Vascular plants on inselberg landscapes in Espírito Santo state: bases for the creation of a protected area in southeastern Brazil

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ABSTRACT. Inselbergs are granitic or gneissic rocky outcrops prevalent in the landscape of southeastern Brazil. These ecosystems represent islands of isolated habitats that harbor a peculiar flora with high richness and endemism. The present study lists the species of vascular plants occurring in the Pedra da Andorinha Complex, located in the municipality of Jerônimo Monteiro/Cachoeiro de Itapemirim, southern Espírito Santo state, aiming to generate subsidies for the creation of a protected area. The survey was performed between July 2017 and October 2018, resulting in a record of 121 species, 96 genera, and 40 families. Bromeliaceae (17), Orchidaceae (12) and Fabaceae (10) were the richest families. The phytophytogeomorphology of exposed rock vegetation comprises a greater number of species (79 species) compared to the woody ripicolous communities (42). Eighteen of the collected species are threatened by extinction; a new species was discovered; and five were described based on materials previously collected in the studied location — Alcantarea patriae, Anthurium martinelli, Coleocephalocereus uebelmanniorum, Stigmatodon attenuoides and Pitcairnia azouryi, the first four being endemic to the region. We also found Tabebuia reticulata, a rare species among Brazilian flora. Our results highlight the biological importance of the Pedra das Andorinhas Complex and reinforce the need to create a protected area to preserve biodiversity and the regional natural heritage.

Keywords: Atlantic rainforest; conservation; rocky outcrops; taxonomy; vegetation island.

Introduction

In Atlantic Forest of southeastern Brazil occurs a special class of residual landforms, composed predominantly by plutonic (granite) and metamorphic (gneiss) rocks, that are ecologically known as inselbergs (from German, insel = island, berg = mountain). They can occur isolated or in groups, separated by a few or many kilometers, forming inselberg landscapes (Hmeljevski, Nazarenro, Bueno, Reis, & Forzza, 2017). These ecosystems differ greatly from the surrounding matrix, having unique edaphic-climatic characteristics that select for a specialized vegetation with high endemicity (see Safford & Martinelli, 2000; Porembski & Barthlott, 2000; Porembski, 2007; de Paula, Forzza, Neri, Bueno, & Porembski, 2016). However, inselberg flora is frequently overlooked in favor of other ecosystems of the Atlantic domain.

Southeastern Brazil is one of three important regions recognized globally as hotspots of plant diversity in inselberg ecosystems, alongside Madagascar and southwestern Australia (Porembski, 2007). In this context, it is worth mentioning that the inselbergs located in southern Espírito Santo, recognized for their significant biological importance, are a priority for floristic studies and ought to be prioritized for the creation of protected areas (Martinelli, 2007; Couto, Dias, Pereira, Fraga, & Pezzopane, 2016a; Couto, Francisco, Manhães, Machado, & Pereira, 2017; Kessous, Couto, Uribbe, & Costa, 2018).

Although inselbergs are not suitable for agriculture, and therefore escape its impacts, the mining industry poses the greatest threat to the flora of these environments worldwide (Porembski et al., 2016). Espírito Santo has a highly developed ornamental rock mining industry— one of the state’s main economic activities— and is among the world’s leaders in mineral exploration (Sardou Filho, Matos, Mendes, & Iza, 2013).
hand, mining is threatening the endemic and endangered flora of the region’s inselbergs. For any proposal of conservation, sustainable use, management, and restoration of inselberg ecosystems, knowledge of their biota is essential. Thus, there is an urgent need for studies on the biodiversity of these unique environments.

This study aimed to inventory the species of vascular plants that grow on the inselbergs of the Pedra das Andorinhas Complex. We aimed to contribute to the knowledge of inselberg flora in southeastern Brazil, and document the occurrence of endemic and endangered species, to support the creation of a protected area in the locality.

### Material and methods

#### Study site

The present study took place on private land (center point: 20° 47’ 24’’ S and 41° 23’ 19.6’’ W) between the municipalities of Cachoeiro de Itapemirim and Jerônimo Monteiro, southern state Espírito Santo, Brazil, in a region denominated by the Pedra das Andorinhas Complex (PAC) (Figure 1 and 2). Covering an area of approximately 360 ha, the study site features large rocky outcrops with patches of Submontane Seasonal Semideciduous Forest (Instituto Brasileiro de Geografia e Estatística [IBGE], 2012) at the base and summit, forming inselberg landscapes.

The PAC ranges from 150 to 500 m in elevation. It is surrounded by agricultural activities (cattle ranching and coffee, eucalyptus and orange plantations), mineral extraction and forest fragments. The climate has been classified as CwA, with dry winters and rainy summers, a mean annual temperature of about 24°C, and a mean annual rainfall of 1,450 mm (Couto et al., 2016b).

![Figure 1. Location of the study area Pedra das Andorinhas Complex, an inselberg landscape located in Jerônimo Monteiro and Cachoeiro de Itapemirim, Espírito Santo State, southeastern Brazil. 1 = Pedra das Andorinhas, 2 = Parada Cristal and 3 = Pedra Três Irmãs.](image)

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According to reports from local residents, the PAC has a history of bushfires (between 15 and 20 years ago) and some mineral exploration. The rocky complex consists of several inselbergs, which are generally difficult to access (Figure 2). In this study, we investigated three rock outcrops, one between Cachoeiro de Itapemirim/ Jerônimo Monteiro, known as Pedra das Andorinhas (1) (20° 46′ 19″ S; 41° 21′ 12″ W), and two others in Jerônimo Monteiro: Parada Cristal (2) (20° 47′ 39″ S; 41° 22′ 20″ W), Pedra Três Irmãs (3) (20° 46′ 19″ S; 41° 21′ 12″ W).

