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New records and conservation status of tree species from environmental licensing studies in highly human-modified areas in Bahia, northeastern Brazil

Aline Costa da Mota[1], Lander de Jesus Alves[2,3], Denise Morais Loureiro[3], Eduardo Saar Santos[3], Jefferson Carvalho-Sobrinho[4,5]

1 *Universidade de Pernambuco, Recife, Brazil*
2 *Universidade Estadual de Santa Cruz, Ilhéus, Brazil*
3 *Bioconsultoria Gestão e Licenciamento Ambiental, Bahia, Brazil*
4 *Universidade Federal do Vale do São Francisco, Petrolina, Brazil*
5 *Universidade Federal Rural de Pernambuco, Recife, Brazil*

Corresponding author: *Jefferson Carvalho-Sobrinho (jefferson.sobrinho@ufrpe.br)*

Abstract. Based on fieldwork for licensing environmental impact studies in Bahia, northeastern Brazil, we present new records of five tree species, including two species known only from their type locality. The records mostly originate from highly human-modified areas in Atlantic Forest, which we argue that should not be underestimated by environmental licensing studies. We assess the conservation status of the five species and highlight the importance of using trained botanists for recording species of conservation concern. Our data demonstrate that studies for environmental licensing can contribute knowledge and aid in biodiversity conservation.

Key words. Atlantic Forest, Flora e Funga do Brasil, IUCN, low-impact activities, rare species, threatened species, Vitória da Conquista Plateau

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INTRODUCTION

The enormously diverse environmental conditions in Bahia promotes a rich flora in the Caatinga, Cerrado, and Atlantic Forest biomes in the state. The southern Bahia Atlantic Forest, in particular, has been widely documented as a center of diversity and endemism of plants (e.g. Mori et al. 1983; Thomas et al. 1998; Amorim et al. 2005, 2008, 2009; Martini et al. 2007; Murray-Smith et al. 2008; Ostroski et al. 2020).

However, about only 7% of conserved, often very fragmented, Atlantic Forest vegetation remains in Bahia and in northeastern Brazil (Saatchi et al. 2001; Tabarelli et al. 2005). The cause of the high level of deforestation and fragmentation is irrational historical use that included illegal logging, harvesting firewood, pasturing of livestock, and production of exotic species, such as eucalyptus, which have led to the extinction of countless trees and the formation of mostly highly anthropogenic landscapes (Fonseca 1985; Dean 2004).

Additionally, the loss of Atlantic Forest biodiversity is caused by the need for infrastructure to meet society's demands (Dean 2004). Since the 1980s, the Brazilian legal framework began to require an environmental impact study prior to the development of activities that potentially cause significant environmental degradation (Brasil 1981, 1988, 1997). Thus, environmental licensing emerged as a series of administrative procedures designed to authorize activities or enterprises that use environmental resources that are potentially polluting or capable of causing environmental degradation (Brasil 2011).

According to current legislation in the state of Bahia, even activities considered to have low environmental impact must be preceded by studies, which minimally include rapid sampling of the flora, to obtain environmental licenses (Bahia 2012, 2016). Low-impact activities include, for example, the installation of distribution power lines to provide access to electrical energy as a social right provided for in the Brazilian Constitution. Considering that such an activity occurs all over the state, licensing studies can provide exceptional opportunities to document a wide diversity of landscapes and vegetation types, often in remote areas with precarious access. Such areas include both well-preserved or, more often, highly anthropized landscapes that frequently lack detailed botanical documentation.

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Herein we aim to demonstrate that environmental licensing studies should not be just a means of complying with administrative and bureaucratic processes provided for by law. Rapid floristic surveys, as demonstrated by Moura et al. (2018), can provide important contributions to floristic knowledge and aid in conservation of a local area or even state-wide. In our study, we highlight floristic results from studies for licensing activities with low environmental impact mostly in the Atlantic Forest in the state of Bahia.

We focus on species of conservation concern and discuss the potential contribution that environmental licensing studies can provide when carried out by trained botanists as argued by Ahrends et al. (2011). Our results should contribute to the knowledge and conservation of the flora of Bahia.

METHODS

Bahia occupies 567,295 km^2, representing 7% of Brazilian territory, and is the largest state in the northeastern Brazil. The state is geologically diverse, bordered on its east by the Atlantic Ocean, and presents a diverse climate associated with continentality effects and landforms (Harley and Giulietti 2004; IBGE 2023a). Altitude in Bahia ranges from sea level to 2,033 m (the highest peak in northeastern Brazil) and in general increases from east to west. It includes several places above 800 m, especially in the extreme west, Chapada Diamantina region, and Vitória da Conquista plateau (Giulietti et al. 2006).

This study was based on fieldwork for the environmental licensing of electrical distribution networks in Bahia. The licensing activities were undertaken by the company Bioconsultoria Ambiental Ltda. and included projects in the municipalities of Itanhém, Itamaraju, Itarantim, Planalto, and Pindaí. The projects had a linear extent of 17.8 km long by 300 m wide. Thus, the total area studied was 5.34 km^2. Each project includes a narrower area 15 m wide, directly below the electricity lines, in which trees larger than 5 cm in diameter and 5 m in height would be suppressed, should licensing of the electric networks be approved. Access roads were also observed, but not included in the calculation of the sampled area.

Fieldwork was carried out in 2021 and 2023, covering the entire area affected by the projects. We (LJA, DLM, ESS) observed, annotated, and made photographic records of trees species and environmental traits. Preliminary taxonomic identification of species was also made based on our expertise. Non-common species were georeferenced, photographed in detail, and later carefully studied by the team using pertinent specialized literature and, whenever available, type materials to achieve accurate taxonomic identification.

We searched online databases of Reflora Virtual Herbarium (https://reflora.jbrj.gov.br/reflora/herbarioVirtual/) and SpeciesLink (https://specieslink.net/) to morphologically compare our photographic records with those identified by specialists in the respective taxonomic groups. Later, we had our identifications confirmed by specialists (see Acknowledgements). In November 2023, two of us (ACM and JCS) revisited some of the localities to look for additional individuals of the focal species and collect vouchers specimens for deposition in the herbaria of the Universidade Federal Rural de Pernambuco (**PEUFR**) and Centro de Pesquisas do Cacau (**CEPEC**).

