrj.gov.br/portal>). In the case of species not included in the Flora do Brasil 2020 database, threat category and origin (native/non-native) were obtained from taxonomists. We considered as non-native all species indicated as cultivated or naturalised by the Flora do Brasil 2020 database. We also assessed whether species of PNC were on the threatened species lists in the States of Espírito Santo (Fraga et al. 2019) and Minas Gerais (COPAM-MG 2008). We classified species as endemic to the Atlantic Forest when their distribution is restricted to the Atlantic Forest phytogeographic domain. We obtained this information from the Flora do Brasil 2020 database through the function *get_domains* from the *flora* package (Carvalho 2017). This classification also included species non-endemic to Brazil as the Atlantic Forest occurs in the countries of Argentina and Paraguay. We classified species as rare in Brazil, based on the publication of Giulietti et al. (2009).

We classified species as a priority for conservation when they had a single record collected before 1970 (Briggs and Leigh 1988) and was simultaneously categorised as Critically Endangered (CR), Vulnerable (VU), Endangered (EN) or Data Deficient (DD), according to Red List Authority for plants in Brazil - CNCFLora (<http://www.cncflora.jbrj.gov.br/portal>).

Geographic coverage

Description: The PNC encompasses a total area of 31,853.12 ha (20° 37' to 20° 19' S, 41° 43' to 41° 55' W), of which 79% is in Espírito Santo (ES) and 21% in Minas Gerais (MG), both in southeast Brazil (ICMBio 2015). Being the second largest conservation unit within ES (Fraga et al. 2019), it encompasses five of its Municipalities (Divino de São Lourenço, Dolores do Rio Preto, Ibitirama, Irupi and Iúna), plus four in MG (Alto Caparaó, Alto Jequitibá, Caparaó and Espera Feliz) (ICMBio 2015). Located in “Serra da Mantiqueira”, PNC has a wide altitudinal gradient (630 to 2,892 m a.s.l.), with “Pico da Bandeira” (2,892 m a.s.l.) being its highest point and the third highest peak in Brazil (Fig. 2a) (ICMBio 2015).

Mean annual rainfall in PNC is 1,481.1 mm, with the greatest rainfall in January (mean 316.7 mm) and the lowest in July (mean 16.2 mm; data are mean rainfall for 1974–2003; ICMBio 2015). The mean annual temperature is 11°C, with a minimum of 2.5°C in July and a maximum of 31°C in December (data are mean temperatures between December 2004 and December 2005 at 2,400 m a.s.l.; Rodrigues et al. 2009). The vegetation of PNC comprises different phytophysognomies, including dense ombrophilous montane forest, dense ombrophilous high-montane forest, seasonal semi-deciduous montane forest and high-altitude grassland (*campos de altitude*) (Fig. 2b, c, d; ICMBio 2015).

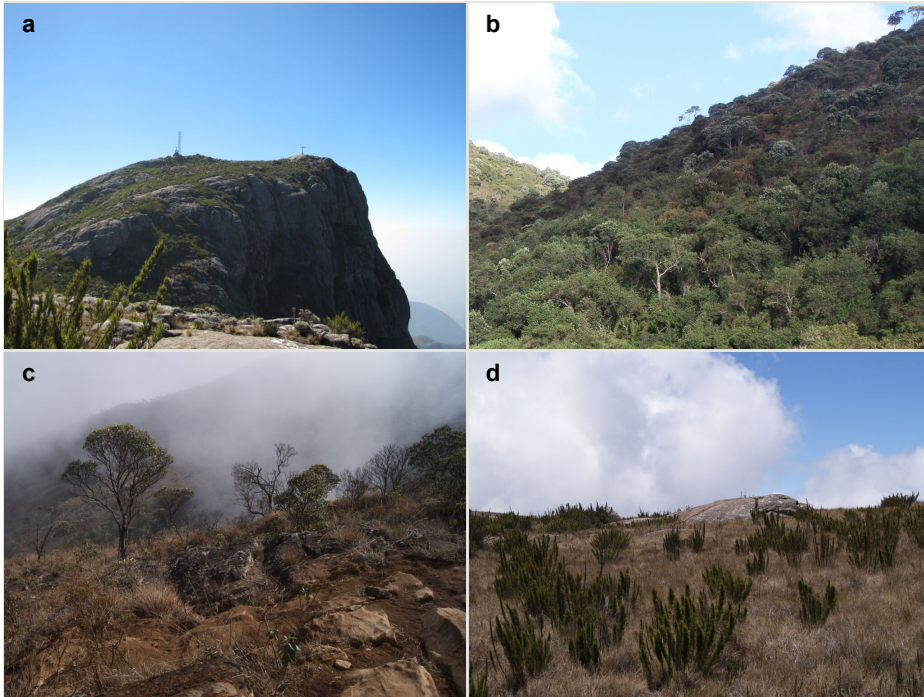


Figure 2.

Phytophysiognomies of “Parque Nacional do Caparaó,” Brazil. (Photos: a and d João Paulo F. Zorzaneli; b Mário Luís Garbin; c Tatiana T. Carrijo).

a: High-altitude grassland, “Pico da Bandeira” [doi](#)

b: Ombrophilous forest [doi](#)

c: High-altitude grassland [doi](#)

d: High-altitude grassland dominated by *Chusquea* Kunth (Poaceae) vegetation [doi](#)

Coordinates: -20° 37' and -20° 19' S Latitude; -41° 55' and -41° 43' Longitude.

Taxonomic coverage

Description: The plant list for “Parque Nacional do Caparaó” contains a total of 1,791 species (Suppl. material 1) of 715 genera and 198 botanical families, with 1,292 angiosperms (500 genera/119 families), 38 lycophytes (9/3), 263 ferns (89/20) and 198 avascular plants (i.e. Antocerotophyta, Bryophyta and Marchantiophyta; 117/56) (Figs 3, 4). We found no records for gymnosperms in PNC in the online databases; however, a recent and unpublished study (Araújo 2016) recorded *Podocarpus lambertii* Klotzsch ex Endl. in PNC. During expeditions to the Park, we only observed some individuals of *Araucaria angustifolia* (Bertol.) Kuntze (Fig. 3f), but this species is usually planted in montane areas of south-eastern Brazil and there are doubts about its natural occurrence in several localities, with it being considered regionally extinct in ES (Tuler et al. 2019).



Figure 3.

