



MAPPING THREATS TO THE ORCHID POPULATIONS IN AN ENVIRONMENTAL PROTECTION AREA IN BAHIA, NORTHEAST BRAZIL

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Abstract: The Área de Proteção Ambiental das Lagoas e Dunas do Abaeté (APA Abaeté) is an environmentally protected restinga fragment located in an urban area in the municipality of Salvador, the third most populous municipality in Brazil. We presented an updated list of Orchidaceae in APA Abaeté, including data on population size, aiming to support effective conservation strategies for orchids in Atlantic Forest remnants in the state. We carried out intensive fieldwork during October 2014 and February 2018, and analyzed several collections from Brazilian herbaria. Photographs, maps, short taxonomic notes and ecological information of the species are provided. We divided APA Abaeté into 16 plots (each with about 1.9 km²) to facilitate the discussion regarding local conservation actions. We found 15 genera and 19 species, including highly ornamental orchids (e.g. *Brassavola tuberculata* and *Encyclia dichroma*). Most species are terricolous and occur in the restinga forest formation (68%). We recognized six species as new occurrences for APA Abaeté: *Catasetum roseoalbum*, *Eltroplectris calcarata*, *Habenaria schenckii*, *Liparis nervosa*, *Pelexia viridis* and *Prescottia leptostachya*. *Epistephium williamsii*, *Galeandra montana*, *H. schenckii*, *P. viridis* and *Vanilla palmarum* deserve immediate conservation actions in order to avoid local extinctions. The mentioned species form small populations (less than 50 individuals) and/or are restricted to up to three plots. Deforestation, occasional changes in habitats, including illegal collection of plants, urban growth of the neighborhoods, and the possible expansion of the international airport in Salvador may drastically reduce the population sizes of the orchids present. *Cyrtopodium parviflorum* and *Koellensteinia florida* may be extinct locally; they were last collected last century and recent attempts to find them in the area were unsuccessful. Conservation efforts must include the management of species, environmental educational actions and the permanent control and surveillance of the area.

Keywords: APA Abaeté; Atlantic Forest; conservation; floristic; restinga.

INTRODUCTION

Orchids are generally ornamental and floristically very prominent, since they are usually among

the most species rich families of several biomes, such as in the Cerrado and in the Atlantic Forest, in the tropical and subtropical regions of Brazil (Giulietti *et al.* 1987, Alves & Kolbek 2009, Lima

et al. 2011). Surveys of Orchidaceae in the state of Bahia in Northeast Brazil became more frequent in the 1990s, which revealed new occurrences for the state (Silva 2002, Ribeiro *et al.* 2005, Vieira *et al.* 2014), although their focus was on rocky outcrop vegetation (*campo rupestre* in Portuguese) mainly in the Chapada Diamantina region (see Azevedo & van den Berg 2007). Notwithstanding, plant conservation in several areas is of great concern, such as Área de Proteção Ambiental das Lagoas e Dunas do Abaeté (APA Abaeté), an Atlantic Forest conservation unit. This protected area is a restinga fragment located in an urban area in the municipality of Salvador, the third most populous municipality in Brazil (Bahia 1987, IBGE 2017). This area has remarkable historical, cultural and natural value, but this heritage has been threatened by several factors, mainly urban growth of the neighborhoods and the probable expansion of Salvador's international airport (Silva 1993, Silva 2012). Although previous floristic studies have been conducted in the region (Britto *et al.* 1993, Conceição & Barbosa 2007, Silva 2012), we performed an extensive survey and provided an updated inventory of Orchidaceae in the APA Abaeté, including data on the location of subpopulations and population sizes, aiming to support effective conservation strategies for orchids in Atlantic Forest remnants in the state.

MATERIAL AND METHODS

The conservation unit of APA Abaeté is located in northeastern Brazil (12°54'–12°57'S, 38°18'–38°21'W), along the north coast of the state of Bahia (Brasil 2018). It was established in 1987 and is a restinga fragment of 1,800 ha (Bahia 1987). The climate is hot and humid, without a dry season (Af, *sensu* Köppen (1948)), and with relative humidity over 70 - 80 % throughout the year (Viana & Kleinert 2005). The mean annual temperature is 25.9 °C, the annual precipitation is 1,885 mm, and April and May are the rainiest months (Schiavone 2014). The landscape in APA Abaeté is heterogeneous and formed by herbaceous, shrub and restinga forest formations, and fixed, semi-mobile and mobile dunes (open areas), with marshes and permanent or temporary lagoons (Britto *et al.* 1993, Silva 2012). The definition of the restinga vegetation follow Brasil (2009).