We assessed the conservation status in Bahia of each species using IUCN (2022) criteria; we used GEOCAT (Bachman et al. 2011) to calculate area of occupancy (AOO) and extent of occurrence (EOO) using a default cell width of 2 km. The localization of each new occurrence were described in relation to the nearest city (distance through roads) that has an herbarium (at least 10 years old) or university campus (advanced campus excluded). A map was produced using QGIS v. 3.28.11 (QGIS 2023) to show known and new records of the focal species in the state. Geographic localization of known records was retrieved from the aforementioned databases. The limits of the biomes are according to IBGE (2023b).

RESULTS

Herein we report new records of the following angiosperms tree species in Bahia: *Handroanthus diamantinensis* F.Esp.Santo & M.M.Silva, *Tabebuia reticulata* A.H.Gentry, *Deguelia costata* (Benth.) A.M.G.Azevedo & R.A.Camargo, *Pterygota brasiliensis* Allemão, and *Pouteria velutinicarpa* Alves-Araújo & M.Alves.

Among these species are two Bahian endemics which were previously known only from their type locality: *H. diamantinensis* (Espírito Santo et al. 2012; Lohmann et al. 2023) and *P. velutinicarpa* (Alves-Araújo and Alves 2012; Alves-Araújo and Nichio-Amaral 2023). We provide new records of *T. reticulata*, which was considered endemic to Minas Gerais (Lohmann et al. 2023) and of *D. costata*, which was known only from southeastern Brazil (Flora e Funga do Brasil 2023b). We also provide records of *P. brasiliensis* (Malvaceae), which had not been reported from Bahia (Fernandes-Júnior 2023) and discuss the occurrence of the species in northeastern Brazil. None of the five species were included in national or regional Red Lists, except *P. velutinicarpa*, which was included in the National List of Brazilian Flora Species Threatened with Extinction (Brasil 2022) but overlooked by the List of Threatened Species Endemic to Bahia (Bahia 2017).

Except for *P. brasiliensis*, which is the most frequently found of the five species, the focal species were not included in the lists of tree species requiring suppression because they do not pose a risk to the installations due to these trees' low height or their occurrence outside the areas requiring suppression. *Pouteria velutinicarpa* was the only species found on an access road outside the areas directly affected by the projects.

Bignoniaceae

***Handroanthus diamantinensis* F.Esp.Santo & M.M.Silva**, Acta Botanica Brasilica 26 (3): 652, 2012.

New records. BRAZIL – Bahia • Municipality of Planalto, 67 km from Vitória da Conquista city; 14°46′19″S, 040°23′54″W; 800 m alt.; 08.XII.2022; E.S. Santos obs.; pasture • same locality; 01.XI.2023; J.G. Carvalho-Sobrinho & A.C. Mota 4024 leg.; PEUFR.

Observations. *Handroanthus diamantinensis* was only known from the type locality in Chapada Diamantina National Park, in central Bahia, where it was living in semideciduous seasonal forests at 950 m. The holotype was with leaves and fruits in September 2011, and the paratype (from the same tree) with flowers in August 2010 (Espírito Santo et al. 2012).

During fieldwork in the municipality of Planalto, in the Conquista Plateau, in September 2021, we discovered one tree of *H. diamantinensis* in a pasture in a semideciduous seasonal forest at 800 m in elevation (Figure 1A–C). This occurrence is about 300 km southeast from the type locality (Figure 2). The tree was about 20 m high and was not flowering nor fruiting. The locality was visited again in November 2023, when we found two additional mature individuals and eight young individuals in an area next to coffee and eucalyptus plantations.

Identification. *Handroanthus diamantinensis* is readily distinguished from its congeners by following combination of vegetative characters: (5–)7-foliolate leaves with long petiolules; strongly discolorous leaflets, with adaxial surface dark green and impressed veins and abaxial surface cream-colored to silvery, densely tomentose, and with prominent veins; margins of leaflet entire, but irregularly serrate when young (Espírito Santo et al. 2012, 2013). We observed that mature leaflets have an irregular outline to inconspicuously serrate margins (Figure 1C).

Conservation assessment. *Handroanthus diamantinensis* was assessed in 2018 and listed as Data Deficient by Fernandez et al. (2021). It is a rare species, represented by fewer than 10 individuals at the type locality (Espírito Santo et al. 2012) and three mature tree individuals inhabiting much-fragmented vegetation. Our calculated AOO is 8,000 km^2 and EOO is 26,641 km^2. Only one of the two localities of occurrence (the type locality) is within a legally protected area. Therefore, we categorized *Handroanthus diamantinensis* as globally Critically Endangered due to its small AAO and EOO, the existence of only two known populations, and habitat fragmentation and degradation (IUCN 2022).

***Tabebuia reticulata* A.H.Gentry**, Flora Neotropica 25 (2): 245, 1992.

New records. BRAZIL – Bahia • Municipality of Pindaí, 50 km from Caetité city; 14°21′26″S, 042°39′46″W; 695 m alt.; 29.VIII.2023; L.J. Alves & D.M. Loureiro obs.; seasonal dry forest with rock outcrops; CEPEC.

Observations. *Tabebuia reticulata* was considered endemic to the state of Minas Gerais, in the Atlantic Forest domain (Lohmann et al. 2023), notwithstanding a single record from Bahia (Espírito Santo et al. 2012). However, online herbaria databases indicate that *T. reticulata* also occurs in the states of Espírito Santo (in 12 municipalities) and Rio de Janeiro (one municipality) on rock outcrops in Atlantic Forest, often below 700 m in elevation. In Bahia, *T. reticulata* was only known from the municipality of Contendas do Sincorá (*R.M. Harley 56194*).

We discovered an individual of *T. reticulata* in reproductive phase in a seasonal forest with rock outcrops at 695 m in elevation in the municipality of Pindaí (Figure 2). This site is 190 km southwest of the Contendas do Sincorá occurrence and 230 km northwest from the type locality. The municipalities of Contendas do Sincorá and Pindaí are on the edge of the Espinhaço Mountains, which are characterized by a mosaic of vegetation types influenced by the Atlantic Forest, Caatinga, and Cerrado domains (Harley 1995; Juncá et al. 2005; Kamino et al. 2008). Both municipalities include areas reaching 850 m in elevation (IBGE 2023a) and are in a poorly sampled area of the Espinhaço (Kamino et al. 2008).