Plant species of “Parque Nacional do Caparaó,” Brazil. (Photos: a and b. Marina M. Moreira; c and d. Tatiana T. Carrijo; e. Renato Goldenberg; f Mário Luís Garbin).

a: *Abatia americana* (Gardner) Eichler - Salicaceae [doi](#)

b: *Barbacenia irwiniana* L.B.Sm. - Velloziaceae [doi](#)

c: *Gaultheria serrata* (Vell.) Sleumer ex Kin.-Gouv. - Ericaceae [doi](#)

d: *Mutisia campanulata* Less. - Asteraceae [doi](#)

e: *Pleroma microphyllum* (Cogn.) P.J.F.Guim. & Michelang. - Melastomataceae [doi](#)

f: *Araucaria angustifolia* (Bertol.) Kuntze - Araucariaceae [doi](#)



Figure 4.

Plant species of “Parque Nacional do Caparaó,” Brazil. (Photos: a. João Paulo F. Zorzaneli; b. Jovani B.S. Pereira; c and d. Thamara A. Feletti).

a: *Cochlidium punctatum* (Raddi) L.E.Bishop - Polypodiaceae [doi](#)

b: *Isoetes caparaoensis* J.B.S.Pereira - Isoetaceae [doi](#)

c: *Plagiomnium rhynchophorum* (Hook.) T.J.Kop. - Mniaceae [doi](#)

d: *Pyrrhobryum spiniforme* (Hedw.) Mitt. - Rhizogoniaceae [doi](#)

The richest families in PNC are: Orchidaceae with 152 species, Asteraceae (139), Poaceae (87), Melastomataceae (74), Solanaceae (53), Dryopteridaceae (52), Fabaceae (51), Myrtaceae (50), Polypodiaceae (47) and Bromeliaceae and Rubiaceae (both with 44). These families comprise 44% (i.e. 793 species) of the species found in PNC (Fig. 5a, b, c). Forty-nine families are represented by a single species. The richest genera are: *Solanum* with 33 species, *Elaphoglossum* (29), *Leandra* (26), *Baccharis* and *Piper* (both with 24), *Myrcia* (23), *Asplenium* (22), *Miconia* (21), *Amauropelta* and *Habenaria* (both with 19), *Peperomia* and *Phlegmariurus* (both with 17) and *Vriesea* (16). These genera comprise 16% (i.e. 290 species) of the species found in PNC (Fig. 5d, e, f). A total of 388 genera are represented by a single species.

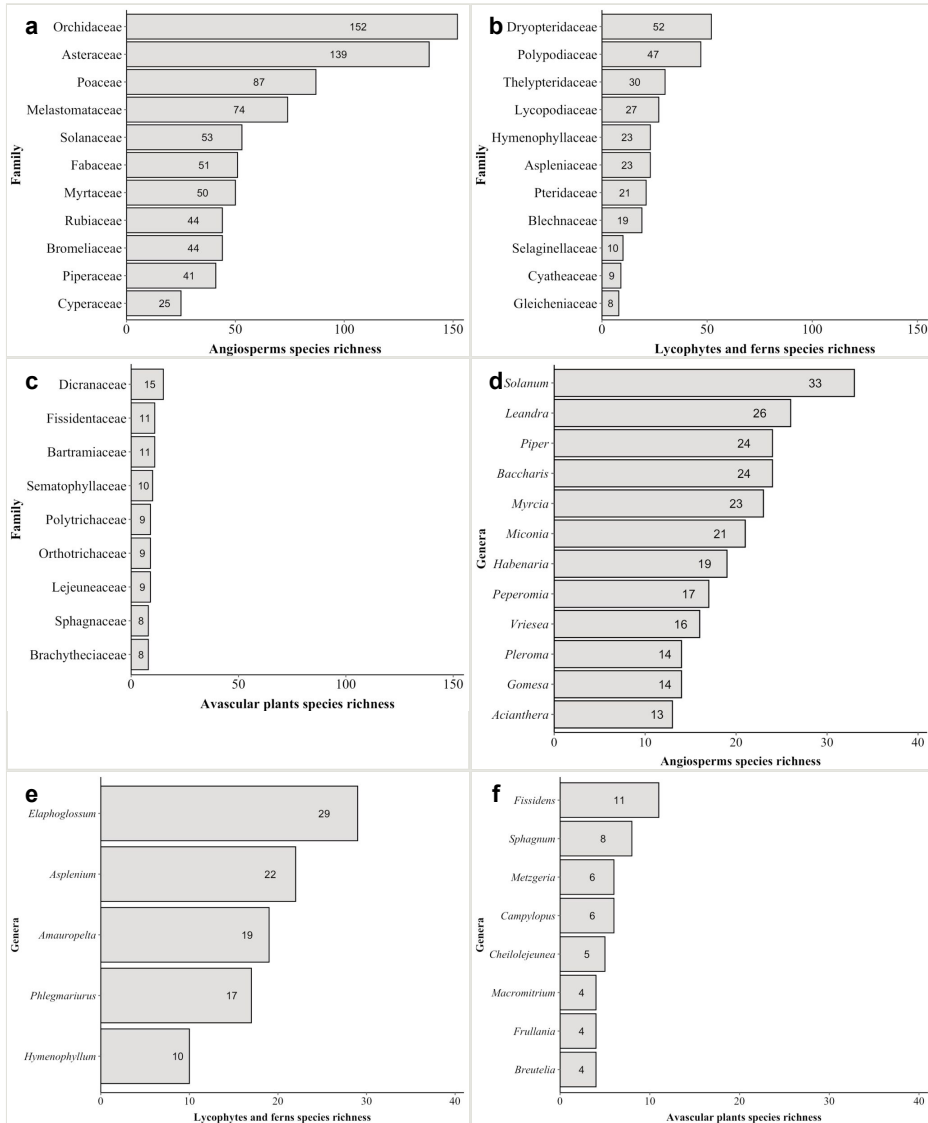


Figure 5.

Richest families and genera of major groups of plants recorded in “Parque Nacional do Caparaó,” Brazil. Values inside the bars indicate the number of species.

a: Top ten families of angiosperms [doi](#)

b: Top ten families of lycophytes and ferns [doi](#)

c: Top five families of avascular plants [doi](#)

d: Top ten genera of angiosperms [doi](#)

e: Top five genera of lycophytes and ferns [doi](#)

f: Top five genera of avascular plants [doi](#)

The list for PNC includes 1,757 native and 34 non-native species to Brazil (Fig. 6). Most of the native species are angiosperms (72%), followed by ferns (15%), avascular plants (11%) and lycophytes (2%; Fig. 6). All lycophyte species occurring in PNC are native. Amongst non-native species, angiosperms accounted for 73%, followed by avascular plants with 21% and ferns with 6% (Suppl. material 1). Asteraceae (8 species) and Poaceae (5) had the highest number of non-native species in PNC (Suppl. material 1). Thirteen families are represented by a single non-native species (Suppl. material 1).