Data collection

Floristic surveys of the rock outcrops in the PAC were conducted during monthly field expeditions between July 2017 and October 2018. Sampling was restricted to inselberg vegetation, which is characterized by rupicolous species that inhabit the rocky surfaces.

Fertile specimens were collected randomly, using the walk-over survey method (Filgueiras, Brochado, Nogueira, & Guala, 1994), and processed according to Mori, Berkov, Gracie, and Hecklau (2011). We accomplished taxonomic identification by consulting specialized taxonomic literature (e.g., regional and local flora monographs), images of exsiccate available in virtual herbaria Jabot (jabot.jbrj.gov.br/) and Reflora (reflora.jbrj.gov.br/reflora/herbarioVirtual/), and experts on each taxon, to whom we sent exsiccate. The
circumscription adopted for angiosperm families are in accordance with APG IV (The Angiosperm Phylogeny Group, 2016). For monilophytes and lycophytes, we followed PPG I (Pteridophyte Phylogeny Group [PPG], 2016). Accepted names, synonymy, and authors were confirmed by reference to Flora do Brasil 2020 (http://floradobrasil.jbrj.gov.br/), Missouri Botanical Garden (http://tropicos.org) and International Plant Names Index (IPNI, 2020). Additional specimens collected at other times were identified through consultation of the database of Brazilian flora.

In general, the rocky outcrops of the PAC can be organized into two main phytophysiognomies: (i) vegetation on exposed rock and (ii) woody rupicolous communities. All species were organized according to their occupation within these two rocky phytophysiognomies.

Vegetation on the exposed rock is groups of plants growing directly on and bounded by the rocky surfaces, with no or very shallow soil (epilithic or saxicolous plants respectively) (Conceição, Pirani, & Meirelles, 2007). This phytophysiognomy is composed mainly of monocot mats (Bromeliaceae and Velloziaceae mainly) and epilithic vegetation, covering large expanses of the rock outcrops. The woody rupicolous communities are composed predominantly by shrubs and small trees less than 10 m high, growing in poorly developed soil (up to 20 cm deep) in large depressions and fissures on the slopes of the inselbergs. Woody species typical of the matrix, such as epiphytes, vines, and herbs, can also occur (Couto et al., 2017).

Species were classified according to vegetative habit as trees, shrubs, subshrubs, climbing plants and herbaceous, following Couto et al. (2017). The endangered species were cited according to the official list of Centro Nacional de Conservação da Flora (cnclfora.jbrj.gov.br), Red List of Espirito Santo state (Fraga, Peixoto, & Leite, 2019) and IUCN Red List (https://www.iucnredlist.org/).

Collections of botanical material were carried out for all species recorded in the study and voucher specimens were deposited in the CAP herbarium (acronym according to Thiers – continuously updated), of the Universidade Federal do Espirito Santo, in Jerônimo Monteiro, state Espirito Santo.

**Results and discussion**

A total of 121 species, belonging to 96 genera and 40 families, were recorded for the PAC (see supplementary material). Eudicotyledons represented the most diverse evolutionary lineage (65 spp., 54% of the total), with 25 families (62.5%), followed by Monocotyledons with 45 spp. (37%) and 10 families (25%), Monilophytes (8 spp., 6.6%) with 3 families (7.5%), Lycophytes (2 spp., 1.6%) with 1 family (2.5%), and Magnoliids (1 spp., 0.8%) with 1 family (2.5%).

The richest families in the PAC were Bromeliaceae (17 spp.), Orchidaceae (12), Fabaceae (10), Asteraceae and Euphorbiaceae (6 spp. each), Cactaceae and Pteridaceae (5 spp. each), Gesneriaceae and Myrtaceae (4 spp. each), Solanaceae and Commelinaceae (3 spp. Each) (Figure 3). These families accounted for 75 species (i.e. 62% of the total) (Table S1).

The genera represented by the most species were Tillandsia (Bromeliaceae), with five species, Pitcairnia (Bromeliaceae) and Sinningia (Gesneriaceae), both with four species each. Selaginella (Selaginellaceae), Doryopteris (Pteridaceae), Cyrtopodium (Orchidaceae), Eugenia (Myrtaceae), Centrosena, Macroptilium (Fabaceae), Cyperus (Cyperaceae), Alcantarea (Bromeliaceae), Anthurium (Araceae), Anemia (Anemiacae), Ipomoea (Convolvulaceae), Dioscorea (Dioscoreaceae), Vellozia (Velloziaceae) and Solanum (Solanaceae) were represented by two species each (Figure 4).

A new species of Araceae (Anthurium genus) recorded during fieldwork (voucher: J. M. C. Covre 93), is in description phase. On the other hand, Alcantarea pattriae Versieux & Wand (Versieux & Wanderley, 2007), Anthurium martelli Nadder & Theófilo (Coelho & Valadares, 2019), Coleocephalocereus uebelmanniorum (Braun & Esteves) Braun, Esteves & Hofacker, Pitcairnia azouryi Martinelli & Forzza (Martinelli & Forzza, 2006), and Stigmatodon attenuatoides (Couto, Manhães & Costa, 2020) were described from collections obtained in the PAC. Of these species, Alcantarea pattriae, Anthurium martelli, Coleocephalocereus uebelmanniorum and Stigmatodon attenuatoides are endemic to the inselbergs of Jerônimo Monteiro and Cachoeiro de Itapemirim.