We carried out intensive fieldwork during October 2014 and February 2018 by the walking survey method (Filgueiras *et al.* 1994). The expeditions were conducted by the same field team and occurred biweekly, monthly or bimonthly until November 2015. From then, until February 2018, field efforts were carried out three times a month and the plots were revisited whenever possible, but bimonthly as a rule. Specimens were georeferenced, pressed and dried according to Peixoto & Maia (2013), and housed in the ALCB (duplicates at HUEFS, MBML, and RB) (acronyms according to Thiers 2018). A collection of flowers in 70% ethanol was also deposited in the herbarium RB (RB spirit). Collections of ALCB, HBR, HUEFS, and RB were also examined.

The APA Abaeté was divided into 16 plots (each with 45 second latitude and longitude intervals or about 1.9 km²) to facilitate discussions regarding local conservation actions (Figure 1). Two municipal parks, whose areas do not overlap, are located completely within APA do Abaeté: Parque do Abaeté (ca. 290 ha) and Parque das Dunas (ca. 270 ha) (Salvador 2011). Parque do Abaeté comprises areas in plots 1, 2, 3, 6 and 7, while Parque Municipal das Dunas partially occupies plots 5, 6, 9, 10, 12, 13, 14 and 15.

We classified plots 1, 4, 8, 11, 12, 14, 15 and 16 as highly urbanized, and plots 2, 3, 5, 6, 7, 9, 10 and 13 as partially urbanized. Below we present summary characterizations of the plots.

Plots highly urbanized

Plot 1: This plot is mainly occupied by urban centers with irregular construction, including temporary camps. The vegetation is composed of shrub and restinga forest formations, but it is restricted to less than 10% of the plot.

Plots 4, 8, 11, 14 and 16: These plots are mainly inserted in disturbed areas, where urban growth of the neighborhoods is notorious. These plots are situated near to the coast, where the local population has established holiday homes. The vegetation fragments are basically restricted to patches of herbaceous and shrub formations.

Plots 12 and 15: These plots encompass areas of the international airport of Salvador, within which scientific research activities are prohibited for security reasons. Access is allowed only in the portions further away from the airport, where

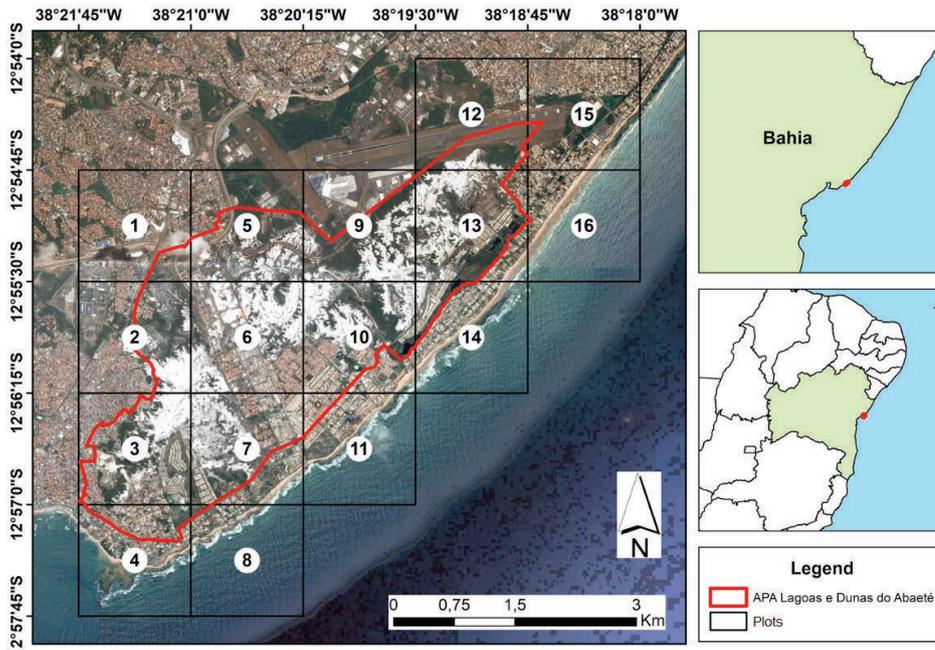


Figure 1. Map showing the 16 plots of Área de Proteção Ambiental Lagoas and Dunas do Abaeté situated in the state of Bahia, Northeast Brazil. Map constructed by José Antônio Lima Rocha Junior.

there is practically no vegetation or it is highly disturbed.

Plots partially urbanized

Plot 2: This plot is characterized by a fragment of continuous vegetation (composed mainly of shrub formation), in addition to an extensive and permanent lagoon (“Lagoa 2 & 2”), a tiny lagoon (not named) and a swamp.