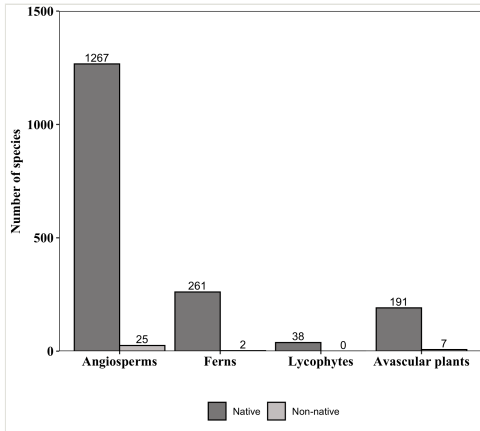


Figure 6. [doi](#)

Native and non-native species to Brazil of major groups of plants that occur in “Parque Nacional do Caparaó,” Brazil. Values above the bars indicate the number of species.

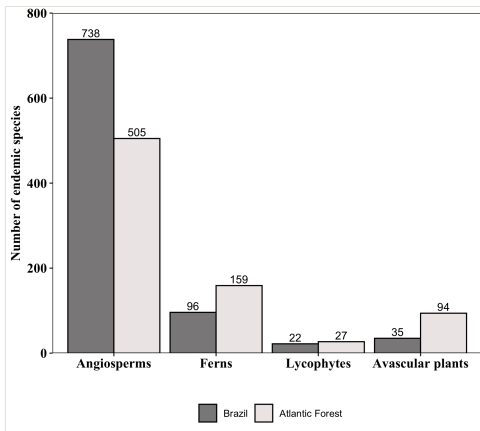


Figure 7. [doi](#)

Number of endemic species to Brazil and to the Atlantic Forest of major groups of plants that occur in the “Parque Nacional do Caparaó,” Brazil. Values above the bars indicate the number of species.

We found a similar number of non-endemic (900) and endemic (891) species to Brazil (Fig. 7). Most of both the endemic and non-endemic species to Brazil are angiosperms (83% and 61%, respectively), followed by ferns (11% and 19%), avascular plants (4% and 18%) and lycophytes (2% and 2%). Orchidaceae and Asteraceae have the highest number of endemic species to Brazil (92 and 74, respectively), followed by Melastomataceae (62), Bromeliaceae (41) and Myrtaceae (37) (Fig. 8). The PNC protects 785 endemic species in the Atlantic Forest domain (Fig. 7), most of which are angiosperms (64.3%), followed by ferns (20.3%), avascular plants (12%) and lycophytes (3.4%). Orchidaceae has the highest number of endemic species to Atlantic Forest (67), followed by Dryopteridaceae and Asteraceae (both with 37), Melastomataceae (35), Solanaceae and Polypodiaceae (both with 33) and Bromeliaceae (32).

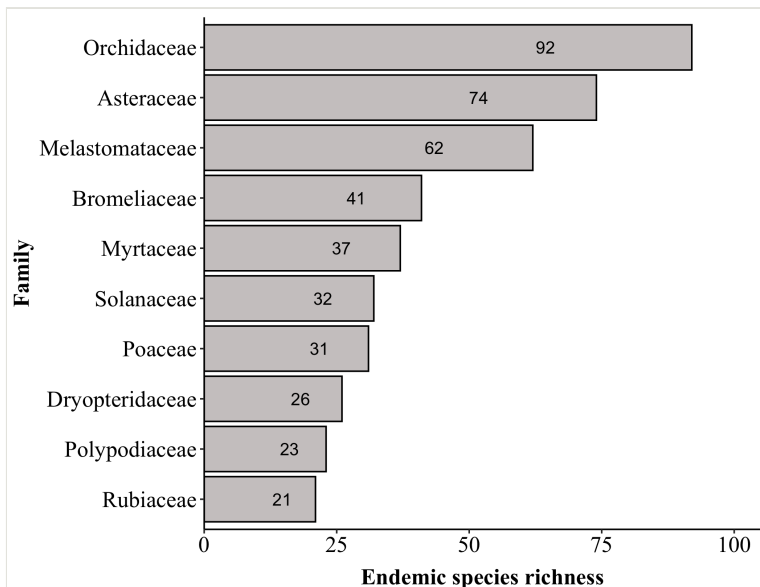


Figure 8. [doi](#)

Families with the most endemic species of Brazil listed in the “Flora do Brasil 2020”, recorded in “Parque Nacional do Caparaó,” Brazil. Values inside the bars indicate the number of species.

Traits coverage

Within the PNC, there are 203 species considered as Least Concern (LC), 34 as Endangered (EN), 22 as Vulnerable (VU), 20 as Near Threatened (NT), seven as Critically Endangered (CR) and seven as Data Deficient (DD), based on the Brazilian National Red List - CNCFlora ([http:// www.cncflora.jbrj.gov.br/portal](http://www.cncflora.jbrj.gov.br/portal)). Most species of PNC (84%; 1,498) have not been evaluated by the Brazilian National Red List (Fig. 9; Suppl. material 1), a figure which is similar to the percentage of Brazilian species without threat evaluation (89%) (Martinelli et al. 2013).



Figure 9.

Some threatened species of “Parque Nacional do Caparaó,” Brazil according to the Red List Authority for plants in Brazil - CNCFLora (Photos: a and b. Marina M. Moreira; c and f. João Paulo F. Zorzanelli; d. Dayvid R. Couto; e Marcelo Monge).

a: *Agalinis bandeirensis* Barringer - Orobanchaceae (CR) [doi](#)

b: *Berberis campos-portoi* Brade - Berberidaceae (CR) [doi](#)

c: *Gaylussacia caparoensis* Sleumer - Ericaceae (EN) [doi](#)

d: *Pitcairnia decidua* L.B.Sm. - Bromeliaceae (EN) [doi](#)

e: *Trixis glaziovii* Baker - Asteraceae (VU) [doi](#)

f: *Vanhouttea leonii* Chautems - Gesneriaceae (EN) [doi](#)

In this regard, PNC houses 63 threatened species (CR, EN and VU) of Brazilian flora and seven Data Deficient species, based on the Brazilian National Red List (Fig. 10; Table 1). These threatened (CR, EN and VU) and DD species belong to 42 families, with

Orchidaceae having the highest number of threatened species (7) followed by Bromeliaceae (6), Asteraceae (5), Polypodiaceae (4) and Gesneriaceae (3) (Table 1). These three most threatened families of angiosperms of PNC are the same as those of Flora do Brasil 2020 (under construction; <http://floradobrasil.jbrj.gov.br>), but at different ranks (Asteraceae, Bromeliaceae and Orchidaceae) (Martinelli et al. 2013). Eight families had two threatened species and 29 families had a single threatened species (Table 1).