As for the distribution of species according to vegetative habit (supplementary material), herbaceous species were predominant, with 72 species (60%), followed by climbing plants with 15 species (12%), shrubs with 14 species (12%), trees with 13 species (11%) and subshrubs with 6 species (5%). The occurrence of species according to phytophysiognomy showed a higher prevalence of species in exposed rocky vegetation than in woody rupicolous communities, with 79 species (65.29%) and 42 species (34.71%), respectively. In total, 18 species (15%) are included on official endangered species lists (Table 1).
Table 1. Endangered species collected on the Inselbergs of the Pedra das Andorinhas Complex, Jerônimo Monteiro/Cachoeiro de Itapemirim, ES, Brazil. Species categorized according to different national and international databases. Categories: VU = vulnerable; EN = endangered; CR = critically endangered.

| Family         | Species                                      | ES Brazil | IUCN |
|----------------|----------------------------------------------|-----------|------|
| Anemiaceae     | Anemia retroflexa Brade                      | VU        |      |
| Amaryllidaceae | Hippeastrum striatum (Lam.) Moore            | VU        | EN   |
| Asteraceae     | Wunderlichia azulensis Maguire & Barroso     | VU        | EN   |
| Bromeliaceae   | Alcantarea patriae Versieux & Wand.          | VU        |      |
| Bromeliaceae   | Encholirium horridum L. B. Sm.               | VU        |      |
| Bromeliaceae   | Neoregelia diversifolia Pereira              | VU        |      |
| Bromeliaceae   | Pitcairnia azouryi Martinelli & Forzza       | EN        |      |
| Bromeliaceae   | Pitcairnia decida L. B. Sm.                  | EN        |      |
| Bromeliaceae   | Vriesea saltensis Leuje & Kollmann          | EN        |      |
| Cactaceae      | Coleocephalocereus uebelmanniourum (Braun & Esteves) | Braun, Esteves & Hofacker | EN         |
| Gesneriaceae   | Sinningia bragae Chautems, Peixoto & Rossini| EN        |      |
| Gesneriaceae   | Sinningia speciosa (Lodd.) Hiern             | VU        |      |
| Malpighiaceae  | Stigmaphyllon vitifolium A. Juss.            | CR        | CR   |
| Moraceae       | Ficus cyclyphylla (Miq.) Miq.                | VU        | VU   |
| Orchidaceae    | Cattleya cernua (Lindl.) van den Berg        | VU        |      |
| Orchidaceae    | Cyrtopodium gigas (Vell.) Hoehne             | EN        |      |
| Pteridaceae    | Cheilanthes geraniifolia (Weath.) Tryon & Tryon | VU        |      |
| Pteridaceae    | Doryopteris redivia Fée                      | VU        |      |
The flora of the Pedra da Andorinha Complex is characterized by genera typical of the inselbergs of southeastern Brazil, such as *Alcantarea*, *Colecephalocereus*, *Encholirium*, *Selaginella* and *Vellozia* (Porembski, Martinelli, Ohlemüller, & Barthlott, 1998; Meirelles, Pivello, & Joly, 1999; Couto et al., 2017; de Paula, Mota, Viana, & Stehmann, 2017), and includes endemic and endangered species. The survey results corroborate previous studies that recognize the southeastern region of Brazil as one of the global centers of richness and endemism among inselberg plants, a distinction shared by Madagascar and eastern Australia (Porembski, 2007).

The survey results differ from some other studies conducted previously in various regions of Brazil (Table 2). In general, the number of species was higher, especially in comparison to inselbergs in the Caatinga Domain, but it was lower compared to inselbergs of the Atlantic Forest, with rare exceptions. These variations can be explained, according to Porembski (2007), by the clear pattern of distinction between different geographic regions, in which environmental filtering differentially shapes inselberg species composition and structure (Yates et al., 2019).

When compared to other inselbergs researched in Espírito Santo, the species richness recorded for the PAC was inferior (Table 2). Compared to montane inselbergs, such as Alto Misterioso (Esgario, Fontana, & Silva, 2009) in the state’s midwestern region, and Pedra dos Pontões (Couto et al., 2017) in its south, the differences in climate (temperature and precipitation) and altitudinal gradient may be the main causes of this distinction.

The PAC is a submontane inselberg under the influence of the surrounding Submontane Seasonal Semideciduous Forest and its dry climate. Alto Misterioso and Pedra dos Pontões are situated between a seasonal and humid (ombrophilous) physiognomy and patches of cloud forest (Esgario et al., 2009; Couto et al., 2017).

### Table 2. Studies conducted on inselberg vegetation in Brazil, showing the phytogeographic domain (sensu Flora Brasil 2020), family, and genera richness. Organized by the areas of greatest species richness (Rich.).