Identification. *Tabebuia reticulata* is very distinct from its congeners due to the combination of unifoliate leaves and purple to vinaceous corollas (Figure 1D).

Conservation assessment. *Tabebuia reticulata* is a rare species in Bahia, and all occurrences are outside of legally protected areas. In Bahia, we calculated AOO of this species as 8,000 km^2, and the EOO as 50,000 km^2. Therefore, we categorize *T. reticulata* as Critically Endangered in Bahia due to its small AOO and EOO, the existence of only two known populations in the state, and habitat fragmentation and degradation (IUCN 2022).

Fabaceae

***Deguelia costata* (Benth.) A.M.G.Azevedo & R.A.Camargo**, Brittonia 66 (1): 26, 2013.

New records. BRAZIL – Bahia • Itanhém, 458 km from Itabuna city; 17°15′50″S, 040°22′06″W; 280 m alt.;

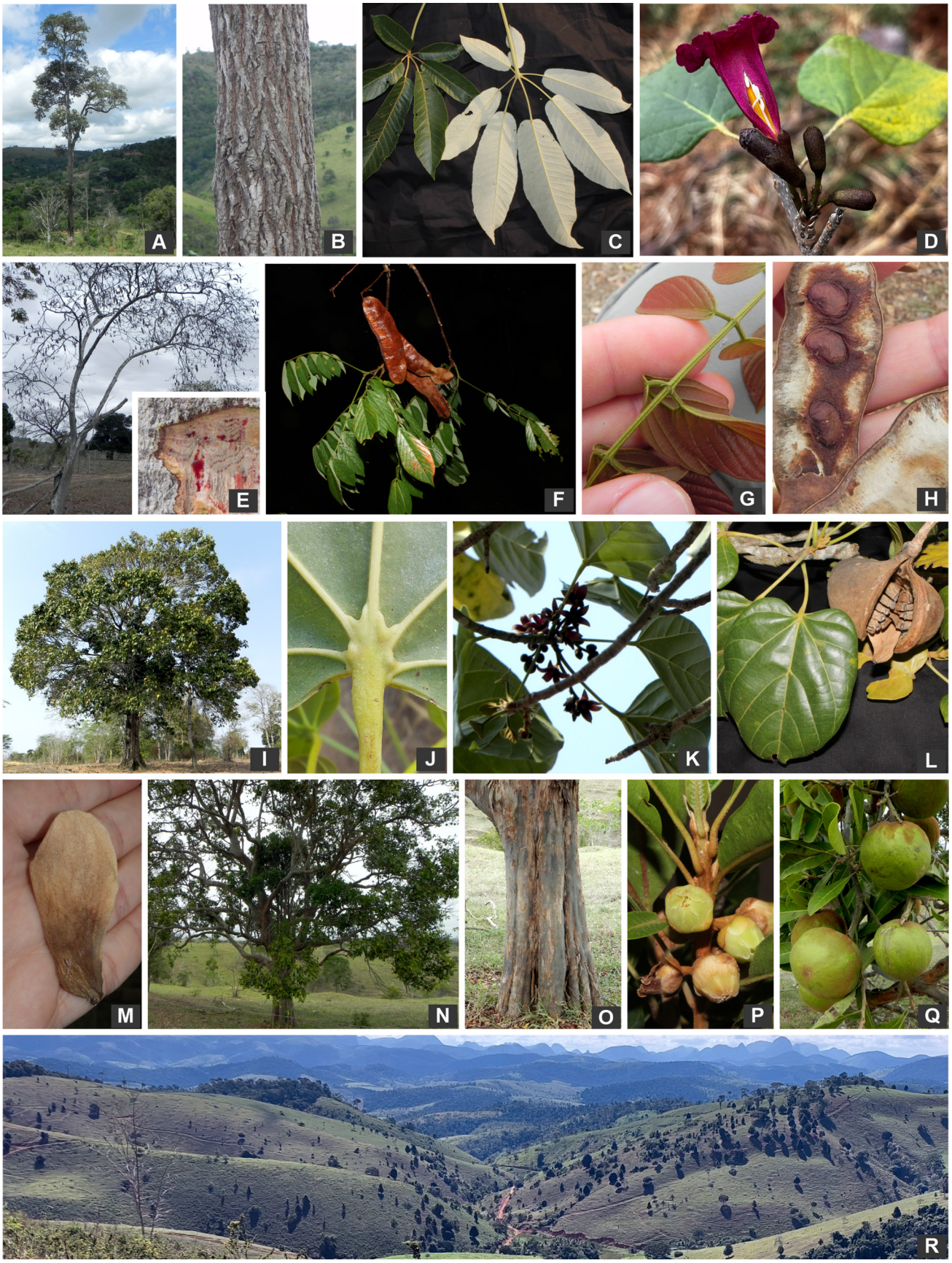

Figure 1. Photographic records of the discussed species showing vegetative, reproductive, and environmental aspects. **A–C.** *Handroanthus diamantinensis*: (**A**) individual in a pasture; (**B**) trunk and bark; (**C**) vegetative branches. **D.** *Tabebuia reticulata*: flowering branch. **E–H.** *Deguelia costata*: (**E**) individual in a pasture and underbark with reddish latex (enlarged); (**F**) branch with leaves and fruits; (**G**) stipels and opposite leaflets with characteristic venation; (**H**) dehisced fruit with seeds. **I–M.** *Pterygota brasiliensis*: (**I**) individual in a pasture; (**J**) domatia at the base of abaxial leaf surface; (**K**) flowering branch; (**L**) branch with dehisced fruits with winged seeds; (**M**) detail of a winged seed. **N–Q.** *Pouteria velutinicarpa*: (**N**) individual in a pasture; (**O**) trunk and bark; (**P**) flowering branch; (**Q**) fruiting branch; (**R**) aspect of a highly human-modified landscape with predominance of pastures in the extreme south of Bahia, northeastern Brazil.

