



Floristic survey of vascular plants of a poorly known area in the Brazilian Atlantic Forest (Flona do Rio Preto, Espírito Santo)

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Abstract

Background

The Atlantic Forest is one of the most threatened biomes in the world. Despite that, this biome still includes many areas that are poorly known floristically, including several protected areas, such as the "Floresta Nacional do Rio Preto" ("Flona do Rio Preto"), located in the Brazilian State of Espírito Santo. This study used a published vascular plant species list for this protected area from the "Catálogo de Plantas das Unidades de Conservação do Brasil" as the basis to synthesise the species richness, endemism, conservation and new species occurrences found in the "Flona do Rio Preto".

New information

The published list of vascular plants was based on field expeditions conducted between 2018 and 2020 and data obtained from herbarium collections available in online databases. Overall, 722 species were documented for the "Flona do Rio Preto", 711 of which are native to Brazil and 349 are endemic to the Atlantic Forest. In addition, 60 species are geographically disjunct between the Atlantic and the Amazon Forests. Most of the documented species are woody and more than 50% of these are trees. Twenty-three species are threatened (CR, EN and VU), while five are Data Deficient (DD). Thirty-two species are new records for the State of Espírito Santo. Our results expand the knowledge of the flora of the Atlantic Forest and provide support for the development of new conservation policies for this protected area.

Keywords

conservation, endemism, new records, threatened species

Introduction

The Atlantic Forest houses one of the highest levels of species diversity and endemism in Brazil (Werneck et al. 2011). Despite that, the Atlantic Forest has been reduced to small and disconnected forest remnants, with only ca. 28% of its original forest cover remaining, of which less than half are protected (Rezende et al. 2018).

Unique in its occupation history, the State of Espírito Santo is completely inserted within the Atlantic Forest and exhibits, from the coast to the mountains, contrasting vegetation types (Dutra et al. 2015). Garbin et al. (2017) described the vision of many naturalists who passed through Espírito Santo in the 19th and early 20th centuries, providing a nice historical overview for the State. These naturalists highlighted the exuberance and distinction between the vegetation located in the southern and northern portions of the Doce River.

Six vegetation types are recognised in Espírito Santo: (i) dense and open ombrophilous forests, (ii) seasonal semi-deciduous forests, (iii) savannahs, (iv) "restingas", (v) mangroves and (vi) ecological refuges (Garbin et al. 2017). These vegetation types are distributed through two main geological zones (IPEMA 2005): A central-southern zone comprising deep montane valleys and a central-northern zone with "tabuleiro" forests. This vegetation mosaic is part of the "Corredor Central da Mata Atlântica" (Aguiar and Marques 2001), one of the regions with highest plant endemism in Brazil (Prado et al. 2003, Ayres et al. 2005, IPEMA 2005).

Floristic inventories were produced for the State of Espírito Santo during the last 30 years (e.g. Peixoto and Gentry 1990, Peixoto et al. 2008, Thomaz 2010, Rolim et al. 2016). The most comprehensive checklist of the angiosperms for the Espírito Santo was produced, based on a synthesis of online data (Dutra et al. 2015). These efforts resulted in the publication of several taxonomic and floristic studies for selected plant families in subsequent years (e.g. Luber et al. 2016, Pena and Alves-Araújo 2017, Silva et al. 2017, Chagas et al. 2017, Souza et al. 2017, Araújo et al. 2018, Torres-Leite et al. 2018, Moreira et al. 2020a, Moreira et al. 2020b). Despite that, the State includes multiple knowledge gaps and botanical data remain scattered (Garbin et al. 2017). A full understanding of the forest dynamics of Espírito Santo depends on more detailed floristic inventories and vegetation data for the State. Information of this nature is crucial to fill knowledge gaps and establish sound conservation policies.

The "Catálogo de Plantas das Unidades de Conservação do Brasil" (<https://catalogo-ucs-brasil.jbrj.gov.br/>) was launched online in 2018 to contribute to the knowledge of the Brazilian protected areas. This digital platform provides comprehensive lists of land plants from the Brazilian protected areas, providing information about species correct names,

conservation status, native/non-native status and digital images. The catalogue currently contains plant lists from 18 conservation units located in different Brazilian phytogeographic domains (e.g. Caatinga, Cerrado, Atlantic Forest and Amazon). The checklist of the vascular plants of the "Parque Nacional do Itatiaia" (Carrijo et al. 2018, Moreira et al. 2020a) and "Parque Nacional do Caparaó" (Moreira et al. 2020b, Carrijo et al. 2021) were the first to be launched, while the checklist of the vascular plants of the "Flona do Rio Preto" was recently added (Carrijo et al. 2021).

The "Flona do Rio Preto" was officially created in 1990 and is located in the northern portion of Espírito Santo (IBGE 2012). This protected area is mainly covered by dense ombrophilous lowland forest (IBGE 2012), despite the vegetation from the northern Espírito Santo having been classified as seasonal evergreen forest (Rolim et al. 2016). Historically, the area has undergone loss of natural vegetation due to anthropogenic disturbances, such as logging, grazing and fires, followed by the cultivation of *Eucalyptus* and sugar cane (Souza and Resende 1999). Despite these threats, the "Flona do Rio Preto" still offers good quality environments and floristic integrity. However, information about the local flora is restricted to the first forest inventory which focused on the documentation of woody trees and climbers (Souza and Resende 1999). Therefore, the vascular plant richness and composition of this protected area is still underestimated, especially due to a lack of documentation of herbaceous and shrubby species. Here, we summarise the information from a recent inventory (Carrijo et al. 2021) and present information about species richness, endemism, conservation and new species records from the "Flona do Rio Preto."

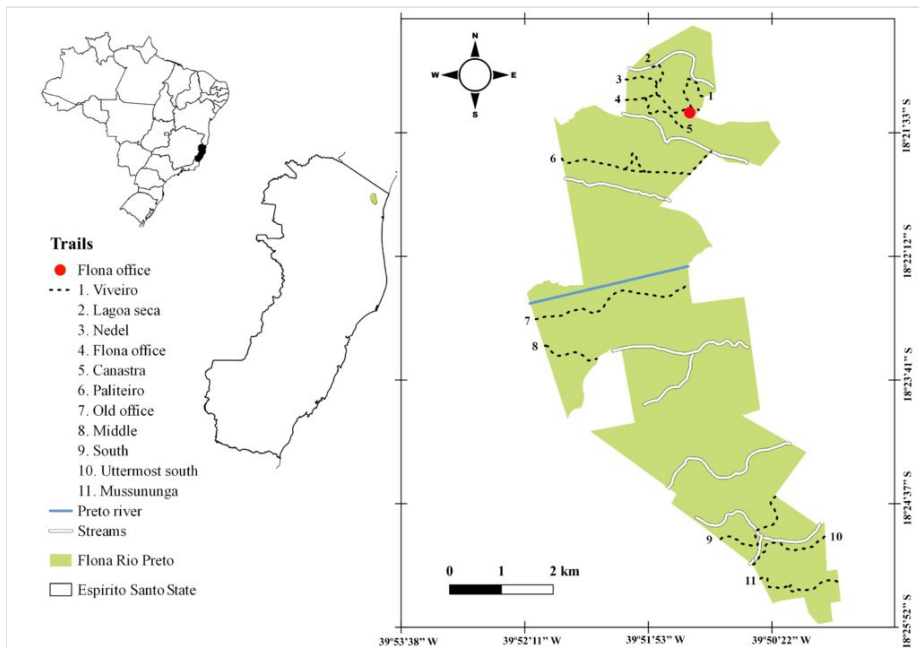


Figure 1. [doi](#)

Map showing the location of the "Flona do Rio Preto," Espírito Santo, Brazil.