Plot 3: In this plot, there is also a fragment of continuous vegetation (composed mainly of shrub formation), in addition to the most famous lagoon of the APA Abaeté — “Lagoa do Abaeté”. This lagoon is a tourist attraction in Salvador, however, it has been registered a reduction in the local visit rate due to urban violence and the reduction in size of the lagoon. The APA Abaeté headquarters is situated in plot 3, near the lagoon.

Plots 5 and 9: Approximately half of these plots are located within the area of the airport. Access is allowed only to the portions farthest from the airport. Plot 5 is composed of herbaceous and shrub formations, two permanent lagoons (“Lagoa S.O.S” and “Lagoa do Urubu”) and one temporary lagoon (“Lagoa da Alameda”), which is used for a variety of purposes, such as recreation and bathing. Plot 9 has one lagoon (“Lagoa do Jacaré”), which is near

plot 5, and two distinct fragments of restinga forest. One fragment (“Mata Fechada”) is approximately linear and comprises several tree species up to 20 m in height. The managers and employees of Parque das Dunas frequently carried out environmental education activities in this fragment, which is situated near the plot 13. The other fragment is approximately circular and located near to the plot 10. There is one permanent lagoon (“Lagoa do Aeroporto”) in this fragment, but access to this lagoon is difficult. *Attalea funifera* Mart. (Arecaceae) is the prevailing species around the lagoon.

Plot 6: This plot is situated at the central region of APA Abaeté and is occupied mainly by mobile and semi-mobile dunes and urban areas. The only significant vegetation fragment comprises a mixture of herbaceous, shrub and restinga forest fragments, situated on the border of plots 5 and 6.

Plot 7: This plot is quite similar to the plot 6. There are basically shrubs forming small clumps. The vegetation of the fragment has been drastically altered over the last few years due to the presence of urban areas (e.g. “Condomínio Petromar”).

Plot 10: This plot contains the most continuous and preserved forest fragment (“Mata da Baronesa”) of APA Abaeté, which is characterized by the high tree species richness. A dirt road

cuts through the plot, which facilitates access by the local population to two permanent lagoons - “Lagoa da Baronesa” and “Lagoa do Camarão”, which are situated near to the coast. The “Lagoa do Camarão” is used for fishing.

Plot 13: There is surveillance and permanent control in this plot due the presence of Parque das Dunas headquarter. The area is composed of herbaceous, shrub and restinga forest formations grouped in clumps, and also encompasses two permanent lagoons (“Lagoa do Junco” and “Lagoa da Vitória”), whose access is controlled. Educational activities are constantly performed by managers and employees of the Parque das Dunas in this region. This is probably the most preserved plot.

All individual orchids found were carefully counted and georeferenced (Wängler *et al.* 2015). Special attention was given to the counting of individuals of *Vanilla bahiana* since they grow and branch out greatly, reaching up to dozens of meters in the area. This activity was performed by two researchers independently, and the results double-checked. Based on population data and distribution among plots, we adopted five groupings for the species: a) Level 1, when the species occurs in three or more plots and there are ≥ 50 individuals; (b) Level 2, when the species occurs in three or more plots and there are < 50 individuals; (c) Level 3, when the species is restricted to one or two plots and there are ≥ 50 individuals; d) Level 4, when the species is restricted to one or two plots and there are < 50 individuals; and e) Level 5, when the species is restricted to one plot (previous records) and no individuals were found despite exhaustive recent field efforts. Data on substrate and vegetation formations were obtained during fieldwork or through the analysis of labels of specimens collected in the area. Maps of APA Abaeté were constructed using ARC-GIS software, version 10.2.2 (ESRI 2014).

RESULTS

We found 15 genera and 19 species of Orchidaceae in APA do Abaeté (Figure 2; Table 1). The genus *Cyrtopodium* R.Br. was represented by three species, *Epidendrum* L. and *Vanilla* Mill. by two species each, and the other genera by only a single species. *Habenaria schenckii* Cogn. and *Pelexia viridis* (Cogn.) Schltr. are here first reported for restinga vegetation. We recognized