Table 1.

Threatened and Data Deficient species of plants occurring in "Parque Nacional do Caparaó," Brazil, their respective groups, families and threat category according to the Red List Authority for plants in Brazil - CNCFLora (CR = Critically Endangered, VU = Vulnerable, EN = Endangered and DD = Data Deficient). *Priority species for conservation.

| Species | Red list category |
|--|-------------------|
| Angiosperms | |
| Amaryllidaceae | |
| <i>Hippeastrum morelianum</i> Lem. | VU |
| Apiaceae | |
| <i>Eryngium glaziovianum</i> Urb. | DD |
| Apocynaceae | |
| <i>Ditassa leonii</i> Fontella & T.U.P.Konno | VU |
| <i>Oxypetalum leonii</i> Fontella | EN |
| Araliaceae | |
| <i>Hydrocotyle langsdorffii</i> DC. | EN |
| Arecaceae | |
| <i>Euterpe edulis</i> Mart. | VU |
| Asteraceae | |
| <i>Chionolaena lychnophorioides</i> Sch.Bip. | VU |
| <i>Mikania additicia</i> B.L.Rob. | EN |
| * <i>Mikania hastato-cordata</i> Malme | VU |
| <i>Senecio caparaoensis</i> Cabrera | EN |
| <i>Trixis glaziovii</i> Baker | VU |
| Berberidaceae | |
| <i>Berberis campos-portoi</i> Brade | CR |
| Bromeliaceae | |
| <i>Aechmea vanhoutteana</i> (Van Houtte) Mez | VU |
| <i>Neoregelia brownii</i> Leme | CR |
| <i>Neoregelia ruschii</i> Leme & B.R.Silva | EN |
| <i>Pitcairnia decudua</i> L.B.Sm. | EN |
| <i>Quesnelia kautskyi</i> C.M.Vieira | VU |

| Species | Red list category |
|---|-------------------|
| <i>Vriesea pabstii</i> McWill. & L.B.Sm | DD |
| Burmanniaceae | |
| <i>Burmannia aprica</i> (Malme) Jonker | DD |
| Cactaceae | |
| <i>Schlumbergera kautskyi</i> (Horobin & McMillan) N.P.Taylor | EN |
| <i>Schlumbergera microsphaerica</i> (K.Schum.) Hoevel | VU |
| Clusiaceae | |
| <i>Clusia aemygdioi</i> Gomes da Silva & B.Weinberg | EN |
| Ericaceae | |
| <i>Gaylussacia caparoensis</i> Sleumer | EN |
| Fabaceae | |
| <i>Bionia bella</i> Mart. ex Benth. | DD |
| Gentianaceae | |
| <i>Senaea janeirensis</i> Brade | EN |
| Gesneriaceae | |
| <i>Codonanthe carnosa</i> (Gardner) Hanst. | VU |
| <i>Vanhouttea leonii</i> Chautems | EN |
| <i>Vanhouttea pendula</i> Chautems | EN |
| Lentibulariaceae | |
| <i>Genlisea lobata</i> Fromm | EN |
| <i>Utricularia tridentata</i> Sylvén | VU |
| Melastomataceae | |
| <i>Miconia setosociliata</i> Cogn. | VU |
| Meliaceae | |
| <i>Cedrela fissilis</i> Vell. | VU |
| <i>Cedrela odorata</i> L. | VU |
| Monimiaceae | |
| <i>Macropelus schwackeanus</i> (Perkins) I.Santos & Peixoto | VU |
| Orchidaceae | |
| * <i>Acianthera heringeri</i> (Hoehne) F.Barros | CR |
| * <i>Encyclia bragancae</i> Ruschi | EN |
| <i>Epidendrum zappii</i> Pabst | EN |
| <i>Grandiphyllum divaricatum</i> (Lindl.) Docha Neto | VU |
| <i>Habenaria achalensis</i> Kraenzl. | VU |
| <i>Habenaria hydrophila</i> Barb.Rodr. | DD |
| <i>Phymatidium geiselii</i> Ruschi | EN |

| Species | Red list category |
|---|-------------------|
| Orobanchaceae | |
| <i>Agalinis bandeirensis</i> Barringer | CR |
| <i>Nothochilus coccineus</i> Radlk. | EN |
| Pentaphragaceae | |
| <i>Ternstroemia cuneifolia</i> Gardner | VU |
| Plantaginaceae | |
| <i>Achetaria caparaense</i> (Brade) V.C.Souza | CR |
| Poaceae | |
| <i>Chusquea baculifera</i> Silveira | CR |
| <i>Chusquea heterophylla</i> Nees | EN |
| Polygalaceae | |
| <i>Polygala vollii</i> Brade | EN |
| Primulaceae | |
| <i>Myrsine villosissima</i> Mart. | EN |
| Rubiaceae | |
| <i>Psychotria paludosa</i> Müll.Arg. | EN |
| Scrophulariaceae | |
| <i>Buddleja longiflora</i> Brade | CR |
| <i>Buddleja speciosissima</i> Taub. | VU |
| Smilacaceae | |
| <i>Smilax lappacea</i> Willd. | EN |
| Symplocaceae | |
| <i>Symplocos itatiaiae</i> Wawra | EN |
| Xyridaceae | |
| <i>Xyris caparaensis</i> Wand. | DD |
| <i>Xyris obtusiuscula</i> L.A.Nilsson | EN |
| Zingiberaceae | |
| * <i>Renealmia brasiliensis</i> K.Schum. | EN |
| Ferns | |
| Anemiaceae | |
| <i>Anemia blechnoides</i> Smith | VU |
| Aspleniaceae | |
| <i>Asplenium castaneum</i> Schldl. et Cham. | EN |
| Dicksoniaceae | |
| <i>Dicksonia sellowiana</i> Hook. | EN |
| Polypodiaceae | |

| Species | Red list category |
|--|-------------------|
| <i>Ceradenia capillaris</i> (Desv.) L.E.Bishop | VU |
| * <i>Grammitis fluminensis</i> Fée | EN |
| <i>Lellingeria tamandarei</i> (Rosenst.) A.R.Sm. & R.C.Moran | EN |
| <i>Pleopeltis monooides</i> (Weath.) Salino | EN |
| Pteridaceae | |
| <i>Doryopteris rediviva</i> Fée | VU |
| Liverworts | |
| Arnelliaceae | |
| <i>Gongylanthus liebmannianus</i> (Lindenb. & Gottsche) Steph. | EN |
| Metzgeriaceae | |
| <i>Metzgeria subaneura</i> Schiffn. | DD |
| Pallaviciniaceae | |
| <i>Jensenia difformis</i> (Nees) Grolle | EN |
| Mosses | |
| Dicranaceae | |
| <i>Atractylocarpus longisetus</i> (Hook.) E.B.Bartram | EN |
| Ditrichaceae | |
| <i>Chrysoblattella chilensis</i> (Mont.) Reimers | EN |