Figure 2.

Phytophysiognomies of the "Flona do Rio Preto," Brazil. Photos by SGV/UFES.

a: Seasonally flooded open field [doi](#)

b: Campos nativos' [doi](#)

c: Non-floodable forest [doi](#)

d: Seasonally flooded forest [doi](#)

e: Mussununga [doi](#)

f: Flooding swampy area. [doi](#)

Sampling methods

Study extent: During this project, we undertook field expeditions to the "Flona do Rio Preto" fortnightly or monthly, from March 2018 to February 2020. Sampling covered all physiognomies (Fig. 1) and was conducted by walking randomly across trails (Fig. 2). Collected materials were dried following standard methods for plant taxonomy (Peixoto and Maia 2013) and deposited at the Herbarium VIES (acronym from Thiers 2021), where samples were also digitised.

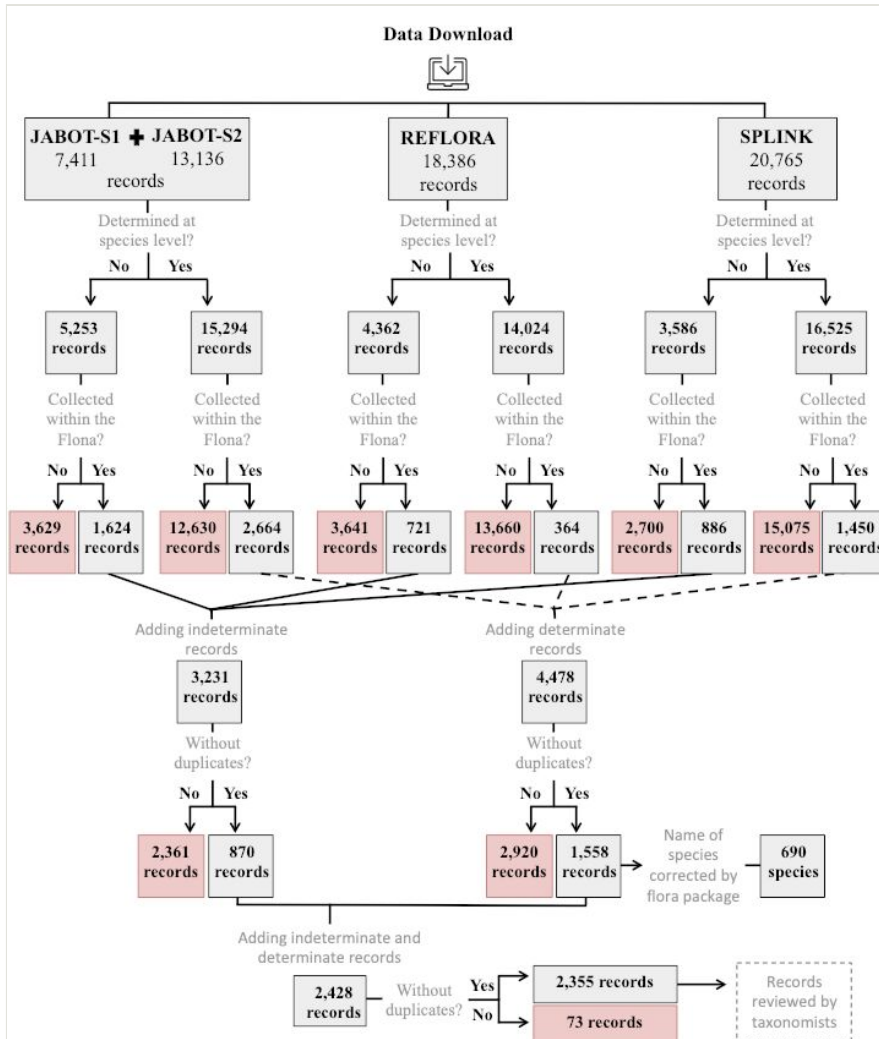


Figure 3. doi

Stages of data cleaning performed in R software to obtain a list of vascular plant species of the "Flona do Rio Preto," Brazil. Specimens kept on the list are shown in grey; specimens removed from the list are shown in red.

In addition to the data collected in the field, we also downloaded information from three online databases: 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>) (Fig. 1) We performed searches in each database on 1 October 2020, using the following filters: **Search 1**: Locality = "Rio Preto" (JABOT = 7,411 specimens; REFLORA = 18,386; Splink = 20,765); and **Search 2**: Locality = "Conceição da Barra" (JABOT = 13,136 specimens). Together, these searches led to a total of 59,698 specimens (Fig. 3).

To obtain a list of species with currently accepted nomenclature, we manually selected all specimens identified to the species level, which led to the following: **Search 1**: JABOT determined = 5,237, undetermined = 2,174; REFLORA determined = 14,024, undetermined = 4,362; and Splink determined = 16,525, undetermined = 3,586; **Search 2**: JABOT determined = 10,057, undetermined = 3,079 (Fig. 3). We then selected specimens for which the localities fall within the area covered by the "Flora do Rio Preto" and removed duplicates, based on the catalogue code, collector name and number and the year when the sample was collected (Fig. 3). For the list of determined specimens, we corrected and updated species names using the function *get.taxa* from the package *flora* (Carvalho 2017) in R 4.0.2 (R Development Core Team 2019). This function compared the names in our list with those from the Flora do Brasil 2020 (<http://floradobrasil.jbrj.gov.br>). After these corrections, we had taxonomists check a preliminary list with 690 determined species (1,558 specimens) and 870 undetermined specimens using images available from online databases (Fig. 3). When a taxonomist modified a plant species name, at least one specimen of that species was updated in the REFLORA database, but not in Splink. Intraspecific taxonomic categories or hybrids were not considered. The final list was published by Carrijo et al. (2021) and is available at (<https://catalogo-ucs-brasil.jbrj.gov.br/>).