six species as new occurrences for APA Abaeté: *Catasetum roseoalbum* (Hook.) Lindl., *Eltroplectris calcarata* (Sw.) Garay & Sweet; *H. schenckii*; *Liparis nervosa* (Thumb.) Lindl.; *P. viridis* and *Prescottia leptostachya* Lindl. Among the species occurring in APA Abaeté, *Brassavola tuberculata* Hook., *Cyrtopodium flavum* Link & Otto ex Rchb.f., *Cyrtopodium holstii* L.C. Menezes, *Cyrtopodium parviflorum* Lindl., *Encyclia dichroma* (Lindl.) Schltr., *Epidendrum cinnabarinum* (Salzm.) Lindl., *Epistephium williamsii* Hook.f., *Galeandra montana* Barb.Rodr., *Vanilla bahiana* Hoehne and *Vanilla palmarum* (Salzm. ex Lindl.) Lindl. are highly ornamental species, mainly due to their coloration, number and/or size of their flowers. Sixty-eight percent of the species present in APA do Abaeté are terricolous, while the others are characteristic holoepiphytes (*V. palmarum*), facultative holoepiphytes (*B. tuberculata* and *E. dichroma*), accidental holoepiphytes (*C. roseoalbum* and *E. cinnabarinum*) or hemiepiphytes (*V. bahiana*). Regarding the vegetation formations, at least 68% of the species occur in restinga forest, at least 58% occur in shrub formations and only *C. roseoalbum* and *Galeandra montana* Barb.Rodr. are found in open areas. Some species occur in more than one vegetation formation. We do not have data on the vegetation formation in which *Koellensteinia florida* (Rchb.f.) Garay was found (Table 1).

Population sizes varied widely among the species. We observed more than 200 individuals of *B. tuberculata* and *C. roseoalbum*, but only four individuals of *V. palmarum* and no individuals of *Cyrtopodium parviflorum* and *Koellensteinia florida* in APA do Abaeté (Table 1). The orchid species richness varied among plots from zero to 12. Plots 9 and 10 were the most diverse in orchid species, followed by plots 5 and 13, with nine and eight species, respectively (Figure 3). No orchid species were found in plots 1, 4, 7, 8, 11, 14, 15 and 16. All of these plots are highly urbanized, except by plot 7. *Brassavola tuberculata*, *E. dichroma* and *V. bahiana* are distributed among a greater number of plots, six in total, whereas *C. parviflorum*, *Epistephium williamsii* Hook.f., *H. schenckii*, *K. florida* and *V. palmarum* are only restricted to one plot (Table 1, Figure 3).

Twelve species were classified as Level 1 since they still have relatively large populations (> 50

individuals) and are distributed among three or more plots (Table 1). Although *G. montana* and *P. viridis* occur in three plots and have small populations (45 and 24 individuals, respectively), being classified as Level 2. The species *H. schenckii* has an aggregate distribution with 92 individuals restricted to an area of only 1 m² (one plot), and so was classified as Level 3 (Figure 4). The situation

of *Epistephium williamsii* and *V. palmarum* are even more worrying in terms of conservation. *Epistephium williamsii* (22 individuals) and *V. palmarum* (4 individuals) similarly occur only in plot 2, on the border of the swamp, which is very close to residences. All individuals of *V. palmarum* were growing on *Elaeis guineensis* Jacq. (Arecaceae). *Cyrtopodium parviflorum* and