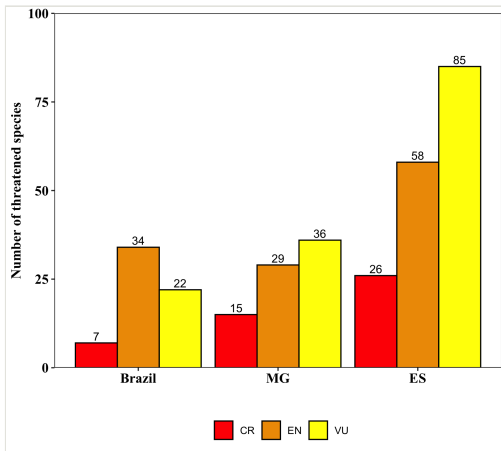


Figure 10. [doi](#)

Number of threatened species housed by “Parque Nacional do Caparaó,” Brazil according to the Red List Authority for plants in Brazil - CNCFLora, Espírito Santo regional Red List (ES) and Minas Gerais regional Red List (MG). CR = Critically Endangered; EN = Endangered; VU = Vulnerable. Values above the bars indicate the number of species.

According to regional Red Lists, the PNC houses 169 threatened species of ES (Fraga et al. 2019; Fig. 10) and 80 threatened species of MG (COPAM-MG 2008), representing 12%

of the threatened flora of ES (1,430 threatened species of ES; Suppl. material 1) and 7% of the threatened flora of MG (1,124 threatened species of MG; Suppl. material 1).

Considering the entire flora of PNC, 24 species belonging to 18 families are rare in Brazil. Asteraceae and Orobanchaceae have the highest number of rare species (three) followed by Bromeliaceae and Scrophulariaceae (two each, Table 2). Fourteen families have a single rare species (Table 2). We retrieved five species, four angiosperms and one fern, which are priorities for conservation in PNC (Table 1).

Table 2.

Rare species of plants occurring in “Parque Nacional do Caparaó,” Brazil and their respective families.

Rare plant species

Apocynaceae

Oxypetalum leonii Fontella

Araceae

Anthurium mourae Engl.

Asteraceae

Baccharis dubia Deble & A.S.Oliveira

Chionolaena lychnophorioides Sch.Bip.

Leptostelma camposportoi (Cabrera) A.M.Teles & Sobral

Bromeliaceae

Dyckia bracteata (Wittm.) Mez

Neoregelia brownii Leme

Cactaceae

Schlumbergera kautskyi (Horobin & McMillan) N.P.Taylor

Eriocaulaceae

Paepalanthus caparoensis Ruhland

Gentianaceae

Senaea janeirensis Brade

Gesneriaceae

Vanhouttea leonii Chautems

Lentibulariaceae

Genlisea lobata Fromm

Monimiaceae

Macropeplus schwackeanus (Perkins) I.Santos & Peixoto

Myrtaceae

Siphoneugena delicata Sobral & Proença

Orchidaceae

| |
|--|
| <i>Phymatidium geiselii</i> Ruschi |
| Orobanchaceae |
| <i>Agalinis bandeirensis</i> Barringer |
| <i>Esterhazyia eitenorum</i> Barringer |
| <i>Nothochilus coccineus</i> Radlk. |
| Piperaceae |
| <i>Peperomia warmingii</i> C.DC. |
| Polygalaceae |
| <i>Polygala vollii</i> Brade |
| Salicaceae |
| <i>Abatia microphylla</i> Taub. |
| Scrophulariaceae |
| <i>Buddleja longiflora</i> Brade |
| <i>Buddleja speciosissima</i> Taub. |
| Velloziaceae |
| <i>Barbacenia irwiniana</i> L.B.Sm. |

Usage licence

Usage licence: Open Data Commons Attribution License

Data resources

Data package title: A list of land plants of Parque Nacional do Caparaó, Brazil, highlights the presence of sampling gaps within this protected area.

Resource link: https://ckan.jbrj.gov.br/dataset/2020_caparao_list

Number of data sets: 1

Data set name: List of species of the Parque Nacional do Caparaó.

Download URL: <https://ckan.jbrj.gov.br/dataset/d8886b0b-f47d-4e2c-aac3-f68d5f1e3036/resource/b184ef97-c1ca-463f-9f35-e7195717b74a/download/table-s1.csv>

| Column label | Column description |
|--------------|---|
| Groups | Controlled vocabulary ("Angiosperms", "Ferns", "Hornworts", "Liverworts", "Lycophytes", "Mosses") |
| Families | The full scientific name of the family in which the taxon is classified |
| Genera | The full scientific name of the genus in which the taxon is classified. |

| | |
|---|--|
| Species | The full scientific name |
| Author name | Authorship of the scientific name |
| Number of specimens | Number of specimens for the species |
| Database or herbarium code | Botanical collection or database of origin of the record |
| Barcode | The unique identifier for the record within botanical collections |
| catalogue.number or collector name and number | Field sed in case of the absence of the barcode |
| The species present a single record? | Controlled vocabulary ("yes", "no") |
| The species present only old records? | Controlled vocabulary ("yes", "no", "NA") |
| The species is native to Brazil? | Controlled vocabulary ("native", "non-native") |
| The species is endemic to Brazil? | Controlled vocabulary ("endemic", "non-endemic") |
| The species occur in the Atlantic Forest, according to Flora do Brasil 2020? | Controlled vocabulary ("yes", "no", "no information") |
| Phytogeographic domain obtained by R | Brazilian phytogeographic domains where the species occur |
| The species is endemic to Atlantic Forest? | Controlled vocabulary ("endemic", "non-endemic", "no information") |
| The species occur in ES and MG States according to the Flora do Brasil 2020? | Controlled vocabulary including the Brazilian states codes ("MG", "ES", "ES and MG", "no", "no information") |
| Threat category according to CNCFLORA | Followed the Red List Authority for plants in Brazil - Centro Nacional de Conservação da Flora - CNCFlora (http://www.cncflora.jbrj.gov.br/portal); DD = Data deficient, NT = Near Threatened, VU = Vulnerable, CR = Critically Endangered, EN = Endangered, LC = Least Concern, NE = Not evaluated |
| Threat category (CR, EN or VU) according to the lists of Espírito Santo State | Followed the regional Red List of the Espírito Santo State |
| Threat category (CR, EN or VU) according to the lists of Minas Gerais State | Followed the regional Red List of the Minas Gerais State |
| The species occur in Dutra et al. 2015 list? | Compared with Dutra et al. (2015) < https://doi.org/10.1590/2175-7860201566414 > |