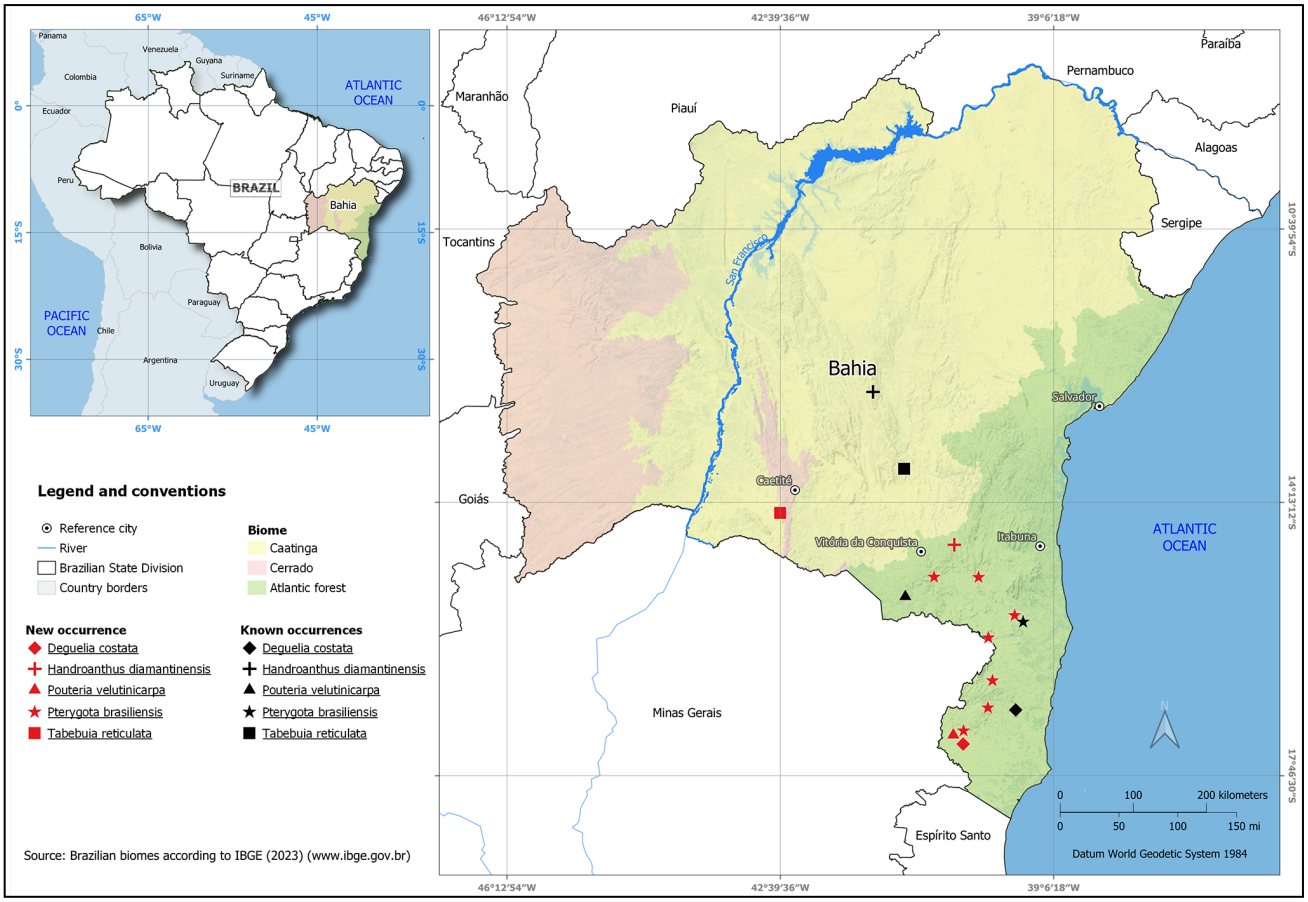

Figure 2. Map of new and previously known occurrences of the five tree species in Bahia, northeastern Brazil.

21.IX.2021; L.J. Alves obs.; pasture • same locality; 05.XI.2023; J.G. Carvalho-Sobrinho & S. Gois 4033 leg.; CEPEC, PEUFR.

Observations. *Deguelia costata* was known from the states of Rio de Janeiro and neighboring Minas Gerais and Espírito Santo in the southeastern Atlantic Forest (Flora e Funga do Brasil 2023b); however, there is also a single specimen (*R.C. Paulino 189*, CEPEC 151196) from the municipality of Jucuruçú, in the extreme south of Bahia, as recorded in online herbarium databases.

We discovered a population of *Deguelia costata* that consisted of a group of three small trees in a pasture in semideciduous seasonal forest in the municipality of Itanhém. This occurrence is 90 km southwest from the Jucuruçú occurrence (Figure 2). The trees had dehisced fruits and leaf flushing in September 2021 (Figure 1E, G, H) and mature leaves and fruits in November 2023 (Figure 1F).

Identification. *Deguelia costata* is characterized by having the leaflets with secondary veins that strongly immersed on the adaxial surface but strongly prominent on the abaxial surface (Figure 1F, G). This species can be distinguished from its congeners occurring in Bahia by its tree habit (it is not a climber) (Flora e Funga do Brasil 2023b). Moreover, *D. costata* has red latex (Figure 1E), strongly discolorous leaflets, and valves that are only coriaceous (Figure 1F, H) and, thus, distinct from woody valves observed in many groups of Fabaceae.

Conservation assessment. *Deguelia costata* is rare in Bahia, known only from two localities outside legally protected areas. We calculated the AOO in Bahia as 8,000 km^2, and the EOO as 67,000 km^2. Therefore, we categorize *D. costata* as Critically Endangered in the state due to its small AOO and EOO, the existence of only two known populations, and habitat fragmentation and degradation (IUCN 2022).