| References               | Location (state) | Domain            | Elevation | Rich. | Fam. | Gen. |
|--------------------------|------------------|-------------------|-----------|-------|------|------|
| Pena et al., 2017        | Pedra do Elefante (ES) | Atlantic Forest    | 50 to 500 m | 302   | 74   | 219  |
| Couto et al., 2017       | Brejo de Agrestina (PE) | Caatinga          | 620 to 740 m | 211   | 69   | 168  |
| Gomes & Alves, 2010      | Alto Misterioso (ES) | Atlantic Forest    | 850 to 1145 m | 170   | 44   | 109  |
| Esgario et al., 2009     | Brejo do Trêvo and Lajedo do Uruçu (PE) | Atlantic Forest | 307 m/451 m | 142   | 51   | 116  |
| Gomes & Sobral-Leite, 2013 | Pedra da Andorinha Complex (ES) | Caatinga | -       | 127   | 53   | 101  |
| Portugal et al., 2008    | Espereança (PB) | Atlantic Forest    | 150 to 500 m | 121   | 46   | 107  |
| This study               | Morro do Carioca (PB) | Caatinga          | 250 to 376 m | 120   | 50   | 101  |
| Lopes-Silva et al., 2017 | Monólitos Quixadã (CE) | Caatinga          | -       | 107   | 45   | 81   |
| Lucena, Lucena, Sousa, Silva, & Souza, 2017 | Espinho Branco (PB) | Caatinga | 250 to 415 m | 101   | 45   | 84   |
| Tölke et al., 2011       | Inselberg Puxinã (PB) | Caatinga          | -       | 97    | 53   | 69   |
| de Paula et al., 2017    | Mucuri (MG) | Atlantic Forest    | 306 to 676 m | 89    | 37   | 73   |

However, the distinction in species richness was most notable concerning submontane inselbergs of Pedra do Elefante in northern Espírito Santo (Pena & Alves-Araújo, 2017). Although the Pedra do Elefante complex covers a large area (2,562.31 ha), its higher species richness compared to the PAC seems to be due only to the greater collection effort in that locality. Historically, it was subject to mineral extraction, but it is now a Protected Area (Conservation Unit – Law 9985/00 SNUC).

Among the richest families found in the PAC, six (Fabaceae, Orchidaceae, Asteraceae, Bromeliaceae, Myrtaceae, and Euphorbiaceae) were also among the richest families in the Atlantic Forest (The Brazil Flora Group [BFG], 2015) and are well represented in inselberg vegetation in Brazil (e.g. França, Melo, & Santos, 1997; Esgario et al., 2009; Couto et al., 2017; Pena & Alves-Araújo, 2017). Fabaceae, for example, has a species richness in the PAC similar to that found on inselbergs in the Caatinga Domain (Araújo, Oliveira, & Lima-Verde, 2008; Tölke, Silva, Pereira, & Melo, 2011; Paulino, Silveira, & Gomes, 2018). This finding contradicts the results of other floristic surveys conducted in Espírito Santo, in which the most-represented families were Orchidaceae, Bromeliaceae, Asteraceae, Melastomataceae, Cyperaceae, Poaceae, Polypodiaceae, Cactaceae and Araceae (Esgario et al., 2009; Couto et al., 2017). Porto, Almeida, Pessoa, Trovão, and Felix (2008) explained this high number of Fabaceae species in Caatinga as evidence of greater variation in its species’ survival strategies in xeric environments. Porembski and Barthlott (2000), in studies conducted in African inselbergs, also showed this family’s ability to adapt effectively to rocky environments.
Of the 96 genera recorded in the present study, 66% were represented by a single species. This finding contradicts results found in floristic surveys conducted on the African continent, where 48% of the collected species belonged to genera represented by a single species (e.g. Porembski & Brown, 1995; for Costa do Marfim). We found a total of 40 families, 16 of which were represented by a single species. This large number has also been observed in other floristic surveys of rocky outcrops in Espírito Santo (Esgario et al., 2009; Couto et al., 2017; Pena & Alves-Araújo, 2017) and is characteristic of high diversity sites (Ratter, Bridgewater, & Ribeiro, 2003). Families such as Bromeliaceae and Orchidaceae were more relevant in terms of species richness among the rock outcrops studied here, possibly due to adaptive strategies that contribute to their survival in these environments, such as the presence of systems that accumulate water, specialized trichomes, thick and crass leaves and the presence of bulbs or pseudobulbs (Porembski, Seine, & Barthlott, 1997; Benzing & Bennett, 2000; Menini Neto, Forzza, & van den Berg, 2013).

Many of the plant species specific to inselberg ecosystems are known as ‘resurrection plants’ because of their desiccation tolerance, a common survival strategy in these environments. In the present study, this survival mechanism was observed in the Velloziaceae (Vellozia candida and Vellozia variegata) family and the monilophytes and lycophytes genera Anemia, Cheilanthes, Doryopteris, and Selaginella. All of these genera have been described as desiccation tolerant in previous studies (Porembski & Barthlott, 2000; Porembski, 2007). Species identified as *Encholirium horridum* (Bromeliaceae), *Coleocephalocereus uselmanniorum* (Cactaceae) and *Cyrtopodium glutiniferum* (Orchidaceae) possessed adaptive mechanisms such as stems that store water or an underground caudex (Porembski, 2007).

Typical genera of Bromeliaceae, such as Alcantarea, Enchlorium, Pitcairnia, Stigmatodon, and Tillandsia, were found on rocky outcrops. These genera have been found in high abundance in Brazil’s inselberg landscapes (de Paula et al., 2016; Couto et al., 2017). We also recorded *Coleocephalocereus* (Cactaceae), *Simningia* (Gesneriaceae) and *Vellozia* (Velloziaceae), which, despite comprising only a few species, are equally important genera typical of South American inselbergs (Porembski, 2007).