Additional information

Conclusions and prospects

The analysis of specimens collected in the PNC allowed us to detect a spatial collection gap. Most (79%) of the specimens analysed were collected in a small portion of the Park (21% of the area of the Park) located in MG. These collections were mainly made in easily accessible places of PNC, such as Vale Verde, Cachoeira Bonita, Vale Encantado, Tronqueira and Terreirão (Fig. 11). Collection bias towards access routes is a common sampling problem that has been reported for various taxonomic groups (i.e. vertebrates, invertebrates and angiosperms) throughout all Brazilian phytogeographic domains and can affect the detection of spatial patterns of species diversity (Oliveira et al. 2016).

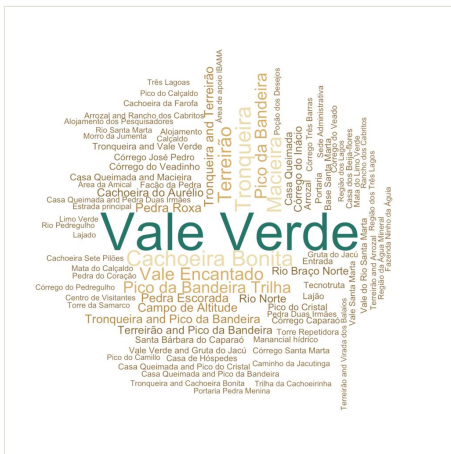


Figure 11. [doi](#)

Word cloud of locations where plants of “Parque Nacional do Caparaó,” Brazil, were collected. The different colours and sizes of the letters represent the frequency of collections at the localities within the Park; larger font size represents a greater number of collections.

Furthermore, amongst the species found in PNC, 445 are described by Flora do Brasil under construction (2020) as occurring in MG, while only 81 species are described as occurring in ES, whereas a total of 1,199 occur in both States (ES and MG; Fig. 12 and Suppl. material 1). The Park also houses only 14% (873 species) of the species, 29% (398) of the genera and 61% (110) of the families of angiosperms listed for ES (Suppl. material 1; Dutra et al. 2015). We did not find information about the state of occurrence for 13 species and 53 species did not appear in Flora do Brasil under construction (2020) as occurring in either ES or MG (Fig. 12 and Suppl. material 1). Despite the Atlantic Forest being one of the most sampled phytogeographic domains in Brazil (Oliveira et al. 2019), our results demonstrate that even areas that have been extensively studied can have collection gaps. Thus, deeper knowledge of the flora of PNC requires increased collection effort in the less accessible areas of the Park located mainly in ES.

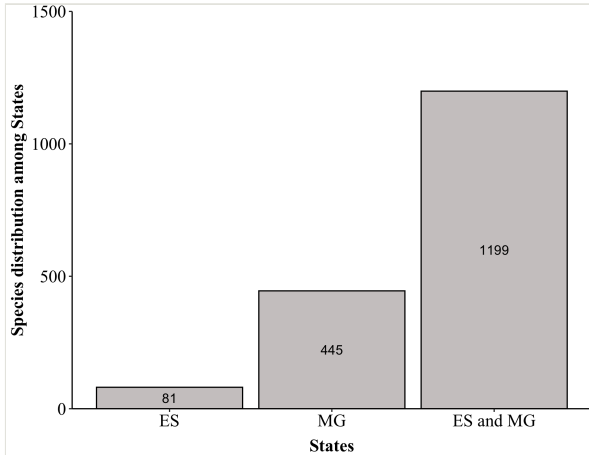


Figure 12. [doi](#)

Species of “Parque Nacional do Caparaó,” Brazil, distributed between the States of Espírito Santo (ES) and Minas Gerais (MG) according to Flora do Brasil (2020). Values inside the bars indicate the number of species.

A particularly interesting result was the 53 species in the list of PNC that were not recorded as occurring in ES or MG. It may be that these species are new occurrences for MG or ES. One recent study, involving the family Araceae in PNC, reported *Xanthosoma maximilianii* Schott and *Philodendron acutatum* Schott of these 53 species, as new occurrences for ES and MG, respectively (Camelo et al. 2020), emphasising the importance of more in-depth assessments of the occurrence of the other 51 species.

The species list for PNC, presented here, was prepared using information acquired from online databases and validated by taxonomists. This method is considered good practice for estimating species diversity in the “era of big data” (Maldonado et al. 2015). The retrieval of information contained in the online databases revealed that PNC houses 10% (1,699 species) of the species recognised for the Brazilian Atlantic Forest (i.e. 17,776 species; Flora do Brasil under construction 2020) and 8% (785) of the species endemic to this domain (i.e. 10,024 species; Flora do Brasil under construction 2020), with 6% (505) of angiosperms, 31% (186) of lycophytes and ferns and 14% (94) of avascular plants. In conclusion, the species list of PNC allowed us not only to identify the species that occur in this protected area, but also to identify gaps in knowledge that can help direct the allocation of future collecting efforts.