Malvaceae

***Pterygota brasiliensis* Allemão**, Trabalhos da Commissão Scientifica de Exploração, Secção Botânica 1: 7, 1862.

New records. BRAZIL – Bahia • Guaratinga, 286 km from Itabuna city; 16°32'15"S, 039°54'06"W; 280 malt.; 03.XI.2023; J.G. Carvalho-Sobrinho & A.C. Mota 4029 leg.; PEUFR; pasture • Itamaraju, 330 km from

Itabuna city; 16°53′27″S, 039°57′42″W; 370 m alt.; 06.VI.2023; E.S. Santos obs.; pasture • Itambé, 49 km from Vitória da Conquista city; 15°11′26″S, 040°39′43″W; 345 m alt.; 02.XI.2023; J.G. Carvalho-Sobrinho & A.C. Mota obs.; pasture • Itanhém, 454 km from Itabuna city; 17°14′00″S, 040°21′57″W; 280 m alt.; 21.IX.2021; E.S. Santos obs.; pasture • Itapetinga, 124 km from Vitória da Conquista city; 15°11′38″S, 040°05′01″W; 254 m alt.; 02.XI.2023; J.G. Carvalho-Sobrinho & A.C. Mota obs.; pasture • Itarantim, 220 km from Itabuna city; 15°58′48″S, 039°57′22″W; 160 m alt.; 01.IV.2023; E.S. Santos obs.; pasture • Potiraguá, 151 km from Itabuna city; 15°41′24″S, 039°36′50″W; 240 m alt.; 02.XI.2023; J.G. Carvalho-Sobrinho & A.C. Mota 4027 leg.; PEUFR; pasture.

Observations. *Pterygota brasiliensis* is the only species of its genus in Brazil, and it is said to be native to the southeastern states of Minas Gerais, Espírito Santo, and Rio de Janeiro. In northeastern Brazil, *P. brasiliensis* was said to occur in Pernambuco (Fernandes-Júnior 2023) and in Ceará, where the type originated (*Fr. Allemão & M. Cysneiros 123*). However, we did not find any specimen of *Pterygota* from Pernambuco in online herbarium databases. *Pterygota* occurs in Pernambuco only as individual cultivated trees in urban squares and gardens in the state's capital, Recife, and are morphologically more similar to *Pterygota amazonica* L.O. Williams ex Dorr, according to us. We found only one herbarium specimen, which could be identified as *P. brasiliensis*, from Bahia; it was collected with leaves only (*F.S. Gomes 1566*).

During our fieldwork in southern Bahia, we observed individuals of *P. brasiliensis* in pastures in areas of semideciduous seasonal forest in the municipalities of Guaratinga, Itambé, Itamaraju, Itanhém, Itapetinga, Itarantim, and Potiraguá (Figure 2). Trees with old flowers and dehisced fruits were observed in September 2021, and with leaves and dehisced fruits in November 2023.

Identification. Of other trees in Brazil, *P. brasiliensis* is superficially similar to *Sterculia excelsa* Mart. due to the entire leaves with palmate venation and woody follicles, but it can be readily distinguished by the presence of domatia on abaxial surface (vs. domatia absent), the internally glabrous follicles (vs. with conspicuous trichomes), and containing perpendicularly arranged seeds with distal wings (Figure 1 I–M) (vs. non-winged seeds).

Conservation assessment. *Pterygota brasiliensis* trees are known from seven localities in Bahia all, all outside of legally protected areas. This species would qualify for Endangered in Bahia based on its small AOO of 32,000 km^2 or Vulnerable based on its EOO of 15,863 km^2 according to IUCN (2022) criteria, regardless of including a sterile specimen (*F.S. Gomes 1566*), which would increase AOO to 36,000 km^2 and EOO to 16,845 km^2. However, *P. brasiliensis* is moderately common in the field, and we categorize this species as Vulnerable in Bahia based on the following IUCN (2022) criteria: geographic range less than 20,000 km^2; severe habitat fragmentation; and projected continued decline of EOO, area of occupancy AOO, and extent and quality of habitat.

Sapotaceae

Pouteria velutinicarpa **Alves-Araújo & M.Alves**, Nordic Journal of Botany 30: 405, 2012.

New records. BRAZIL – Bahia • Itanhém, 456 km from Itabuna city; 17°15′04″S, 040°22′28″W; 300 m alt.; 21.IX.2021; L.J. Alves obs.; pasture • Same locality; 03.XI.2023; J.G. Carvalho-Sobrinho & S. Gois 4032 leg.; CEPEC, PEUFR.

Observations. *Pouteria velutinicarpa* was newly described only in 2012, based on a single fruiting collection made in August 1984 in the municipality of Encruzilhada, southern Bahia; it is considered endemic to the state (Alves-Araújo and Nichio-Amaral 2023). We found a specimen identified as *P. velutinicarpa* (*D. Foli 2266*) in online herbarium databases that was collected in Minas Gerais about 500 km south of the type locality. However, we compared this specimen with the holotype of *P. velutinicarpa* and refrain from considering it to be the same species.

During our fieldwork in the municipality of Itanhém, in the extreme south of Bahia, we discovered a single individual of *P. velutinicarpa* in a pasture outside of the area directly affected by the electrification project (Figure 2N–Q). The new occurrence is about 150 km southeast of the type locality. The tree was had leaves and mature fruits in September 2021. We revisited the tree in November 2023 and observed it with leaves, flowers, and fruits; no additional individual was found in the locality.

Identification. *Pouteria velutinicarpa* can be identified by the combination of the tomentose young stems and the globose, large fruits, approximately 5 cm in diameter, which are externally brown and tomentose to velutinous (Alves-Araújo and Alves 2012), the rounded crown, and the sulcate trunk with defoliant bark which appears grayish–light brown (Figure 1N–O).

Conservation assessment. *Pouteria velutinicarpa* is a rare species, with an extremely low frequency as indicated on the holotype label and observed in the field. The two known occurrences are outside legally protected areas and represent a small AOO of 8,000 km^2 and EOO of 171,145 km^2. Therefore, we categorize *P. velutinicarpa* as globally Critically Endangered due to its small AOO and EOO, the existence of only two

known populations, and habitat fragmentation and degradation (IUCN 2022). This categorization agrees with that of Fernandez et al. (2020) and accepted by the Brazilian National List of Threatened Flora Species (Brasil 2022).

DISCUSSION

The new records include two species, *Handroanthus diamantinensis* and *Pouteria velutinicarpa*, that are endemic to Bahia and previously known only from their type locality; the other new records are for three species with wider distributions in the Atlantic Forest, *Deguelia costata*, *Pterygota brasiliensis*, and *Tabebuia reticulata*, and whose occurrence in Bahia have been overlooked in recent taxonomic treatments (Flora do Brasil 2023a).