In this study, we observed the woody rupicolous species - *Ceiba erianthos* (Malvaceae), *Eugenia punicifolia* (Myrtaceae), *Pseudobombax* aff. *petropolitanum* (Malvaceae), *Tabebuia reticulata* (Bignoniaceae) and *Wunderlichia azulensis* (Asteraceae) - hosted 12 species of vascular epiphytes, mainly Bromeliaceae (*Tillandsia gardneri, T. loliacea, T. recurvata, T. stricta* and *T. usneoides*), and Orchidaceae (*Brassavola tuberculata, Cattleya cernua* and *Laelia gloriosa*). Of the phorophytes mentioned, *Pseudobombax* aff. *petropolitanum* is recognized as an important facilitator tree in inselberg vegetation of Espírito Santo (Couto et al., 2016a; Francisco, Couto, Evans, Garbin, & Ruiz-Miranda, 2018). Owing to its architecture and size, including the large roots exposed on the rock surface, this phorophyte hosts an impressive diversity of vascular epiphytes, particularly on montane inselbergs (Couto et al., 2016a; Couto et al., 2019). Although these woody rupicolous communities are an important component of inselberg vegetation, they are scarcely studied (Couto et al., 2017; Francisco et al., 2018). More research ought to be focused on these communities, as they are an essential component in restoration strategies for globally threatened inselberg ecosystems (Porembski et al., 2016).

**Conservation of Pedra das Andorinhas complex**

PAC has a high diversity of known species, some of which are endemic to the complex itself and nearby outcrops. Some of those species have been described only recently, using botanical materials from the site. Collection efforts are fundamental to filling research gaps and expanding the floristic and phytogeographic knowledge of the rocky outcrops in the Atlantic Forest in the state of Espírito Santo. Also, conservation policies are essential for protecting this unique vegetation, including many endangered species, some of which are rare (e.g. *Tabebuia reticulata*; see Lohmann & Silva-Castro, 2009) or restricted to rock outcrops (e.g. *Pitcairnia decidua, Pitcairnia azoury*, *Coleocephalocereus uselmanniorum, Encholirium horridum*). These species are recognized worldwide as prevalence indicators for the creation of protected areas (Brooks et al., 2006).

Because the PAC is an outcrop of granite origin and close to one of Brazil’s most important ornamental stone beneficiation industries (Xavier, Azevedo, Alexandre, Monteiro, & Pedroti, 2019), the locale is extremely vulnerable to speculative mining. Despite the importance of the mining sector for the Espírito Santo economy, mining activity is the biggest threat to inselberg vegetation, not only in Brazil but also around the world (Porembski et al., 2016). Historically, inselberg vegetation has been neglected by environmental agencies during the environmental licensing of mining activities, causing irreparable damage to these
important ecosystems of the Atlantic Forest (Couto et al., 2019). Now, the populations of many inselberg plant species (e.g. *Pitcairnia azouryi*) are under serious threat of extinction (Manhães, Couto, Miranda, & Carrijo, 2016). For these reasons, we call the attention of public authorities to the importance of inselberg vegetation.

Furthermore, the PAC is surrounded by an anthropized matrix, where exotic grasses, mainly Panicoideae genera (e.g. *Panicum* and *Urochloa*) (observed), grow extensively and are used widely for cattle grazing. The existence of these grasses, their persistence, and high abundance in seed banks (Correia & Martins, 2015) is worrying. Wherever they manage to colonize natural areas, these grasses impair the development and establishment of native monocotyledons on rocky outcrops due to their hardiness in competition for resources. Another aggravation associated with colonization by grass species is the deposition of combustible material, which leaves the PAC high susceptible to fire. Inselberg fires modify community structure and composition and lead to the loss of endemic species, resulting in homogenization of the flora of these important refuges (Hunter, 2017).

Occurrence and distribution data on invasive alien species are essential for developing appropriate control measures and management strategies for natural areas protected under Brazilian law 9985/00. Much of the work on protected areas neglect this information despite invasive species being a major cause of global biodiversity loss (Haddad et al., 2015). Therefore, to guide conservation policy makers, we have incorporated the occurrence of exotic species with invasive potential into our plant list.

Finally, a few characteristics and particularities of the existing flora in the PAC justify and support the creation of a Protected Area that would preserve a significant portion of the flora in the South Espirito Santo region, mainly the inselberg vegetation.

**Conclusion**

This study provides important knowledge about the flora of the Pedra da Andorinha Complex and justifies the need to create a Conservation Unit in the locality, defining it as a priority for conservation due to the recorded wealth, the number of endangered, endemic species and new species that are being described for this location.

It is worth mentioning that the carrying out of more regional inventories is highly recommended to improve the quality of knowledge and, consequently, the efforts to conserve the vegetation of these singular areas and the Atlantic Forest.

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Vascular plants on inselberg landscapes

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### SUPPLEMENTARY MATERIAL

#### Table S1. List of vascular plants from Pedra da Andorinha Complex, Espírito Santo State, Brazil. Life form: Climb. = climbing; Herb = herbaceous; Subsh = subshrubs. PHYTO = Phytophysiognomy: VER = vegetation on exposed rock; WRC = woody rupicolous communities.