Life forms

We obtained information on life forms from the Flora do Brasil 2020 (<http://floradobrasil.jbrj.gov.br>) through the function *get_lifeform* of the *flora* package (Carvalho 2017). Considering that the Flora do Brasil 2020 indicated more than one life form for several species, we conducted searches using three categories: (i) woody species (trees, shrubs and subshrubs, excluding climbers); (ii) herbaceous species (including palms and excluding climbers); and (iii) climbers (woody and/or herbaceous). When species were simultaneously assigned as a "climber" and "shrub" in the database, we chose to classify them as a "shrub" since "scandent shrubs" are often mistakenly treated as "climbers." As far as substrates are concerned, plants were classified as aquatic, epiphytic, hemiepiphytic, hemiparasitic, mycoheterotrophic or terrestrial.

Endemic and threatened species

We classified all species as native or non-native and endemic or non-endemic to Brazil using information from the Flora do Brasil 2020 (<http://floradobrasil.jbrj.gov.br>). Threat categories were assigned according to the Brazilian National Red List (CNCFlora; <http://www.cncflora.jbrj.gov.br/portal>). For binomials not included in the Flora do Brasil

2020, their native/non-native or endemic/non-endemic status was obtained from taxonomists and experts in those groups. We considered as non-native all species indicated as cultivated or naturalised within the Flora do Brasil 2020 (<http://floradobrasil.jbrj.gov.br>). We classified species as endemic to the Atlantic Forest when their distribution was classified as restricted to this phylogeographic domain in the Flora do Brasil 2020 (<http://floradobrasil.jbrj.gov.br>). We obtained this information using the function `get_domains` of the flora package (Carvalho 2017).

Geographic coverage

Description: The "Floresta Nacional do Rio Preto" ("Flona do Rio Preto") is located in the Municipality of Conceição da Barra, in the northern portion of the Brazilian State of Espírito Santo (ES), in south-eastern Brazil (Souza and Resende 1999) (Fig. 2). This protected area encompasses approximately 2,830 ha and includes different vegetation types (see Garbin et al. 2017), namely: (i) seasonally flooded open field, (ii) native fields (in Portuguese, "Campo nativo"), (iii) non-floodable forests, (iv) seasonally flooded forests, (v) "Mussununga" and (vi) seasonally flooded swampy areas (Fig. 1). The climate is tropical Aw (rainy tropical; Álvares et al. 2013), with total annual rainfall between 1,210 mm and 1,259 mm and an average annual temperature of 22°C or higher (Souza and Resende 1999).

Coordinates: -18.445 and -18.342 Latitude; -39.874 and -39.817 Longitude.

Taxonomic coverage

Description: The list of vascular plants of the "Flona do Rio Preto" contains a total of 722 species (683 angiosperms, 38 ferns and one lycophyte) belonging to 425 genera (398 angiosperms, 26 ferns and one lycophyte) and 126 families (111 angiosperms, 14 ferns and one lycophyte). We found no records for gymnosperms at the study site during fieldwork nor in the online databases.

The vascular plant list of the "Flona do Rio Preto" exhibits levels of taxonomic richness that are similar to those documented in other floristic inventories conducted in the northern portions of Espírito Santo. For example, a study conducted in an area of alluvial floodplain of the Doce River found 408 angiosperm species (Rolim et al. 2016), while the plant list of the "Reserva Natural da Vale" listed 2,095 vascular plant species (1,999 angiosperms, 93 ferns and three lycophytes) (Rolim et al. 2016, Sylvestre et al. 2016). The "Reserva Natural da Vale" encompasses an area of 23,000 ha, representing one of the largest conservation units within the Atlantic Forest (Rolim et al. 2016).

Overall, the "Flona do Rio Preto" houses approximately 11% of the vascular plants that occur in Espírito Santo (Flora do Brasil 2020). The richest plant families in the "Flona do Rio Preto" are Fabaceae, Rubiaceae, Bignoniaceae, Myrtaceae, Asteraceae, Sapotaceae, Melastomataceae, Apocynaceae, Sapindaceae, Euphorbiaceae, Poaceae,

Lauraceae, Malpighiaceae and Malvaceae, respectively (Fig. 4). These families comprise 50% (i.e. 363 spp.) of all species found in the area. Forty-two families are represented by a single species. These findings are consistent with floristic inventories conducted in other forests remnants located in the Brazilian States of Espírito Santo and Bahia (Paula 2006, Amorim et al. 2008, Siqueira et al. 2014, Rolim et al. 2016), where the same richest families are generally documented. Despite the high floristic similarity documented in those inventories, only four species of Orchidaceae were found in the "Flona do Rio Preto," contrasting with the 103 spp. of Orchidaceae documented by Rolim et al. (2016). The low number of orchid species documented might be due to a shorter sampling period, incipient sampling efforts for epiphytes, in general, at the "Flona do Rio Preto," differences in climatic conditions or even the historical conservation of the "Flona do Rio Preto."

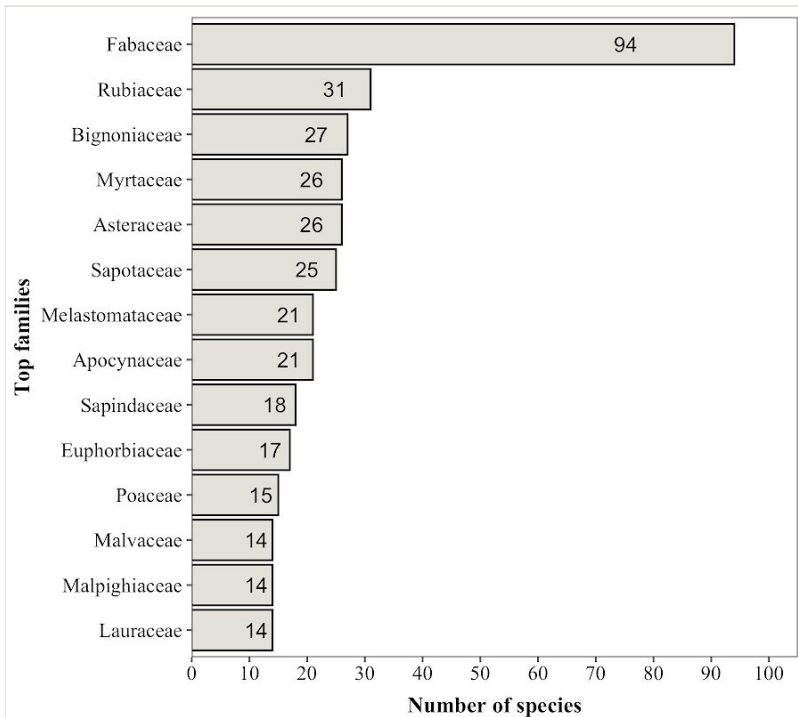


Figure 4. [doi](#)

Richest families of major groups of plants recorded in the "Flona do Rio Preto," Brazil. Values inside bars indicate species numbers.