Our data provide important new knowledge of these five species, especially considering that they were either not known from Bahia, or known from Bahia by only one record at best. Both *H. diamantinensis* and *P. velutinicarpa* were recorded for the first time outside their type localities. The record of *P. velutinicarpa* is especially important for conservation since there was no certainty about the existence of the type population since 1984; moreover, we Figure the flowers of *P. velutinicarpa* for the first time. The scarcity of herbarium records of *P. brasiliensis* in Bahia is impressive considering that we have observed individuals inhabiting pastures in seven municipalities in southern Bahia; moreover, our records are the first showing the reproductive stage of this species in the state.

Our finding *D. costata* in the municipality of Itanhém is especially important because the physical specimen of *R.C. Paulino 189* (100 km north in the municipality of Jucuruçú) has not been located in the CEPEC herbarium according to its curator Dr. Jomar Jardim (personal communication, 8 November 2023), and, therefore, our records may represent the only currently available herbarium specimens of *D. costata* from Bahia.

The discovery of these new records of tree species in Bahia is possible due to biases which result in some areas little sampled (e.g. Daru et al. 2018; Hughes et al. 2021; Ostroski et al. 2020; Zwiener et al. 2021). Generalist floristic sampling generally seeks representative and best-preserved areas of the various vegetation types; the aim of such sampling is to reveal floristic richness and endemism (Werneck et al. 2011), and this is often done within legally protected reserves. Areas sampled by plant taxonomists tend to be those where taxa of interest have been previously reported; this is a strategy to optimize resources and efforts for data collection, and these areas are also not infrequently the most representative and best preserved (Werneck et al. 2011). Such a historical context causes sampling bias in flora sampling.

Our observations and records were made mostly in areas in Bahia characterized by intense habitat destruction, as exemplified in Figurere 1R; it is these kinds of areas that often lack detailed botanical documentation (Sousa-Baena et al. 2013; Zwiener et al. 2021). We sampled remote areas that are far away from large cities and, consequently, from universities, herbaria, and consolidated graduate programs. Furthermore, the areas are all outside any legally protected reserves, which are less numerous in the extreme south of Bahia than in the southern region, where there has been more sampling done (Ostroski et al. 2020).

All these conditions are known to originate bias in data collection (Daru et al. 2018; Hughes et al. 2021; Zwiener et al. 2021) and help to explain the discovery of overlooked species. The areas where the new records originated are within or near priority areas for biodiversity conservation in the Caatinga, Cerrado, and Atlantic Forest biomes (BRASIL 2007) in a region with the potential to lead to the discovery of undocumented plant species.

Our findings illustrate the importance of environmental studies during the licensing process in contributing towards the biodiversity knowledge, as argued by Moura et al. (2018). Field observation data from such studies, especially in regions with a greatly diverse flora such Bahia, can provide important floristic records that contribute to species' distribution and aid in conservation, especially when trained botanists are involved (Moura et al. 2018).

As demonstrated by Ahrends et al. (2011), trained botanists record both more species and more species of conservation concern, especially endemic and threatened species. Their participation increases the recording efficiency and data reliability and supports conservation planning (Ahrends et al. 2018). Our data support the conclusions of Ahrends et al. (2018), since we discovered, in highly human-modified areas, rarely encountered tree species that could easily be overlooked through rapid sampling.

Such highly human-modified areas are characterized by the predominance of extensive cattle pastures and the scarcity of trees; in these areas the presence of rare and/or threatened species would not be expected. While highly human-modified areas can appear as having little value for biodiversity, our findings suggest that they are not to be underestimated during environmental studies for licensing processes, especially in phytogeographic domains with high floristic and vegetational diversity such as the Atlantic Forest.

In addition to contributing to the knowledge of the five species discussed herein, our results add up-to-date field information for these state or globally threatened taxa; such data are critical for the development of conservation action plans for these species (Couch et al. 2022; Vercillo et al. 2023). It is important to consider that field surveys, such as those in our study, provide an opportunity to observe varied

environments, often in anthropic and difficult-to-access rural areas, that otherwise would probably not have been the studied by botanists. Thus, our results can help managers define conservation policies focusing on species or areas that include the five species studied here.

Furthermore, our data can add to the Flora e Funga do Brasil (2023a), as well as Red Lists of threatened species, at state, national, and global levels. Particularly, we suggest that *H. diamantinensis* and *P. velutinicarpa* be included in the next version of the List of Threatened Taxa Endemic to Bahia (Bahia 2017).

Red Lists are an important tool for conservation (Rodrigues et al. 2006; Convention on Biological Diversity 2012). The assessment of the conservation status of all plant species has been a target of the Global Strategy for Plant Conservation; assessments can help guide conservation actions (Convention on Biological Diversity 2012). While maintaining Red Lists and updating online floras can be challenging, this is critical for achieve high quality in both academic and environmental licensing studies. Floristic data and conservation status can support conservation strategies and mitigation action plans that are often required for the obtaining of environmental licenses. Moreover, publicizing field photos of threatened species should be promoted to facilitate identification by non-specialists during environmental studies and avoid these species being overlooked. Such photographs can also aid in verification of these species in field by professionals who work for environmental inspection agencies.

The results of our study should encourage the monitoring of these five species in the wild, especially at the sites of the new occurrence where additional data, including population size and area of occupancy, can be collected; additional data would be useful refining the conservation assessments of these species and contribute to the knowledge and conservation of the species as a whole and to national Red Lists status of the species (Keller and Bollmann 2004). Conservation status is, by definition, not definitive and must be reevaluated whenever new data are available. Listing a species in Red Lists does not guarantee its conservation, and taxonomists are often better placed to assess conservation status than non-specialists in taxonomic groups due to more comprehensive understanding of the species in the field and specimens in herbaria.

Thus, we make a call for plant taxonomists: do not refrain from assessing a species as threatened if it meets the widely adopted IUCN criteria. This is especially critical when fragmentation and loss of habitat are evident, such as in the Brazilian Atlantic Forest, where only 11–16% (Ribeiro et al. 2009) or 28% of native vegetation remains (Rezende et al. 2018).