| Evolutionary Lineages (species number) | Family/Species | Life form | PHYTO | Vouchers (Herbaria) |
|----------------------------------------|----------------|-----------|-------|---------------------|
| **Lycophytes (2)**                     | SELAGINELLACEAE (2) | Herb | X | J.M.C. Covre 90; D.R. Couto 5670, 3998 (CAP) |
| 1 family                               | Selaginella convoluta (Arn.) Spring | Herb | X | J.M.C. Covre 89; D.R. Couto 5668, 3669 (CAP) |
|                                        | Selaginella sellowii Hieron. | Herb | X | J.M.C. Covre 89; D.R. Couto 3670, 3998 (CAP) |
| **Monilophytes (8)**                   | ANEMIACEAE (2) | Herb | X | D.R. Couto 4005 (CAP) |
| 3 families                             | Anemia retroflexa Brade | Herb | X | J.M.C. Covre 120 (CAP) |
|                                        | Anemia tomentosa (Sav.) Sw. | Herb | X | J.M.C. Covre 161 (CAP); D.R. Couto 3996 (CAP) |
|                                        | Polypodiaceae (1) | Herb | X | J.M.C. Covre 106; D.R. Couto 3679, 3680 (CAP) |
|                                        | Pteridaceae (5) | Herb | X | J.M.C. Covre 90; D.R. Couto 3998 (CAP) |
|                                        | Adiantum sp. | Herb | X | J.M.C. Covre 199 (CAP); D.R. Couto 3986 (CAP) |
|                                        | Cheilanthes geraniifolia (Weath.) R.M.Tryon & A.F.Tryon | Herb | X | J.M.C. Covre 199 (CAP); D.R. Couto 3986 (CAP) |
|                                        | Doryopteris collina (Raddi) J.Sm. | Herb | X | D.R. Couto 3670, 3669 (CAP) |
|                                        | Doryopteris rediviva Fée | Herb | X | J.M.C. Covre 86 (CAP) |
|                                        | Hemionitis tomentosa (Lam.) Raddi | Herb | X | J.M.C. Covre 106; D.R. Couto 3679, 3680 (CAP) |
| **Magnoliids (1)**                     | PIPERACEAE (1) | Herb | X | J.M.C. Covre 75 (CAP); D.R. Couto 3664, 3665 (CAP) |
| 1 family                               | Peperomia cf. spiritus-sancti E.F. Guim. & Carv.-Silva | Herb | X | J.M.C. Covre 165 (CAP) |
| **Monocots (45)**                      | AMARYLLIDACEAE (1) | Herb | X | J.M.C. Covre 157 (CAP); G. Martinelli 15977 (RB) |
| 10 families                            | Hippeastrum stratum (Lam.) Moore | Herb | X | J.M.C. Covre 157 (CAP); G. Martinelli 15977 (RB) |
|                                        | Anthurium martineili Nadruz & Theófilo | Herb | X | J.M.C. Covre 95 (CAP) |
|                                        | Philodendron edmundoi G.M.Barroso | Herb | X | Observed |
|                                        | Bromeliaceae (17) | Herb | X | J.M.C. Covre 119 (CAP) |
|                                        | Aechmea saxicola L.B.Sm. | Herb | X | J.M.C. Covre 119 (CAP) |
|                                        | Alcantarea extensa (L.B.Sm.) J.R.Grant | Herb | X | Observed |
|                                        | Alcantarea patriae Versieux & Wand. | Herb | X | J.M.C. Covre 215 (CAP); Versieux 565 (SP, RB) |
|                                        | Billbergia tridifolia (Nees & Mart.) Lindl. | Herb | X | D.R. Couto 2347 (R) |
|                                        | Encholirium horridum L.B.Sm. | Herb | X | Observed |
|                                        | Neoregelia diversifolia E. Pereira | Herb | X | G. Martinelli 15751 (RB) |
|                                        | Pitcairnia azouryi Martinelli & Forzza | Herb | X | J.M.C. Covre 173 (CAP); G. Martinelli 15977 (RB); V.C. Manhães 287 (VIES); D.R. Couto 4011 (CAP) |
|                                        | Pitcairnia decidua L.B.Sm. | Herb | X | J.M.C. Covre 50 (CAP); D.R. Couto 2345 (R) |
|                                        | Pitcairnia flavmea Lindl. | Herb | X | J.M.C. Covre 122 (CAP); V.C. Manhães 259 (VIES); D.R. Couto 2346 (R) |
|                                        | Pitcairnia flavmea var. macropoda L.B.Sm. & Reitz | Herb | X | J.M.C. Covre 119 (CAP) |
|                                        | Tillandsia gardneri Lindl. | Herb | X | J.M.C. Covre 189; D.R. Couto 3990, 3994, 4011 (CAP) |
|                                        | Tillandsia loliacea Mart. ex Schult. & Schult.f. | Herb | X | J.M.C. Covre 5 (CAP); D.R. Couto 2343 (R); D.R. Couto 2155 (VIES); D.R. Couto 3989 (CAP); D.R. Couto 3989 (VIES) |
|                                        | Tillandsia recurvata (L.) L. | Herb | X | D.R. Couto 4006 (CAP); D.R. Couto 2355 (R) |
|                                        | Tillandsia stricta Sol. | Herb | X | D.R. Couto 2344 (R) |
|                                        | Tillandsia usneoides (L.) L. | Herb | X | D.R. Couto 2344 (R) |
|                                        | Stigmatodon attenuatoides D.R. Couto, Manhães & A.F. Costa | Herb | X | D.R. Couto 2350 (R); D.R. Couto 3971 (CAP) |
|                                        | Vriesea saltensis Leme & L. Kollmann | Herb | X | J.M.C. Covre 105 (CAP); D.R. Couto 5504 (R) |
|                                        | Anellemma brasiliense C.B.Clarke | Herb | X | J.M.C. Covre 207 (CAP) |
|                                        | Dichorisandra procera Mart. ex Schult. & Schult.f. | Herb | X | J.M.C. Covre 53 (CAP) |
|                                        | Gibasis geniculata (Jacq.) Rohweder | Herb | X | J.M.C. Covre 160 (CAP) |