Traits coverage

Life forms

In total, 447 species (61.9%) occurring in the "Flona do Rio Preto" are woody (trees, shrubs and subshrubs, excluding climbers), of which 219 are trees. Herbs (excluding

climbing plants) are represented by 164 species (22.7%) and climbers (herbaceous or woody) are composed of 111 species (15.4%). The richest woody families are Fabaceae (82 spp.), Myrtaceae and Rubiaceae (26 spp. each), Sapotaceae (25 spp.), Melastomataceae (18 spp.) and Lauraceae (14 spp.). The richest families of herbs are Poaceae (15 spp.), Marantaceae (13 spp.), Arecaceae (9 spp.), Asteraceae (8 spp.) and Cyperaceae (7 spp.). The most diverse liana families are Bignoniaceae (19 spp.), Fabaceae (12 spp.), Apocynaceae (11 spp.), Passifloraceae (10 spp.), Malpighiaceae and Sapindaceae (9 spp. each). In total, 682 species (94.5%) are terrestrial, followed by aquatic, epiphytes, hemi-epiphytes, mycoheterotrophic plants and hemiparasites which together comprise 40 species (5.5%). Bromeliaceae (8 spp.) and Cyperaceae (3 spp.) emerged as the richest families amongst epiphytes and aquatic plants, respectively.

Endemic and threatened species

The list of the "Flona do Rio Preto" includes 711 native and 11 non-native species to Brazil. Some non-native species were found in the "Flona do Rio Preto," but were not included in the final list because no herbarium records were found, such as *Mangifera indica* L. (Anacardiaceae); *Cocos nucifera* L. (Arecaceae); *Terminalia catappa* L. (Combretaceae); *Acacia mangium* Willd. and *Acacia auriculiformis* A.Cunn. ex Benth. (Fabaceae); *Artocarpus heterophyllus* Lam. (Moraceae); *Eucalyptus* L'Hér. spp., *Psidium guajava* L., *Syzygium cumini* (L.) Skeels and *Syzygium malaccense* (L.) Merr. & L.M.Perry (Myrtaceae). Despite that, we highlight the occurrence of these taxa in the "Flora do Rio Preto" as the occurrence of these species represents important information for the establishment of sound management policies (Moro et al. 2012). Amongst the species recorded at the "Flona do Rio Preto," 349 are endemic (Figs 5, 6, 7) and 373 are non-endemic to Brazil. Furthermore, 253 species are endemic to the Brazilian Atlantic Forest, while 464 are non-endemic to this biome.

Thirty-five percent of the species that occur in the "Flona do Rio Preto" are endemic to the Atlantic Forest. Another 60 species that occur in the studied area (8.3%) have a known geographical distribution that is disjunct between the Atlantic and Amazon Forests. Amongst the plant families with the highest number of Amazon-Atlantic Forest disjunct species are the Fabaceae (6 spp.), Pteridaceae (6 spp.), Sapindaceae (4 spp.), Euphorbiaceae (3 spp.) and Moraceae (3 spp.). In addition, 46 of the species recorded in the "Flona do Rio Preto" are disjunctly distributed between the Atlantic Forest and the Cerrado, while 17 species are disjunctly distributed between the Atlantic Forest and Caatinga. The remaining 346 species (48%) are widely distributed throughout Brazil.

Overall, the final list of vascular plants includes 55 species not cited in the Flora do Brasil 2020 for Espírito Santo (Suppl. material 1). Amongst these, 23 were listed in previous floristic studies carried out in Espírito Santo (Dutra et al. 2015, Souza et al. 2016) (Suppl. material 1). Therefore, 32 species, belonging to 29 genera and 22 families, represent new records for the State (Suppl. material 1).

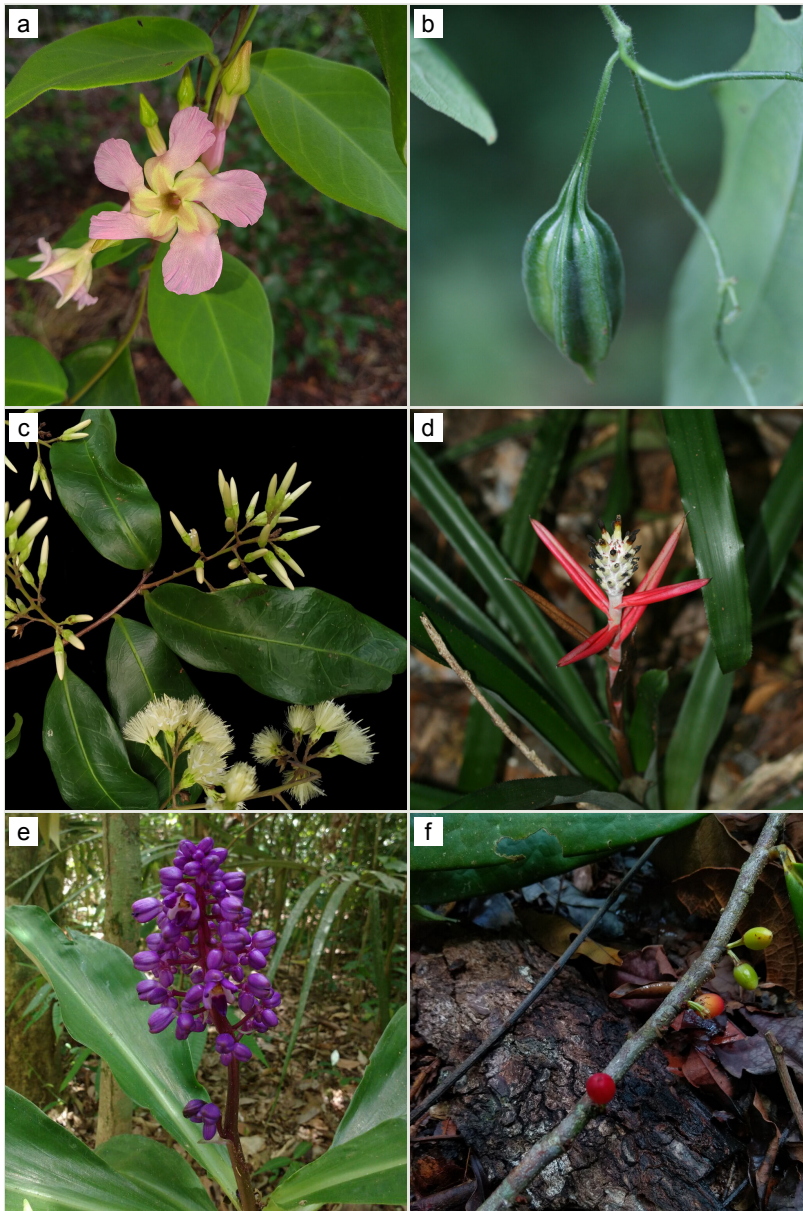


Figure 5.

Brazilian endemic species recorded in the "Flona do Rio Preto". Photos by SGV/UFES.