Finally, we argue that environmental studies for licensing processes may benefit from reciprocal collaboration between private sector and academics. Furthermore, such collaboration could be led by public power through university and research institutes, and especially state regulatory and inspection agencies, to ensure the participation of trained botanists. Consequently, this would contribute not only to the quality of environmental studies but also to the knowledge and conservation of native flora and vegetation.

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ADDITIONAL INFORMATION

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The authors declare that no competing interests exist.

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No ethical statement is reported.

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Author contributions
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Author ORCID iDs
Jefferson Carvalho-Sobrinho https://orcid.org/0000-0003-3605-0707
Lander de Jesus Alves https://orcid.org/0000-0003-4448-6594
Aline Costa Mota https://orcid.org/0000-0002-8440-1420

Data availability
All data that support the findings of this study are available in the main text.

REFERENCES

Ahrends A, Carsten R, Bulling MT, Burgess ND, Platts PJ, Lovett JC, Kindemba VW, Owen N, Sallu AN, Marshall AR, Mhoro BE, Fanning E, Marchant R (2011) Conservation and the botanist effect. Biological Conservation 144 (1): 131–140. https://doi.org/10.1016/j.biocon.2010.08.008

Allemão FF, Allemão MF (1862) *Pterygota brasiliensis*. Trabalhos da Commissão Scientifica de Exploração, Secção Botânica 1: 7–9, 1 pl.

Alves-Araújo A, Alves M (2012) *Pouteria ciliata*, *P. confusa*, *P. nordestinensis* and *P. velutinicarpa* spp. nov. (Sapotaceae) from Brazil. Nordic Journal of Botany 30 (4): 399–406. https://doi.org/10.1111/j.1756-1051.2011.01259.x

Alves-Araújo A, Nichio-Amaral R (2023) *Pouteria*. In: Flora e Funga do Brasil. Jardim Botânico do Rio de Janeiro, Rio de Janeiro, Brazil. https://floradobrasil.jbrj.gov.br/FB127553. Accessed on: 2023-10-12.

Amorim AM, Thomas WW, de Carvalho AMV, Jardim JG (2008) Floristic of the Una Biological Reserve, Bahia, Brazil. Memoirs of the New York Botanical Garden 100: 67–146.

Amorim AM, Fiaschi P, Jardim JG, Thomas WW, Clifton BC, de Carvalho AMV (2005) The vascular plants of a forest fragment in southern Bahia, Brazil. Sida 21 (3): 1727–1752.

Amorim AM, Jardim JG, Lopes MMM, Fiaschi P, Borges RAX, Perdiz RO, Thomas WW (2009) Angiospermas em remanescentes de floresta montana no sul da Bahia, Brasil. Biota Neotropica 9 (3): 313–348. https://doi.org/10.1590/s1676-06032009000300028

Bachman S, Moat J, Hill AW, de la Torre J, Scott B (2011) Supporting Red List threat assessments with GeoCAT: geospatial conservation assessment tool. In: Smith V, Penev L (Eds.) e-Infrastructures for data publishing in biodiversity science. ZooKeys 150: 117–126. https://doi.org/10.3897/zookeys.150.2109

Bahia (2012) Decreto Estadual nº 14.024/2012. http://www.seia.ba.gov.br/legislacao-ambiental/decretos/decreto-n-12024. Accessed on: 2023-09-28.

Bahia (2016) Portaria INEMA nº 11.292 de 13/02/2016. https://cdn.agenciapeixevivo.org.br/media/2020/02/Portaria_INEMA_n_11.292_2016consolidada.pdf. Accessed on: 2023-09-28.

Bahia (2017) Portaria SEMA nº 40 de 21 de agosto de 2017, Lista Oficial das Espécies Endêmicas da Flora Ameaçadas de Extinção do Estado da Bahia. Diário Oficial do Estado da Bahia, ed. 22244: 22.

Brasil (1981) Lei nº 6.938, de 31 de agosto de 1981. Dispõe sobre a Política Nacional do Meio Ambiente, seus fins e mecanismos de formulação e aplicação, e dá outras providências. https://www.planalto.gov.br/ccivil_03/leis/l6938.htm. Accessed on: 2023-10-22.

Brasil (1997) Ministério do Meio Ambiente (MMA). Conselho Nacional do Meio Ambiente (CONAMA). Resolução CONAMA nº 237, de 19 de dezembro de 1997. https://www.ibama.gov.br/sophia/cnia/legislacao/MMA/RE0237-191297.PDF. Accessed on: 2023-10-22.

Brasil (2007) Ministério do Meio Ambiente (MMA). Portaria nº 463 de 18 de dezembro de 2018. Diário Oficial da União 243 (1): 160. https://www.in.gov.br/materia/-/asset_publisher/Kujrw0TZC2Mb/content/id/55881195/do1-2018-12-19-portaria-n-463-de-18-de-dezembro-de-2018-55880954. Accessed on: 2023-10-24.

Brasil (2011) Lei Complementar nº 140, de 8 de dezembro de 2011. Fixa normas para a cooperação entre a União, os Estados, o Distrito Federal e os Municípios nas ações administrativas decorrentes do exercício da competência comum relativas à proteção das paisagens naturais notáveis, à proteção do meio ambiente, ao combate à poluição em qualquer de suas formas e à preservação das florestas, da fauna e da flora, e dá outras providências. https://www.planalto.gov.br/ccivil_03/leis/lcp/lcp140.htm. Accessed on: 2024-02-10.

Brasil (2022) Portaria MMA nº 148 de 07 de junho de 2022. Lista Nacional de Espécies Ameaçadas de Extinção. Diário Oficial da União 108 (1): 74. https://in.gov.br/en/web/dou/-/portaria-mma-n-148-de-7-de-junho-de-2022-406272733. Accessed on: 2023-10-24.

Camargo RA, Tozzi AMGA (2013) A synopsis of the genus *Deguelia* (Leguminosae, Papilionoideae, Milllettieae) in Brazil. Brittonia 66 (1): 12–32.

Convention on Biological Diversity (2012) Global strategy for plant conservation: 2011–2020. Botanic Gardens Conservation International, Richmond, UK, 36 pp.