Acta Scientiarum. Biological Sciences, v. 43, e54760, 2021
| Evolutionary Lineages (species number) | Family/ Species | Life form | PHYTO VE WR R | Vouchers (Herbaria) |
|----------------------------------------|-----------------|-----------|---------------|---------------------|
| Vascular plants on inselberg landscapes | Costus spiralis (Jacq.) Roscoe | Herb | X | J.M.C. Covre 15 (CAP) |
| CYPERACEAE (4)                         | Cyperus coriolius Boeckeler | Herb | X | D.R. Couto 4005 (CAP) |
| | Cyperus sp. | Herb | X | J.M.C. Covre 4 (CAP) |
| | Scleria sp. | Herb | X | J.M.C. Covre 45 (CAP) |
| | Trilepis lhotzkiana Nees ex Arn. | Herb | X | J.M.C. Covre 214 (CAP) |
| MARANTACEAE (1) | Maranta divaricata Roscoe | Herb | X | J.M.C. Covre 72 (CAP) |
| | ORCHIDACEAE (12) | | | |
| | Pabstilia sp. | Herb | X | J.M.C. Covre 82; D.R. Couto 3657 (CAP) |
| | Cyperus coriifolius Boeckeler | Herb | X | J.M.C. Covre 184 (CAP) |
| | Scleria sp. | Herb | X | D.R. Couto 3658 (CAP) |
| | Trilepis lhotzkiana Nees ex Arn. | Herb | X | J.M.C. Covre 174 (CAP) |
| | Maranta divaricata Roscoe | Herb | X | H.M. Dias 528 (CAP) |
| | Eulophiopsis tuberculata Hook. | Herb | X | J.M.C. Covre 12; D.R. Couto 3993 (CAP) |
| | Laelia gloriosa (Rchb.f.) L.O.Williams | Herb | X | J.M.C. Covre 1 (CAP) |
| | Prescottia plantaginifolia Lindl. ex Hook. | Herb | X | D.R.Couto 3656, 3661 (CAP) |
| | Trichocentrum pumilum (Lindl.) M.W.Chase & N.H.Williams | Herb | X | J.M.C. Covre 1 (CAP) |
| | TALINACEAE (1) | Talinum paniculatum (Jacq.) Gaertn. | Herb | X | J.M.C. Covre 66 (CAP) |
| | VELLOZIACEAE (2) | Vellozia candida Mart. | Herb | X | J.M.C. Covre 44 (CAP) |
| | Vellozia variegata Goethart & Henrard | Herb | X | H.M. Dias 529 (VIES) |
| | Eudicots (65) | | | |
| | APOCYNACEAE (2) | Aspidosperma gomezianum A. DC. | Tree | X | J.M.C. Covre 188 (CAP) |
| | | Mandevilla sp. | Subsh | X | J.M.C. Covre 187 (CAP) |
| | ASTERACEAE (6) | Baccharis serrulata (Lam.) Pers. | Subsh | X | D.R. Couto 3991 (CAP) |
| | | Bidens sp. | Herb | X | J.M.C. Covre 225 (CAP) |
| | CYRTOPODIUM gigas (Vell.) Hoehne | Herb | X | J.M.C. Covre 12; D.R. Couto 3995 (CAP) |
| | Euphorbia fasciculata Willd. | Herb | X | J.M.C. Covre 158; D.R. Couto 3992 (CAP) |
| | | Laelia gloriosa (Rchb.f.) L.O.Williams | Herb | X | J.M.C. Covre 1 (CAP) |
| | | Prescottia plantaginifolia Lindl. ex Hook. | Herb | X | J.M.C. Covre 107; D.R. Couto 2361 (CAP) |
| | | Speculina grobyi (Batem. ex Lindl.) F.Barros | Herb | X | D.R.Couto 3656, 3661 (CAP) |
| | | Trichocentrum pumilum (Lindl.) M.W.Chase & N.H.Williams | Herb | X | D.R.Couto 3656, 3661 (CAP) |
| | BIGNONIACEAE (2) | Anemopaegma setilobum A.H.Gentry | Climb. | X | J.M.C. Covre 41 (CAP) |
| | | Tabebuia reticulata A.H.Gentry | Tree | X | J.M.C. Covre 162 (CAP) |
| | | | | |
| | CALOPHYLLACEAE (1) | Kielmeyera membranacea Casar. | Subsh | X | J.M.C. Covre 162 (CAP) |
| | | | | |
| | BORAGINACEAE (1) | Tournefortia bicolor Mill. | Climb. | X | J.M.C. Covre 197 (CAP) |
| | | | | |
| | CONVOLVULACEAE (5) | Brasiliopuntia setalibum A.H.Gentry | Shrub | X | J.M.C. Covre 16 (CAP) |
| | | Coleus fernambucensis Lem. | Shrub | X | J.M.C. Covre 28 (CAP); D.R. Couto 1730 (VIES) |
| | | Ceropegia sp. | Shrub | X | J.M.C. Covre 28 (CAP); D.R. Couto 1730 (VIES) |
| | | Ipomoea quamoclit L. | Climb. | X | J.M.C. Covre 2 (CAP); D.R. Couto 1729 (VIES) |
| | | Ipomoea sp. | Climb. | X | J.M.C. Covre 6 (CAP) |
| | | | | |
| | | Rhynchospermum acutum (Mill.) | Herb | X | J.M.C. Covre 51 (CAP) |
| | | | | |
| | | Cleome spinulosa K.Schum. | Climb. | X | J.M.C. Covre 50 (CAP) |