- a: *Temnadenia odorifera* (Apocynaceae) [doi](#)
 b: *Aristolochia pubescens* (Aristolochiaceae) [doi](#)
 c: *Stifftia hatschbachii* (Asteraceae) [doi](#)
 d: *Aechmea maasii* (Bromeliaceae) [doi](#)
 e: *Dichorisandra procera* (Commelinaceae) [doi](#)
 f: *Erythroxylum columbinum* (Erythroxylaceae). [doi](#)

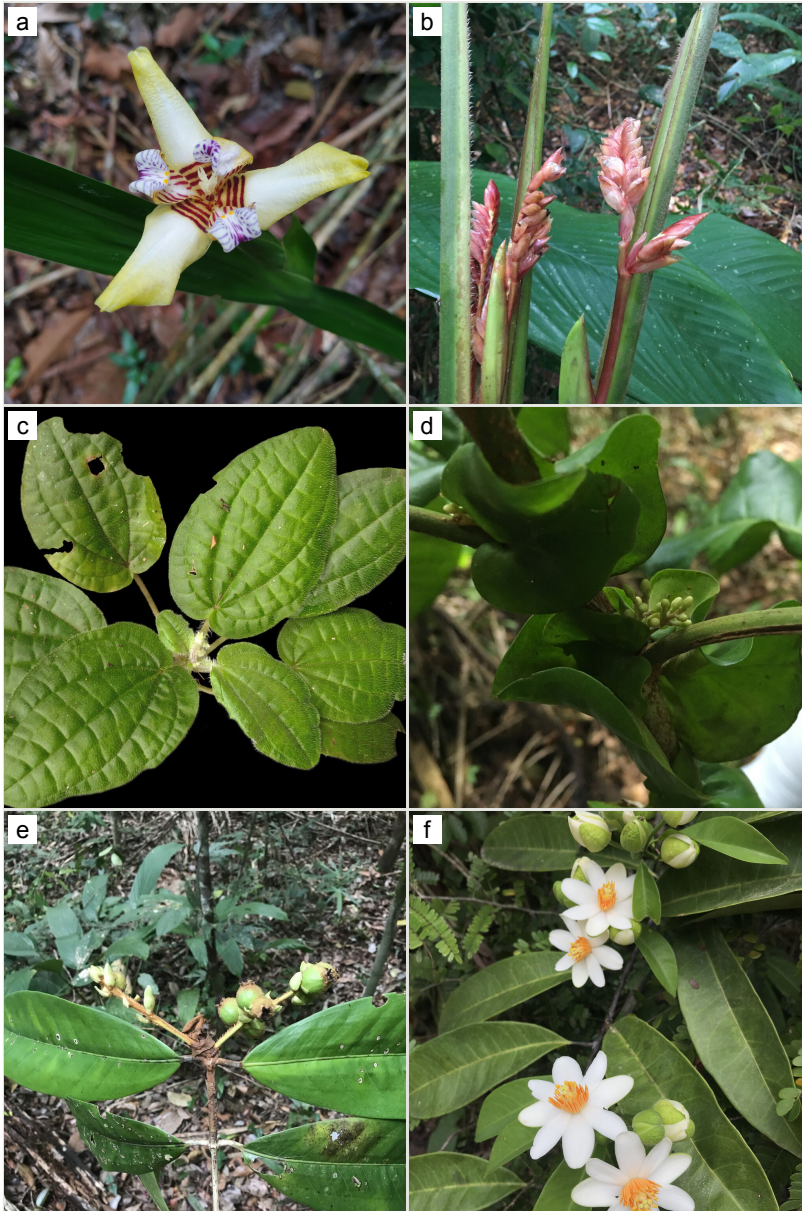


Figure 6.

Brazilian endemic species recorded in the "Flona do Rio Preto". Photos by SGV/UFES.

- a: *Neomarica kollmannii* (Iridaceae) [doi](#)
 b: *Saranthe composita* (Marantaceae) [doi](#)
 c: *Bertolonia maculata* (Melastomataceae) [doi](#)
 d: *Trichilia pseudostipularis* (Meliaceae) [doi](#)
 e: *Myrcia sucrei* (Myrtaceae) [doi](#)
 f: *Mitostemma glaziovii* (Passifloraceae). [doi](#)

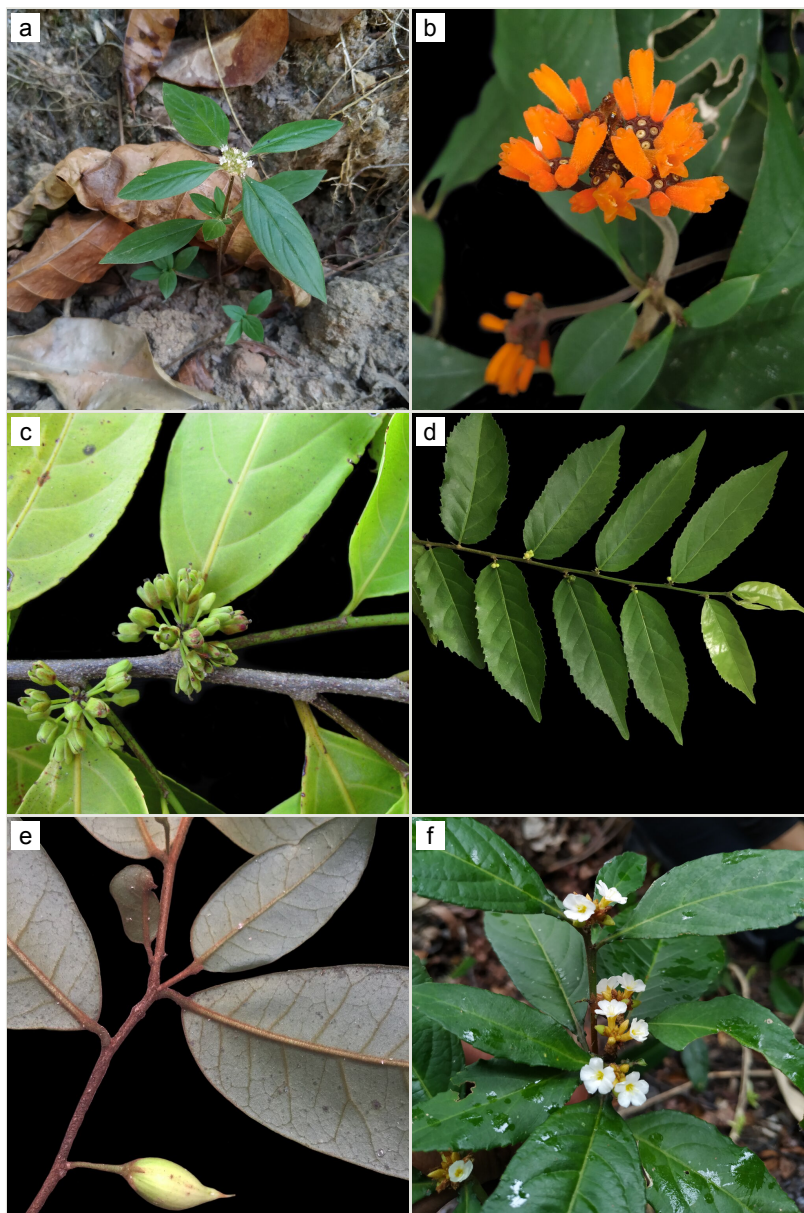


Figure 7.