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References

- Aguiar A, Marques M (2001) Flora Fanerogâmica do Parque Nacional do Caparaó: Polygalaceae. *Pabstia* 12 (3): 1-3.
- Araújo E (2016) Estrutura, composição florística e relação vegetação-ambiente em Floresta Ombrófila Densa no Parque Nacional do Caparaó, Espírito Santo. Dissertação de Mestrado. Programa de Pós-graduação em Ciências Agrárias e Engenharias da Universidade Federal do Espírito Santo, 115 pp.
- Araújo EA, Kunz SH, Dias HM, Carrijo TT, Zorzanelli JPF (2018) Inventários florísticos na região do Caparaó Capixaba revelam novos registros para a flora do Espírito Santo. *Rodriguésia* 69 (4): 1953-1963. <https://doi.org/10.1590/2175-7860201869429>
- Brade AC (1942) Excursão à Serra do Caparaó. *Rodriguésia* 15: 87-92.
- Briggs J, Leigh J (1988) Rare or Threatened Australian Plants. Special Publication No. 14. Australian National Parks and Wildlife Service, Canberra. [ISBN 0642526729]
- Camelo MdC, Coelho MAN, Leoni L, Temponi LG (2020) Araceae do Parque Nacional do Caparaó, MG-ES, Brasil. *Rodriguésia* 71 <https://doi.org/10.1590/2175-7860202071065>
- Cardoso PH, Santos-Silva F, Neto LM, Salimena FRG (2019) Verbenaceae in the Parque Nacional do Caparaó, Serra da Mantiqueira, Brazil. *SciELO journals* <https://doi.org/10.6084/m9.figshare.10257929.v1>
- Carrijo TT, Alves-Araújo AG, Amorim AM, Barbosa DE, Barcelos LB, Baumgratz JF, Bueno VR, Coelho RL, Costa DP, Couto DR, Delgado CN, Dutra VF, Flores TB, Furtado SG, Giacomini LL, Goldenberg R, Gomes M, Gonzaga DR, Guimarães EF, Heiden G, Kameyama C, Labiak PH, Lírio EJ, Lohmann LG, Matos FB, Moraes PL, Meireles LD, Menini-Neto L, Monteiro D, Moreira MM, Morim MP, Mota MC, Oliveira JR, Pastore JF, Pederneiras LC, Pereira LC, Rapini A, Salimena FR, Silva AV, Silva-Neto SJ, Sobral ME, Souza MC, Sylvestre LS, Trovó M, Viana PL, Forzza RC (2018) Lista de espécies de plantas terrestres do Parque Nacional do Itatiaia. In: *Catálogo de Plantas das Unidades de Conservação do Brasil*. Jardim Botânico do Rio de Janeiro. <https://catalogo-ucs-brasil.jbrj.gov.br>. Accessed on: 2020-8-11.

- Carrijo TT, Alves-Araújo AG, Amorim AM, Antar GM, Antunes K, Barbosa DE, Baumgratz JF, Bueno VR, Cardoso PH, Chagas AP, Couto DR, Da Silva LN, Delgado CN, Dittrich VA, Dutra VF, Firmino AD, Freitas J, Furtado SG, Giacomini LL, Goldenberg R, Gomes M, Gonzaga DR, Heiden G, Labiak PH, Lírio EJ, Lopes IT, Luber J, Marques D, Matos FB, Meireles LD, Menini Neto L, Meyer FS, Monge M, Monteiro D, Moraes QS, Moraes PL, Moreira MM, Morim MP, Nakajima JN, Nichio-Amaral R, Oliveiram JR, Pederneiras LC, Peixoto AL, Pereira JB, Pereira LC, Prado J, Rapini A, Reginato M, Rollim IM, Salimena FR, Salino A, Schwartsburd PB, Silva AV, Silva C, Sobral ME, Souza FS, Sousa HC, Sylvestre LS, Trovó M, Tuler AC, Versiane AF, Viana PL, J.P.F Z, Forzza RC (2020) Catálogo de Plantas das Unidades de Conservação do Brasil. Jardim Botânico do Rio de Janeiro. <https://catalogo-ucs-brasil.jbrj.gov.br>. Accessed on: 2020-8-11.
- Carvalho G (2017) Flora: Tools for interacting with the Brazilian Flora 2020. R package. 0.3.0. URL: <https://cran.r-project.org/web/packages/flora/index.html>
- Colli-Silva M, Reginato M, Cabral A, Forzza RC, Pirani JR, Vasconcelos TdC (2020) Evaluating shortfalls and spatial accuracy of biodiversity documentation in the Atlantic Forest, the most diverse and threatened Brazilian phytogeographic domain. *Taxon* 69 (3): 567-577. <https://doi.org/10.1002/tax.12239>
- COPAM-MG (2008) Conselho Estadual de Política Ambiental. Deliberação COPAM nº 367, de 15 de dezembro de 2008. Aprova a Lista das Espécies Ameaçadas de Extinção da Flora do Estado de Minas Gerais. http://www.siam.mg.gov.br/sla/download.pdf?idNorma=9450#_ftn1. Accessed on: 2020-8-11.
- Dutra VF, Alves-Araújo A, Carrijo TT (2015) Angiosperm checklist of Espírito Santo: using electronic tools to improve the knowledge of an Atlantic Forest biodiversity hotspot. *Rodriguésia* 66 (4): 1145-1152. <https://doi.org/10.1590/2175-7860201566414>
- Fellows I (2018) wordcloud: Word Clouds. R package. 2.6. URL: <https://CRAN.R-project.org/package=wordcloud>
- Flora do Brasil under construction (2020) <http://floradobrasil.jbrj.gov.br/>. Accessed on: 2020-7-29.
- Forster W, Souza VC (2013) Laeliinae (Orchidaceae) do parque nacional do Caparaó, Estados do Espírito Santo e Minas Gerais, Brasil. *Hoehnea* 40 (4): 701-726. <https://doi.org/10.1590/s2236-89062013000400010>
- Fraga CN, Formigoni MH, Chaves FG (2019) Fauna e flora ameaçadas de extinção no estado do Espírito. Instituto Nacional da Mata Atlântica, Santa Teresa, ES, 432 pp.
- Giulietti AM, Rapini A, Andrade MJ, Queiroz LP, Silva JM (2009) Plantas raras do Brasil. Conservação Internacional, Belo Horizonte, MG, 496 pp.
- Góes-Neto LA, Heringer G, Salino A (2015) *Selaginella salinoi* (Selaginellaceae), a new species from Brazil. *Phytotaxa* 224 (3). <https://doi.org/10.11646/phytotaxa.224.3.8>
- Góes-Neto LA, Salino A (2018) *Selaginella kriegeeriana* (Selaginellaceae - Lycopodiopsida), an endemic new species from Brazil with notes about the genus in Caparaó National Park. *Systematic Botany* 43 (4): 920-929. <https://doi.org/10.1600/036364418x697643>
- ICMBio (2015) Chico Mendes de Conservação da Biodiversidade. Plano de manejo para Parque Nacional do Caparaó. Agência Comunica, Brasília, 517 pp. URL: https://www.icmbio.gov.br/parnacaparao/images/stories/Download/Plano_de_Manejo_09_2019/PlanoManejo_PNC_completo_atualizado_Portaria_478_de_09_setembro_de_2019.pdf