| | | | | |
| | | ERYTHROXYLACEAE (1) | Erythroxylum sp. | Tree | X | J.M.C. Covre 112 (CAP) |
| | | | | |
| | | Dipsocoreae glandulosa (Griseb.) Kunth. | Tree | X | J.M.C. Covre 209 (CAP) |
| | | Dipsocoreae subhastata Vell. | Tree | X | J.M.C. Covre 222 (CAP) |
| | | | | |
| | | | | |
| Evolutionary Lineages (species number) | Family/Species | Life form | Phyto Vouchers (Herbaria) |
|---------------------------------------|----------------|-----------|--------------------------|
| Acalypha amblyodonta (Müll.Arg.) Müll.Arg. | Shrub | X | J.M.C. Covre 100 (CAP) |
| Aстраea gracilis (Müll.Arg.) O.L.M. Silva & Cordeiro | Herb | X | J.M.C. Covre 211 (CAP) |
| Cnidoscolus oligandrus (Müll.Arg.) Paxon | Tree | X | J.M.C. Covre 176 (CAP) |
| Euphorbia comosa Vell. | Herb | X | J.M.C. Covre 232 (CAP) |
| Manihot sp. | Shrub | X | J.M.C. Covre 205 (CAP) |
| Romanoa tamnoides (A.Juss.) Radcl.-Sm. | Climb. | X | J.M.C. Covre 115 (CAP) |
| FABACEAE (10) | | | |
| Albizia polypephala (Benth.) Killip ex Record | Tree | X | J.M.C.Covre 253 (CAP) |
| Aeschynomene sp. | Herb | X | J.M.C. Covre 181 (CAP) |
| Calliandra sp. Benthi. | Tree | X | J.M.C. Covre 254 (CAP) |
| Camptosema isopetalum (Lam.) Taub. | Climb. | X | J.M.C. Covre 64 (CAP) |
| Centrosema sp. | Subsh | X | J.M.C. Covre 218 (CAP) |
| Centrosema arenarium Benth. | Subsh | X | J.M.C. Covre 164 (CAP) |
| Machaerium sp. | Climb. | X | J.M.C. Covre 158 (CAP) |
| Macroptilium atropurpureum (Sessé & Moc. ex DC.) Urb. | Climb. | X | J.M.C. Covre 143 (CAP) |
| Macroptilium erythroloma (Mart. ex Benth.) Urb. | Climb. | X | J.M.C. Covre 229 (CAP) |
| Sigmoidotropis speciosa (Kunth) A. Delgado | Climb. | X | J.M.C. Covre 99 (CAP) |
| GESNERIACEAE (4) | | | |
| Sinningia bragae Chautems,M. Peixoto & Rossini | Herb | X | J.M.C. Covre 171 (CAP) |
| Sinningia brasiliensis (Regel & Schmidt) Wiehler & Chautems | Herb | X | J.M.C. Covre 191 (CAP) |
| Sinningia speciosa (Lodd.) Hiern | Herb | X | J.M.C. Covre 216 (CAP) |
| Sinningia sp. | Herb | X | J.M.C. Covre 88 (CAP) |
| LOASACEAE (1) | | | |
| Aosa parviflora (Schrad. ex DC.) Weigend | Herb | X | J.M.C. Covre 65 (CAP) |
| MALPIGHIACEAE (1) | | | |
| Stigmaphyllon vitifolium A.Juss. | Herb | X | J.M.C. Covre 210 (CAP) |
| MALVACEAE (2) | | | |
| Ceiba erianthos (Cav.) K.Schum. | Tree | X | Observed |
| Pseudobombax aff petropolitanum A.Robyns | Tree | X | J.M.C. Covre 141; D.R. Couto 2562, 4000 (CAP) |
| MELASTOMATACEAE (1) | | | |
| Pleroma heteroramalum D. Don (D.Don) | Shrub | X | J.M.C. Covre 98 (CAP) |
| MORACEAE (1) | | | |
| Ficus cyclophylla (Miq.) Miq. | Tree | X | J.M.C. Covre 198 (CAP) |
| MYRTACEAE (4) | | | |
| Eugenia punicifolia (Kunth) DC. | Shrub | X | J.M.C. Covre 43 (CAP) |
| Eugenia sp. | Shrub | X | J.M.C. Covre 55 (CAP) |
| Myrciaria floribunda (H.West ex Willd.) O.Berg | Shrub | X | J.M.C. Covre 183 (CAP) |
| Veg. 1 | Shrub | X | J.M.C. Covre 144 (CAP) |
| RUTACEAE (2) | | | |
| Enshebeckia sp. | Tree | X | J.M.C. Covre 48 (CAP) |
| Physalis peruviana L. | Shrub | X | J.M.C. Covre 129 (CAP) |
| Solanum americanum Mill. | Herb | X | J.M.C. Covre 110 (CAP) |
| URTICACEAE (2) | | | |
| Laportea aestuans (L.) Chew | Herb | X | J.M.C. Covre 92 (CAP) |
| Uerea baccifera (L.) Gaudich. ex Wedd. | Shrub | X | J.M.C. Covre 54 (CAP) |
| VERBENACEAE (2) | | | |
| Lantana camara L. | Shrub | X | J.M.C. Covre 154 (CAP) |
| Lippia origanoides Kunth | Subsh | X | J.M.C. Covre 46 (CAP) |
| VITACEAE (1) | | | |
| Cassia erosa Rich. | Climb. | X | J.M.C. Covre 233 (CAP) |
| VOCHYSIACEAE (1) | Shrub | X | J.M.C. Covre 148 (CAP) |