Brazilian endemic species recorded in the "Flona do Rio Preto". Photos by SGV/UFES.

- a: *Borreria cupularis* DC. (Rubiaceae) [doi](#)
 b: *Palicourea fulgens* (Müll.Arg.) Standl. (Rubiaceae) [doi](#)
 c: *Casearia arborea* (Rich.) Urb. (Salicaceae) [doi](#)
 d: *Casearia souzae* R. Marquete & Mansano (Salicaceae) [doi](#)
 e: *Chrysophyllum lancisepalum* R.Lima (Sapotaceae) [doi](#)
 f: *Oxossia spicata* (L.Rocha & Arbo) L.Rocha (Turneraceae). [doi](#)

Based on the Brazilian National Red List, the "Flona do Rio Preto" includes 76 species considered as Least Concern (LC), 11 as Endangered (EN), 11 as Vulnerable (VU), 12 as Near Threatened (NT), one as Critically Endangered (CR) and five as Data Deficient (DD). In other words, the "Flona do Rio Preto" houses 23 threatened species (CR, EN and VU) and five Data Deficient species (Table 1, Figs 5c, 6b, 7b, f). These species belong to 15 families, with Sapotaceae including the highest number of threatened species (7 spp.) followed by Chrysobalanaceae, Fabaceae (3 spp.), Rubiaceae (3 spp.) and Bignoniaceae (2 spp.); ten other families included one threatened species (Table 1). In total, 606 species (84%) that occur in the "Flona do Rio Preto" have not been evaluated by the Brazilian National Red List.

Table 1.

Threatened and Data Deficient species of plants occurring in "Flona do Rio Preto," Brazil with their respective groups, families and Red List category according to the Brazilian National Red List - CNCFLORA (CR = Critically Endangered, VU = Vulnerable, EN = Endangered and DD = Data Deficient).

Species	Red List category
Angiosperms	
Acanthaceae	
<i>Stenostephanus lobeliiformis</i> Nees	DD
Arecaceae	
<i>Euterpe edulis</i> Mart.	VU
Asteraceae	
<i>Piptocarpha robusta</i> G.M.Barroso	EN
Bignoniaceae	
<i>Handroanthus arianae</i> (A.H.Gentry) S.O.Grose	EN
<i>Handroanthus riocensis</i> (A.H.Gentry) S.O.Grose	EN
Burseraceae	
<i>Protium heptaphyllum</i> (Aubl.) Marchand	DD
Chrysobalanaceae	
<i>Couepia belemii</i> Prance	VU
<i>Couepia schottii</i> Fritsch	EN
<i>Exellodendron gracile</i> (Kuhlm.) Prance	EN
Fabaceae	
<i>Apuleia leiocarpa</i> (Vogel) J.F.Macbr.	VU
<i>Inga leptantha</i> Benth.	DD

Species	Red List category
<i>Melanoxylon brauna</i> Schott	VU
Lauraceae	
<i>Williamodendron cinnamomeum</i> van der Werff	CR
Lecythidaceae	
<i>Cariniana legalis</i> (Mart.) Kuntze	EN
Marantaceae	
<i>Sarantia composita</i> (Link) K.Schum.	VU
Meliaceae	
<i>Cedrela fissilis</i> Vell.	VU
Myristicaceae	
<i>Virola bicuhyba</i> (Schott ex Spreng.) Warb.	EN
Myrtaceae	
<i>Myrcia isaiana</i> G.M. Barroso & Peixoto	EN
Rubiaceae	
<i>Melanopsidium nigrum</i> Colla	VU
<i>Palicourea fulgens</i> (Müll.Arg.) Standl.	VU
<i>Standleya kuhlmanni</i> Brade	EN
Sapotaceae	
<i>Manilkara bella</i> Monach.	EN
<i>Manilkara elata</i> (Allemão ex Miq.) Monach.	DD
<i>Manilkara multifida</i> T.D.Penn.	VU
<i>Pouteria bullata</i> (S.Moore) Baehni	EN
<i>Pouteria coelomatica</i> Rizzini	VU
<i>Pouteria macrocarpa</i> (Mart.) D.Dietr.	VU
<i>Pradosia glaziovii</i> (Pierre) T.D.Penn.	DD

Temporal coverage

Notes: Temporal and spatial coverage

The taxonomists, associated with this project, verified a total of 1,959 specimens. These specimens are deposited in nine Brazilian Herbaria (BHCB, CEN, CESJ, ESA, HUEMG, RB, SAMES, VIC and VIES) with VIES hosting 80% (1,572) of these specimens (acronyms

follow Thiers 2021). The examined specimens were collected by thirty-four collectors, with R. Nichio-Amaral having collected the highest number of specimens (229 specimens), followed by A. Nepomuceno (179), B.N. Mello (175), A. Luiza (164), S.C. Dutra (153), B.G. Sossai (141), "Grupo de Coletores do Núcleo Juçara" (128), R.M. Oliveira (113), B.S. Mendes (93), V.S. Miranda (93) and A.F.A. Scheidegger (86).

Field sampling in the "Flona do Rio Preto" started in 1953, even before its creation and extended until 2020. The years of 2019 (1,015 specimens), 2018 (257 specimens), 2020 (184 specimens) and 1995 (156 specimens) were the most intensively sampled. Collections conducted between 2018 and 2020 highlight the importance of the project "Rediscovering species threatened with extinction: Basis for management and information access," for increased knowledge about the flora of the "Flona do Rio Preto."

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Data resources

Data package title: Floristic survey of vascular plants of a poorly known area in the Brazilian Atlantic Forest (Flona do Rio Preto, Espírito Santo)

Resource link: <https://doi.org/10.5281/zenodo.5824423>

Number of data sets: 1

Data set name: lista-flona-rio-preto.tsv

Download URL: <https://zenodo.org/record/5824423/files/lista-flona-rio-preto.tsv?download=1>

Data format: tsv

Column label	Column description
fieldNotes	Name of the National Conservation Unit
Grupos	Taxonomic group
family	Botanical families names
genus	Botanical genus names
specificEpithet	Botanical species epithet names
scientificNameAuthorship	Species authors' names
scientificName (according to Flora do Brasil 2020)	Táxon according to Flora do Brasil 2020 project
barcode	Barcode of the specimen

Banco de Origem	Database of origin
otherCatalogNumbers	Catalogue number of the specimen
collectionCode	Acronym of the collection
recordedBy	Name of the specimen collector
recordNumber	Collector number

Additional information

Conclusions and prospects

The list of the vascular plants of the "Flona do Rio Preto" expands the knowledge of the flora of the Atlantic Forest and provides important data for the development of sound conservation policies. Our study documented 253 endemic Atlantic Forest taxa at the "Flona do Rio Preto" and 32 new records of angiosperms for the State of Espírito Santo. The small number of epiphytes found in the studied area suggests that the "Flona do Rio Preto" has a vegetation type that does not match an Ombrophilous Dense Forest, the phytophysognomy under which it was previously classified. The species list, provided here, contributes important information for an improved vegetation classification.