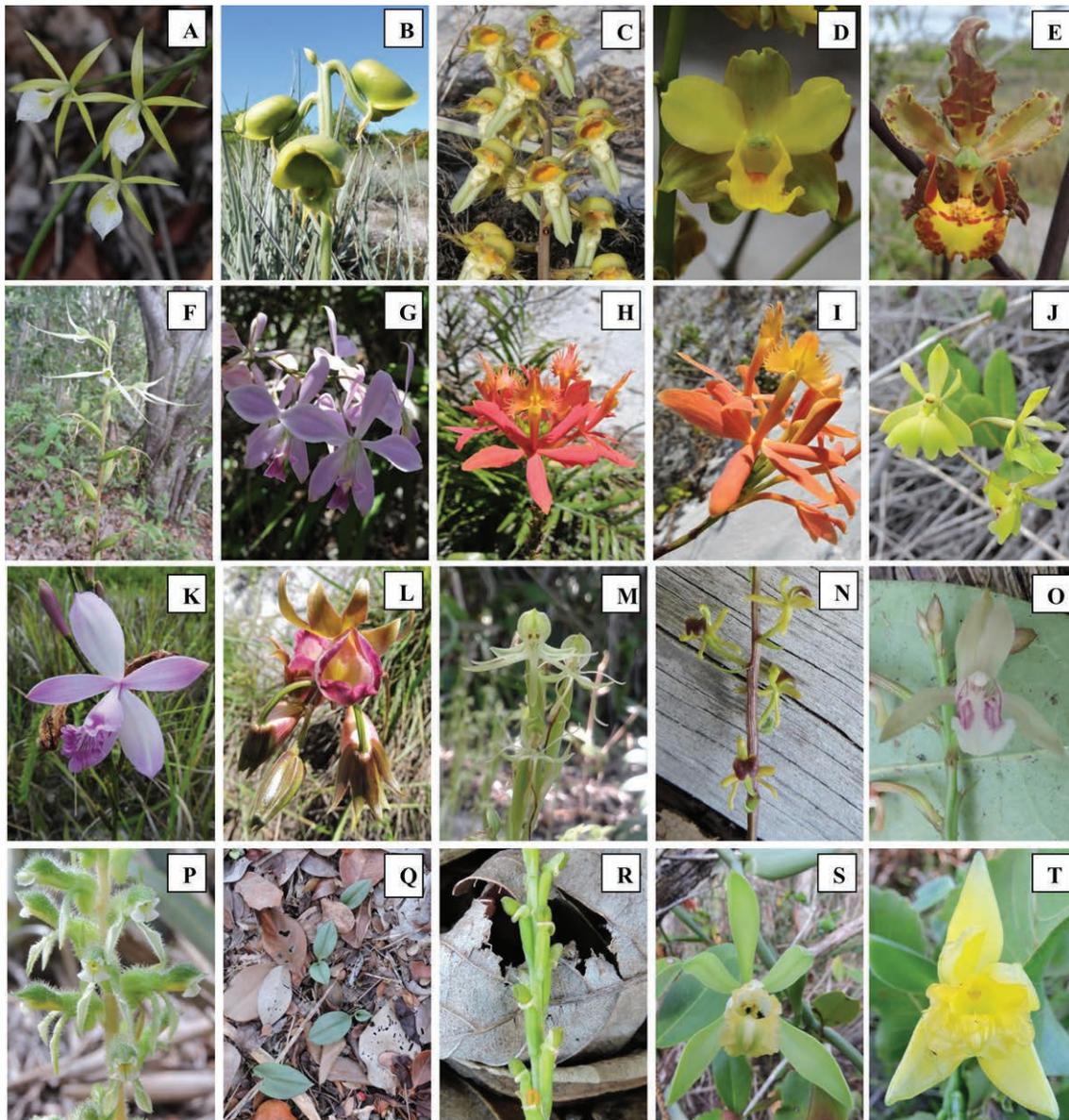


Figure 2. Species of Orchidaceae in APA Lagoas and Dunas do Abaeté, Northeastern Brazil. A. *Brassavola tuberculata* Hook. B-C. *Catasetum roseoalbum* (Hook.) Lindl. D. *Cyrtopodium flavum* Link & Otto ex Rchb.f. E. *Cyrtopodium holstii* L.C. Menezes. F. *Eltroplectris calcarata* (Sw.) Garay & Sweet. G. *Encyclia dichroma* (Lindl.) Schltr. H-I. *Epidendrum cinnabarinum* (Salzm.) Lindl. J. *Epidendrum orchidiflorum* (Salzm.) Lindl. K. *Epistephium williamsii* Hook.f. L. *Galeandra montana* Barb.Rodr. M. *Habenaria schenckii* Cogn. N. *Liparis nervosa* (Thumb.) Lindl. O. *Oeoclades maculata* (Lindl.) Lindl. P. *Pelexia viridis* (Cogn.) Schltr. Q-R. *Prescottia leptostachya* Lindl. S. *Vanilla bahiana* Hoehne T. *Vanilla palmarum* (Salzm. ex Lindl.) Lindl. Photographed by Felipe Fajardo Villela Antolin Barberena.