- Leoni LS, Chautems A (2004) Flora Fanerogâmica do Parque Nacional do Caparaó: Gesneriaceae. *Pabstia* 15 (3): 1-11.
- Leoni LS (2009a) Flora Fanerogâmica do Parque Nacional do Caparaó: Hypoxidaceae. *Pabstia* 20 (2): 2-4.
- Leoni LS (2009b) Flora Fanerogâmica do Parque Nacional do Caparaó: Droseraceae. *Pabstia* 20 (2): 5-7.
- Machado TM, Forzza RC, Stehmann JR (2016) Bromeliaceae from Caparaó National Park, Minas Gerais/Espírito Santo States, Brazil, with notes on distribution and conservation. *Oecologia Australis* 20 (02): 271-284. <https://doi.org/10.4257/oeco.2016.2002.10>
- Maldonado C, Molina C, Zizka A, Persson C, Taylor C, Albán J, Chilquillo E, Rønsted N, Antonelli A (2015) Estimating species diversity and distribution in the era of Big Data: to what extent can we trust public databases? *Global Ecology and Biogeography* 24 (8): 973-984. <https://doi.org/10.1111/geb.12326>
- Marques MC, Grelle CE (2020) The Atlantic Forest: History, biodiversity, threats and opportunities of the mega-diverse forest. Springer, 588 pp.
- Martinelli G, Valente AS, Maurenza D, Kutschenko DC, Judice DM, Silva DS, Fernandez EP, Martins EM, Barros FS, Sfair JC, Santos Filho LA, Abreu MB, Moraes MA, Monteiro NP, Pietro PV, Fernandes RA, Hering RL, Messina T, Penedo TS (2013) Avaliações de risco de extinção de espécies da flora brasileira. In: Jakobsson A (Ed.) Livro Vermelho da Flora do Brasil. 1. Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, Rio de Janeiro.
- Massart J, Bouillenne R, Brien P, Ledoux P, Navez A (1929) Une mission biologique Belge au Brésil (Août 1922 - Mai 1923). Tome I. Imprimerie Medicale et Scientifique (S. A.), Bruxelles, 67 pp., 549 figs pp.
- Mazine FF, Souza VC (2008) Myrtaceae dos campos de altitude do Parque Nacional do Caparaó - Espírito Santo/Minas Gerais, Brasil. *Rodriguésia* 59 (1): 57-74. <https://doi.org/10.1590/2175-7860200859102>
- MMA (2020) Unidades de Conservação - Mata Atlântica. Ministério do Meio Ambiente. <http://www.icmbio.gov.br/portal/unidadesdeconservacao/biomasbrasileiros/mataatlantica/unidades-de-conservacao-mata-atlantica>. Accessed on: 2020-8-11.
- Nualart N, Ibáñez N, Soriano I, López-Pujol J (2017) Assessing the Relevance of Herbarium Collections as Tools for Conservation Biology. *The Botanical Review* 83 (3): 303-325. <https://doi.org/10.1007/s12229-017-9188-z>
- Oliveira U, Paglia AP, Brescovit A, de Carvalho CB, Silva DP, Rezende D, Leite FSF, Batista JAN, Barbosa JPPP, Stehmann JR, Ascher J, de Vasconcelos MF, De Marco P, Löwenberg-Neto P, Dias PG, Ferro VG, Santos A (2016) The strong influence of collection bias on biodiversity knowledge shortfalls of Brazilian terrestrial biodiversity. *Diversity and Distributions* 22 (12): 1232-1244. <https://doi.org/10.1111/ddi.12489>
- Oliveira U, Soares-Filho BS, Paglia AP, Brescovit A, de Carvalho CB, Silva DP, Rezende D, Leite FSF, Batista JAN, Barbosa JPPP, Stehmann JR, Ascher J, de Vasconcelos MF, De Marco P, Löwenberg-Neto P, Ferro VG, Santos A (2017) Biodiversity conservation gaps in the Brazilian protected areas. *Scientific Reports* 7 (1). <https://doi.org/10.1038/s41598-017-08707-2>
- Oliveira U, Soares-Filho BS, Santos A, Paglia AP, Brescovit A, de Carvalho CB, Silva DP, Rezende D, Leite FSF, Batista JAN, Barbosa JPPP, Stehmann JR, Ascher J, Vasconcelos M, Marco PD, Löwenberg-Neto P, Ferro VG (2019) Modelling Highly

- Biodiverse Areas in Brazil. *Scientific Reports* 9 (1). <https://doi.org/10.1038/s41598-019-42881-9>
- R Development Core Team (2019) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL: <http://www.Rproject.org>
 - Rezende CL, Scarano FR, Assad ED, Joly CA, Metzger JP, Strassburg BB, Tabarelli M, Fonseca GA, Mittermeier RA (2018) From hotspot to hopespot: An opportunity for the Brazilian Atlantic Forest. *Perspectives in Ecology and Conservation* 16 (4): 208-214. <https://doi.org/10.1016/j.pecon.2018.10.002>
 - Rodrigues MT, Cassimiro J, Pavan D, Curcio FF, Verdade VK, Pellegrino KC (2009) A new genus of Microtidi lizard from the Caparaó mountains southeastern Brazil, with a discussion of relationships among Gymnophthalminae (Squamata). *American Museum Novitates* (3673)1-27.
 - Romão GO, Souza VC (2003) Flora Fanerogâmica do Parque Nacional do Caparaó: Ericaceae. *Pabstia* 14 (1): 1-12.
 - Santos EM (2004) Parque Nacional do Caparaó: histórias de um lugar. *HALAC* (3)117-143.
 - Souza JP, Souza VC (2002) Flora fanerogâmica do Parque Nacional do Caparaó: Plantaginaceae. *Pabstia* 13 (2): 1-5.
 - Thiers B (2020) Index Herbariorum: a global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. Continuously updated. <http://sweetgum.nybg.org/science/ih/>. Accessed on: 2020-7-15.
 - Tuler AC, Leite FT, Verdi M (2019) Gimnospermas ameaçadas de extinção no estado do Espírito Santo. In: Fraga CN, Formigoni MH, Chaves FG (Eds) *Fauna e flora ameaçadas de extinção no estado do Espírito Santo*. Instituto Nacional da Mata Atlântica, Santa Teresa, 136-149 pp.

Supplementary material

Suppl. material 1: List of plants occurring in the "Parque Nacional do Caparaó" providing information on the number of specimens per species in the database, presence of single records, presence of old records, origin (native vs. non-native), endemism in Brazil, species occurrence in the Atlantic Forest, Phytogeographic domain, endemism in Atlantic Forest, Threat category according to CNCFLORA, Threat category (CR, EN or VU) according to the lists of Espírito State, Threat category (CR, EN or VU) according to the lists of Minas Gerais State and species occurrence in the list of Dutra et al. 2015. No information = indicates that data is lacking for that species. [doi](#)

Authors: Moreira et al.

Data type: Inventory regional

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