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References

- Aguiar A, Marques M (2001) Flora fanerogâmica do Parque Nacional do Caparaó: Polygalaceae. *Pabstia* 12 (3): 1-3.

- Álvares C, Stape J, Sentelhas P, Gonçalves J, Sparovek G (2013) Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift* 22 (6): 711-728. <https://doi.org/10.1127/0941-2948/2013/0507>
- Amorim A, Thomas W, Carvalho A, Jardim J (2008) Floristics of the Una Biological Reserve, Bahia, Brazil. *Memoirs of the New York Botanical Garden* 100: 67-146.
- Araújo E, Kunz S, Dias H, Carrijo T, Zorzanelli J (2018) Inventários florísticos na região do Caparaó Capixaba revelam novos registros para a flora do Espírito Santo. *Rodriguésia* 69: 1953-1963. <https://doi.org/10.1590/2175-7860201869429>
- Ayres J, Fonseca G, Rylands A, HL Q, Pinto L, Masterson D, Cavalcanti R (2005) Os corredores ecológicos das florestas tropicais do Brasil. Sociedade Civil Maminaurá, Belém, 256 pp. [ISBN 8585924128]
- Carrijo T, Alves-Araújo A, Amorim A, Barbosa D, Barcelos L, Baumgratz J, Bueno V, Coelho R, Costa D, Couto D, Delgado C, Dutra V, Flores T, Furtado S, Giacomini L, Goldenberg R, Gomes M, Gonzaga D, Guimarães E, Heiden G, Kameyama C, Labiak P, Lírio E, Lohmann L, Matos F, Moraes P, Meireles L, Menini-Neto L, Monteiro D, Moreira M, Morim M, Mota M, Oliveira J, Pastore J, Pederneiras L, Pereira L, Rapini A, Salimena F, Silva A, Silva-Neto S, Sobral M, Souza M, Sylvestre L, Trovó M, Viana P, Forzza R (2018) Lista de espécies de plantas terrestres do Parque Nacional do Itatiaia. *Catálogo de plantas das unidades de conservação do Brasil*. Jardim Botânico do Rio de Janeiro. <https://catalogo-ucs-brasil.jbrj.gov.br>
- Carrijo TT, Alves-Araújo AG, Moreira MM, Dutra VF, Salimena F, Lubner J, Amorim A, Antar GM, Asprino RC, Cardoso PH, Christ JA, Couto DR, Couto RS, Dutra SC, Firmino AD, Flores TB, Fraga FR, Freitas J, Giacomini LL, Goldenberg R, Hoyos-Gómez SE, Labiak PH, Lima DF, Lima HC, Lírio EJ, Lohmann LG, Magnago R, Manhães VC, Medeiros H, Melo A, Melo JI, Menini NL, Miranda VS, Monteiro D, Moraes PL, Moraes QS, Moreira AL, Morim MP, Nepomuceno A, Nichio-Amaral R, Pastore J, Paula-Souza J, Pederneiras LC, Pena NT, Pinto LJ, Ramos E, Ribeiro M, Scheidegger AF, Shimizu GH, Silva C, Sossai BG, Torres-Leite F, Trovó M, Tuler AC, Viana PL, Vieira TA, Zorzanelli JP, Forzza RC (2021) Lista de espécies de plantas terrestres da Flona do Rio Preto. *Catálogo de plantas das unidades de conservação do Brasil*. Jardim Botânico do Rio de Janeiro. <https://catalogo-ucs-brasil.jbrj.gov.br>
- Carvalho G (2017) Flora: Tools for interacting with the Brazilian flora 2020. R package version 0.3.0. URL: <https://cran.r-project.org/web/packages/flora/index.html>
- Chagas AP, Dutra VF, Garcia FC (2017) Flora do Espírito Santo: Ingeae Benth. (Leguminosae): parte 1. *Rodriguésia* 68: 1613-1631. <https://doi.org/10.1590/2175-7860201768508>
- 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>
- Flora do Brasil 2020 (2020) <http://floradobrasil.jbrj.gov.br/>. Accessed on: 2021-3-18.
- Garbin ML, Saiter FZ, Carrijo TT, Peixoto AL (2017) Breve histórico e classificação da vegetação capixaba. *Rodriguésia* 68 (5): 1883-1894. <https://doi.org/10.1590/2175-7860201768521>
- IBGE (2012) Manual técnico da vegetação brasileira - Série manuais técnicos em geociências. 2. Instituto Brasileiro de Geografia e Estatística, Rio de Janeiro, 275 pp.
- IPEMA (2005) Conservação da Mata Atlântica no Estado do Espírito Santo: cobertura florestal e unidades de conservação. IPEMA, Vitória, 152 pp.