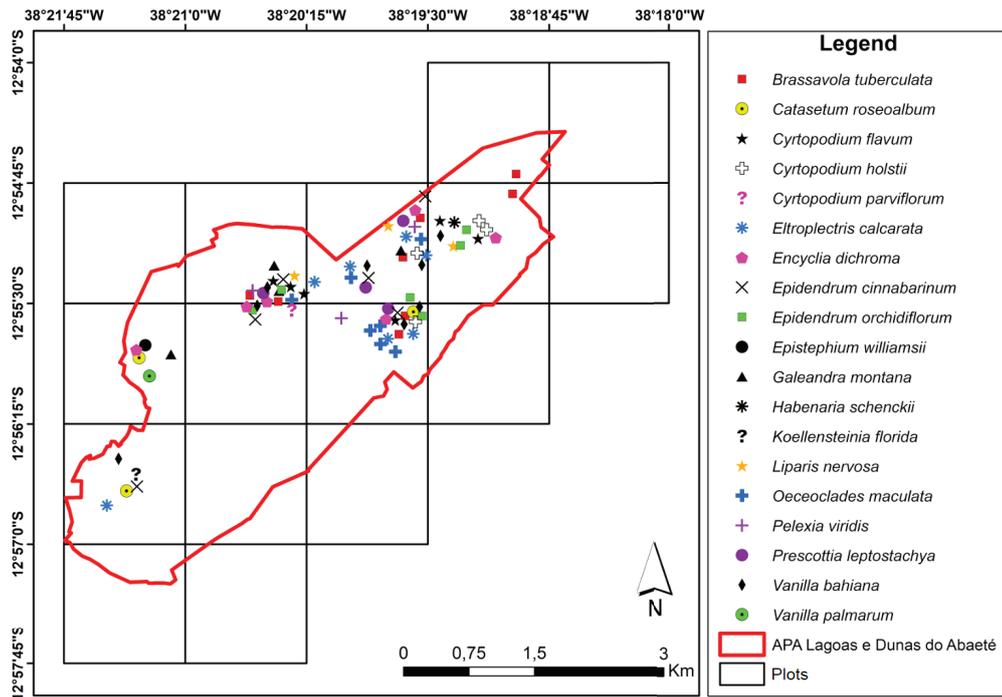


Figure 3. Current spatial distribution of subpopulations of orchids in Área de Proteção Ambiental Lagoas e Dunas do Abaeté. The locations of *Cyrtopodium parviflorum* Lindl. and *Koellensteinia florida* (Rchb.f.) Garay are approximated and based on herbaria data. Map credits: José Antônio Lima Rocha Junior.

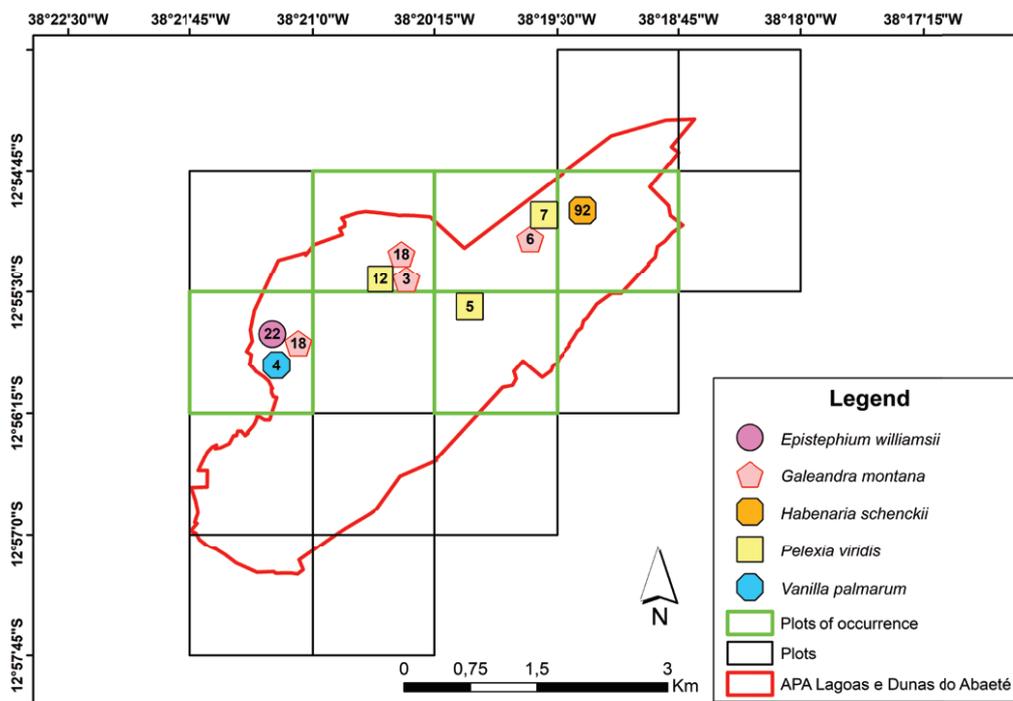


Figure 4. Current number of individuals and locations of occurrence of subpopulations of orchid species classified as Level 2, Level 3 and Level 4 in Área de Proteção Ambiental Lagoas e Dunas do Abaeté. Map credits: José Antônio Lima Rocha Junior.

Table 1. Species of Orchidaceae found in Área de Proteção Ambiental Lagoas e Dunas do Abaeté, northeastern Brazil, highlighting information about substrate, vegetation formation, population size, number of plots in which the species occurs, and level of concern regarding local conservation of the species. New records are indicated by an asterisk (*). Voucher: FFVAB = Felipe Fajardo Villela Antolin Barberena. LRN = Larry Ronald Noblick. TSS = Tainan da Silva Sousa. Substrate: AH = Accidental Holoepiphyte. CH = Characteristic Holoepiphyte. FH = Facultative Holoepiphyte. HE = Hemiepiphyte. T = Terricolous. Vegetation Formation: MD = Missing data. OA = Open Area. RF = Restinga Forest. SF = Shrub formation.

Species	Voucher – Herbarium	Substrate	Vegetation Formation	Population Size	Nº Plots	Level
<i>Brassavola tuberculata</i> Hook.	FFVAB 366 – ALCB	FH	RF/SF	216	6	1
<i>Catasetum roseoalbum</i> (Hook.) Lindl.*	FFVAB 341 – ALCB	AH	OA/RF/SF	259	3	1
<i>Cyrtopodium flavum</i> Link & Otto ex Rchb.f.	FFVAB 342 – ALCB	T	RF/SF	130	3	1
<i>Cyrtopodium holstii</i> L.C.Menezes	FFVAB 347 – ALCB	T	SF	99	3	1
<i>Cyrtopodium parviflorum</i> Lindl.	LRN 4479 – HUEFS	T	SF	0	1	5
<i>Eltroplectris calcarata</i> (Sw.) Garay & Sweet*	FFVAB 342 – ALCB	T	RF	149	3	1
<i>Encyclia dichroma</i> (Lindl.) Schltr.	FFVAB 351 – ALCB	FH	RF/SF	182	6	1
<i>Epidendrum cinnabarinum</i> (Salzm.) Lindl.	FFVAB 348 – ALCB	AH	RF/SF	152	4	1
<i>Epidendrum orchidiflorum</i> (Salzm.) Lindl.	FFVAB 346 – ALCB	T	SF	112	4	1
<i>Epistephium williamsii</i> Hook.f.	FFVAB 357 – ALCB	T	RF	22	1	4
<i>Galeandra montana</i> Barb.Rodr.	FFVAB 365 – ALCB	T	OA/SF	45	4	2
<i>Habenaria schenckii</i> Cogn.*	TSS 73 – ALCB	T	SF	92	1	3
<i>Koellensteinia florida</i> (Rchb.f.) Garay	LRN 1298 – ALCB	T	MD	0	1	5
<i>Liparis nervosa</i> (Thumb.) Lindl.*	FFVAB 369 – ALCB	T	RF	97	3	1
<i>Oeceoclades maculata</i> (Lindl.) Lindl.	FFVAB 350 – ALCB	T	RF	98	3	1
<i>Pelexia viridis</i> (Cogn.) Schltr.*	FFVAB 373 – ALCB	T	RF	24	3	2
<i>Prescottia leptostachya</i> Lindl.*	FFVAB 340 – ALCB	T	RF	110	3	1
<i>Vanilla bahiana</i> Hoehne	FFVAB 360 – ALCB	HE	RF/SF	162	6	1
<i>Vanilla palmarum</i> (Salzm. ex Lindl.) Lindl.	FFVAB 359 – ALCB	CH	RF	4	1	4

K. florida are restricted to one plot (previous records), but recent attempts to find them in the area were unsuccessful, and consequently both species were classified as Level 5.

DISCUSSION

Updated regional species lists are important tools for establishing conservation actions, mainly when they encompass flagship plant groups in hotspots (Colli-Silva *et al.* 2016, Barberena *et al.* 2018). The conservation unit APA Abaeté is a small, urbanized fragment of restinga, but one fifth of the orchids that occur in the restingas of Bahia (19 of 83 species) are encountered in this Environmental Protection Area (Flora do Brasil 2020). In addition, despite the occurrence of scientific collections of orchids in the area since the 1970s (based on herbaria data), and considering previous floristic studies on Orchidaceae (Britto *et al.* 1993, Conceição & Barbosa 2007, Silva 2012), we recognized six new occurrences for APA Abaeté. Of these, *Eltroplectris calcarata*, *H. schenckii*, *L. nervosa*, *P. viridis* and *P. leptostachya* grow more intensively during the rainy season in Salvador (May to September), when tourist visits and field efforts in the area are less frequent. These species are seasonal plants, blooming and fruiting immediately (flowers and fruits on the same inflorescence), and then senescing, making it difficult to observe their phenology. In contrast, *C. roseoalbum* has been historically collected in the area, but has been misidentified as *Catasetum discolor* (Lindl.) Lindl., which does not occur in APA do Abaeté. Both species are morphologically similar but differ in relation to geographic distribution and habitat (Bastos & Van den Berg 2012). In the state of Bahia, *C. roseoalbum* is restricted to restinga (Bastos & Van den Berg 2012).

On the other hand, the occurrence of *Cyrtopodium parviflorum* was verified through the analysis of the specimen *Noblick 4479* (HUEFS). It was collected almost 35 years ago, near Lagoa do Urubu (possibly in plot 6). The other three specimens previously identified as *C. parviflorum* were poorly preserved or lacked flowers (diagnostic character), precluding a reliable identification since the three species of *Cyrtopodium* that occur in APA Abaeté are morphologically very similar when sterile or with fruits. Similarly, *K. florida* was

collected only once, almost 40 years ago, in a humid local near the “Lagoa do Abaeté” (possibly in plot 2), one of the areas most altered over the past few decades. Due to the absence of recent collections and the intensive and constant field efforts of the last years to find it, mainly in the aforementioned locations, we conclude that both species are presumably locally extinct or restricted to the airport area.