- Luber J, Tuler A, Torres-Leite F, Christ JA, Martins KG, Zanetti M, Holunder RK, Manhes VC, Zorzanelli JP, Mendona ES, Garbin ML, Carrijo TT (2016) List of angiosperm species in an Atlantic Forest fragment reveals collection gaps in Espírito Santo state, Brazil. *Check List* 12 (1835).
- Moreira MM, Carrijo TT, Alves-Araújo A, Amorim AM, Rapini A, Silva AV, Cosenza BA, Lopes CR, Delgado CN, Kameyama C, Couto DR, Barbosa DE, Monteiro D, Gonzaga DR, Dalcin EC, Guimares EF, Lirio EJ, Matos FB, Salimena FR, Oliveira FA, Heiden G, Lanna JM, Baumgratz JF, Pastore JF, Oliveira JR, Barcelos LB, Sylvestre LS, Freitas L, Giacomini LL, Pederneiras L, Meireles LD, Lohmann LG, Pereira LC, Silva LA, Neto LM, Souza MC, Trov M, Sobral ME, Garbin ML, Gomes M, Morim MP, Mota MC, Labiak PH, Viana PL, Moraes PL, Goldenberg R, Coelho RL, Furtado SG, Silva-Neto SJ, Flores TB, Dutra VF, Bueno VR, Forzza RC (2020a) Using online databases to produce comprehensive accounts of the vascular plants from the Brazilian protected areas: The Parque Nacional do Itatiaia as a case study. *Biodiversity Data Journal* 8: e50837. <https://doi.org/10.3897/BDJ.8.e50837>
- Moreira MM, Carrijo TT, Alves-Araújo A, Rapini A, Salino A, Firmino AD, Chagas AP, Versiane AF, Amorim AM, Silva AV, Tuler AC, Peixoto AL, Soares BS, Cosenza BA, Delgado CN, Lopes CR, Silva C, Barbosa DE, Monteiro D, Marques D, Couto DR, Gonzaga DR, Dalcin E, Lirio EJ, Meyer FS, Salimena FR, Oliveira FA, Souza FS, Matos FB, Depiantti G, Antar GM, Heiden G, Dias HM, Sousa HC, Lopes IT, Rollim IM, Luber J, Prado J, Nakajima JN, Lanna J, Zorzanelli JP, Freitas J, Baumgratz JF, Pereira JB, Oliveira JR, Antunes K, Sylvestre LS, Pederneiras LC, Freitas L, Giacomini LL, Meireles LD, Silva LN, Pereira LC, Silva LA, Neto LM, Monge M, Trov ML, Reginato M, Sobral ME, Gomes M, Garbin ML, Morim MP, Soares ND, Labiak PH, Viana PL, Cardoso PH, Moraes PL, Schwartsburd PB, Moraes QS, Zorzanelli RF, Nichio-Amaral R, Goldenberg R, Furtado SG, Feletti T, Dutra VF, Bueno VR, Dittrich VA, Forzza RC (2020b) A list of land plants of Parque Nacional do Caparaó, Brazil, highlights the presence of sampling gaps within this protected area. *Biodiversity Data Journal* 8: e59664. <https://doi.org/10.3897/BDJ.8.e59664>
- Moro MM, Souza VC, Oliveira-Filho AT, Queiroz LP, Fraga CN, Rodal MJ, Arajo FS, Martins FR (2012) Alienígenas na sala: o que fazer com espécies extintas em trabalhos de taxonomia, florística e fitossociologia? *Acta Botanica Brasílica* 26 (4): 991-999. <https://doi.org/10.1590/S0102-33062012000400029>
- Paula A (2006) Florística e fitossociologia de um trecho de floresta ombrófila densa das terras baixas na Reserva Biológicas de Sooretama, Linhares - ES. UFSCar, São Carlos-SP, 84 pp.
- Peixoto AL, Gentry AH (1990) Diversidade e composição florística da mata de tabuleiro na Reserva Florestal de Linhares (Espírito Santo, Brasil). *Revista Brasileira de Botânica* 13: 19-25.
- Peixoto AL, Silva IM, Pereira OJ, Simonelli M, Jesus RM, Rolim SG (2008) Tabuleiro forests north of the Rio Doce: their representation in the Vale do Rio Doce Natural Reserve, Espírito Santo, Brazil. *Memoirs of the New York Botanical Garden* 100: 319-350.
- Peixoto AL, Maia LC (Eds) (2013) *Manual de procedimentos para herbários*. Editora Universitária, UFPE, Recife. URL: http://inct.florabrasil.net/wpcontent/uploads/2013/11/Manual_Herbario.pdf

- Pena NT, Alves-Araújo A (2017) Angiosperms from rocky outcrops of Pedra do Elefante, Nova Venécia, Espírito Santo, Brazil. *Rodriguésia* 68: 1895-1905. <https://doi.org/10.1590/2175-7860201768522>
- Prado PI, Landau EC, Moura RT, Pinto LP, Fonseca GA, Alger K (2003) Corredor de biodiversidade na Mata Atlântica do Sul da Bahia. CD-ROM II. IESB/CII/ CABS/UFMG/ UNICAMP. Ilhéus
- 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/](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: 208-214. <https://doi.org/10.1016/j.pecon.2018.10.002>
- Rolim SG, Magnago LF, Saiter FZ, Amorim AM, Abreu KM (2016) São as florestas do norte do Espírito Santo e sul da Bahia as mais ricas em espécies arbóreas no domínio da Floresta Atlântica? In: Rolim S, Menezes L, Srbek-Araujo A (Eds) Floresta Atlântica de tabuleiro: Diversidade e endemismos na Reserva Natural Vale. 1. Editora Rupestre, Belo Horizonte-MG.
- Silva LA, Alves-Araújo A, Dutra VF (2017) Flora do Espírito Santo: Mimoseae (Leguminosae): parte 1. *Rodriguésia* 68: 1633-1661. <https://doi.org/10.1590/2175-7860201768509>
- Siqueira GS, Kierulff MC, Alves-Araújo A (2014) Florística das plantas vasculares da Reserva Natural Vale, Linhares, Espírito Santo, Brasil. *Ciência & Ambiente* 49: 67-129.
- Souza AL, Resende JL (1999) Plano de Manejo da Floresta Nacional do Rio Preto - ES. SIF/IBAMA, 126 pp.
- Souza W, Machado J, Tognella MM, Alves-Araújo A (2016) Checklist de angiospermas do Parque Estadual de Itaúnas, Espírito Santo, Brasil. *Rodriguésia* 67: 571-581. <https://doi.org/10.1590/2175-7860201667303>
- Souza W, Pena NT, Alves-Araújo A (2017) Macrófitas aquática do Parque Estadual de Itaúnas, Espírito Santo, Brasil. *Rodriguésia* 68: 1907-1919. <https://doi.org/10.1590/2175-7860201768523>
- Sylvestre L, Almeida T, Mynssen C, Salino A (2016) Samambaias e licófitas da Reserva Natural Vale, Linhares/ES. In: Rolim S, Menezes L, Srbek-Araujo A (Eds) Floresta Atlântica de tabuleiro: Diversidade e endemismos na Reserva Natural. 1. Editora Rupestre, Belo Horizonte-MG.
- Thiers B (2021) Index Herbariorum: a global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. <http://sweetgum.nybg.org/science/ih/>. Accessed on: 2020-7-15.
- Thomaz LD (2010) A Mata Atlântica no estado do Espírito Santo, Brasil: de Vasco Fernandes Coutinho ao século XXI. *Boletim do Museu de Biologia Mello Leito* 27: 5-20.
- Torres-Leite F, Holunder RK, Garbin ML, Carrijo TT (2018) Florística de Rubiaceae em um remanescente de Floresta Atlântica do Espírito Santo, Brasil. *Rodriguésia* 69: 561-576. <https://doi.org/10.1590/2175-7860201869222>
- Werneck M, Sobral M, Rocha C, Landau E, Stehmann J (2011) Distribution and Endemism of Angiosperms in the Atlantic Forest. *Natureza & Conservação* 9 (2): 188-193. <https://doi.org/10.4322/natcon.2011.024>

Supplementary material

Suppl. material 1: New records for the State of Espírito Santo [doi](#)

Authors: Alves-Araújo et al. (2021)

Data type: taxonomic

Brief description: List of new species records for the State of Espírito Santo (ES), according to Flora do Brasil 2020.

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