A great orchid species richness is still found in APA Abaeté (up to 12 species per plot). However, an absence of orchids was observed in half of the plots, especially in those that have been highly urbanized. Future continuous impacts caused by urban sprawl are difficult to pinpoint, but a loss of species in APA Abaeté in a short period of time may be considered a disastrous scenario. We suspect that these orchids are also target of clandestine collections in the region, since there are several highly ornamental species (e.g. *B. tuberculata* and *E. dichroma*). Furthermore, the loss and reduction of populations due to illegal collections has been reported for the ornamental genus *Cattleya* Lindl. in the state of Bahia (Cruz *et al.* 2003). Another alarming situation is that of *H. schenckii*, which was classified as Level 3, and *E. williamsii* and *V. palmarum*, which were classified as Level 4. These species are found at a single-site. Major changes in a specific locality (the swamp in the plot 2) can cause the local extinction of *E. williamsii* and *V. palmarum*, which also form small populations. In the Atlantic Forest remnants of the state of Bahia, *Vanilla palmarum* grows exclusively on *E. guineensis* and *S. schizophylla* (Mart.) Glassman; this specificity also reinforces the need for local protection of these palm species. Similarly, *H. schenckii* is restricted to a tiny area, and local impacts will reduce its population or even result in local extinction. Furthermore, many species are terricolous and occur in, or are restricted to, restinga forest. Deforestation or changes in tree composition in this vegetation formation would have negative effects on temperature and local humidity (Silva 2012), and consequently negative effects on herbaceous species, including orchids. Fortunately, this vegetation formation is well represented in plots 5, 9 and 10, which are relatively well preserved at the moment.

The application of IUCN Red List categories and criteria at regional levels is not recommended for restricted geographical areas (IUCN 2012). However,

accurate data on population size and information about substrate and vegetation formation are needed for appropriate assessments of the status for conservation of a species and directly influence regional management and the development of effective conservation strategies (Cardoso *et al.* 2016, Barberena *et al.* 2018). More than 50% of the orchid species (10 species) that occur in APA Abaeté are restricted to Brazilian territory, while *E. dichroma* and *K. florida* are endemic to restinga vegetation (Flora do Brasil 2020). Among the orchid species of APA Abaeté, *Cyrtopodium flavum*, *C. holstii* and *E. calcarata* are the only species that had their conservation status evaluated for Brazil, and were classified as Least Concern (Flora do Brasil 2020).

The conservation of plant species (mainly orchids) only through protected areas is hardly enough (Swarts & Dixon 2009). It is common that the exact location of specimen collecting sites and data on population size are purposely omitted from scientific reports, but we understand that researchers, local populations and heads of APA Abaeté, Parque do Abaeté and Parque das Dunas must work together because they are co-responsible for the future of the species in the region. There is no doubt that the orchid flora in the APA Abaeté is strongly threatened. Therefore, mapping the orchid populations (or subpopulations) and the threats to conservation of the flora are a starting point for successful conservation actions.

The greatest challenge for the future of the region is to reconcile political, economic and social interests with the environmental perspective. In order to recommend a path ahead for heads of APA Abaeté, Parque das Dunas and Parque do Abaeté, and collaborators, we propose several complementary conservation initiatives: (i) permanent control and surveillance of APA Abaeté, Parque do Abaeté and Parque das Dunas (increasing the number of officials and guards is desirable); (ii) monitor urban sprawl of the surrounding areas; (iii) strict control of access to the perimeter of the swamp in plot 2; (iv) avoid fragmentation of restinga forest remnants through the establishment of new trails (especially in plots 9, 10 and 13); (v) continue and increase environmental education activities (especially in plot 3, near the 'Lagoa do Abaeté'); (vi) encourage ecotourism (photograph, but do not remove plants); (vii) seek partnerships with governmental

and non-governmental environmental agencies in order to strengthen public policies for plant conservation; (viii) provide logistic support for researchers (several locations are distant from the headquarters); (ix) encourage biodiversity inventories, focusing on ornamental families (e.g. Bromeliaceae and Cactaceae); (x) encourage a broad network of people (local population and visitors) to gather and share information on the location of orchid species with the managers of the APA Abaeté, Parque das Dunas and Parque do Abaeté; and (xi) species management, including artificial pollination, asexual reproduction, and transportation of species to other locations of APA Abaeté (e.g. *Vanilla palmarum* is autogamous and has high pollination rates (Householder *et al.* 2010, Soto Arenas & Cribb 2010); seeds can be dispersed on *E. guineensis*).

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