Couch C, Molmou D, Magassouba S, Doumbouya S, Diawara M, Diallo MY, Keita SM, Koné F, Diallo MC, Kourouma S, Diallo MB, Keita MS, Oularé A, Darbyshire I, Gosline G, Lughadha EN, Burgt X, Larridon I, Cheek M (2022) Piloting development of species conservation action plans in Guinea. Oryx 57 (4): 497–506. https://doi.org/10.1017/s0030605322000138

Daru BH, Park DS, Primack RB, Willis CG, Barrington DS, Whitfeld TJS, Seidler TG, Sweeney PW, Foster DR, Ellison AM, Davis CC (2018) Widespread sampling biases in herbaria revealed from large-scale digitization. New Phytologist 217 (2): 939–955. https://doi.org/10.1111/nph.14855

Dean W (2004) A ferro e fogo: a história e a devastação da Mata Atlântica brasileira. 1. ed. Companhia das Letras, São Paulo, Brazil, 484 pp.

Espírito Santo F da S, da Silva-Castro MM, Rapini A (2012) Two new species of *Handroanthus* Mattos (Bignoniaceae) from the state of Bahia, Brazil. Acta Botanica Brasilica 26 (3): 651–657. https://doi.org/10.1590/S0102-33062012000300014.

Espírito Santo F da S, da Silva-Castro MM, Rapini A (2013) Flora of Bahia: Bignoniaceae 2 – *Tabebuia* Alliance. Sitientibus série Ciências Biológicas 13: 1–38.

Fernandes-Júnior AJ (2023) *Pterygota* in Flora e Funga do Brasil. Jardim Botânico do Rio de Janeiro, Rio de Janeiro, Brazil. https://floradobrasil.jbrj.gov.br/FB9197. Accessed on: 2023-09-20.

Fernandez E, Moraes M, Martinelli G, Lohmann L (2021) *Handroanthus diamantinensis*. The IUCN Red List of Threatened Species 2021: e.T189433307A189613312. https://doi.org/10.2305/iucn.uk.2021-2.rlts.t189433307a189613312.pt. Accessed on: 2023-10-19.

Fernandez E, Arguello L, Jordão L, Martinelli G, Carneiro C (2020) *Pouteria velutinicarpa*. The IUCN Red List of Threatened Species 2020: e.T180254922A180254930. https://doi.org/10.2305/iucn.uk.2020-3.rlts.t180254922a180254930.pt. Accessed on: 2023-10-19.

Flora e Funga do Brasil (2023a) Jardim Botânico do Rio de Janeiro. https://reflora.jbrj.gov.br/consulta/. Accessed on: 2023-10-17.

Flora e Funga do Brasil (2023b) *Deguelia costata* in Flora e Funga do Brasil. Jardim Botânico do Rio de Janeiro, Rio de Janeiro, Brazil. https://floradobrasil.jbrj.gov.br/FB101067. Accessed on: 2023-09-20.

Fonseca GAB (1985) The vanishing Brazilian Atlantic Forest. Biological Conservation 34 (1): 17–34. https://doi.org/10.1016/0006-3207(85)90055-2

GBIF (2023) GBIF occurrence download. https://doi.org/10.15468/dl.69ha97. Accessed on: 2023-09-25.

Gentry AH (1992) Bignoniaceae: part II (tribe Tecomeae). Flora Neotropica 25 (2): 1–370.

Giulietti AM, Queiroz LP, Silva TRS, França F, Guedes ML, Amorim AM (2006) Flora da Bahia. Sitientibus Série Ciências Biológicas 6 (3): 169–173. https://doi.org/10.13102/scb8174

Harley RM (1995) Introduction. In: Stannard BL (Ed.) Flora of the Pico das Almas, Chapada Diamantina, Brazil. Royal Botanic Gardens, Kew, UK, 1–42.

Harley RM, Giulietti AM (2004) Flores nativas da Chapada Diamantina. RiMa, São Carlos, Brazil. 319 pp.

Hughes AC, Orr MC, Ma K, Costello MJ, Waller J, Provoost P, Yang, Q, Zhu C, Qiao H (2021) Sampling biases shape our view of the natural world. Ecography 44 (9): 1259–1269. https://doi.org/10.1111/ecog.05926

IBGE (2023a) Cidades e estados do Brasil. https://cidades.ibge.gov.br/brasil/ba/pindai/panorama. Accessed on: 2023-10-11.

IBGE (2023b) Biomas. https://www.ibge.gov.br/geociencias/cartas-e-mapas/informacoes-ambientais/15842-biomas.html. Accessed on: 2023-11-20.

IUCN Standards and Petitions Committee (2022) Guidelines for using the IUCN Red List categories and criteria. Version 15.1. Prepared by the Standards and Petitions Committee. http://www.iucnredlist.org/documents/RedListGuidelines.pdf. Accessed on: 2023-09-28.

Juncá F, Funch L, Rocha W (2005) Biodiversidade e conservação da Chapada Diamantina. Ministério do Meio Ambiente, Brasília, 435 pp. https://antigo.mma.gov.br/publicacoes/biodiversidade/category/142-serie-biodiversidade.html?start=40. Accessed on: 2023-12-06.

Kamino LHY, Oliveira-Filho AT, Stehmann JR (2008) Relações florísticas entre as fitofisionomias florestais da Cadeia do Espinhaço, Brasil. Megadiversidade 4 (1–2): 39–49.

Keller V, Bollmann K (2004) From Red Lists to Species of Conservation Concern. Conservation Biology 18 (6): 1636–1644. https://doi.org/10.1111/j.1523-1739.2004.00464.x

Lohmann LG, Kaehler M, Fonseca LHM, Farias-Singer R, Firetti F, Silva-Castro MM, Gomes BM, Frazão A, Francisco JNC, Thode VA, Zuntini AR, Medeiros MCMP, Kataoka EY, Beyer M (2023) Bignoniaceae in Flora e Funga do Brasil. Jardim Botânico do Rio de Janeiro, Rio de Janeiro, Brazil. https://floradobrasil.jbrj.gov.br/FB112305. Accessed on: 2023-10-12.

Martini AMZ, Fiaschi P, Amorim AM, Paixão JL (2007) A hot-point within a hot-spot: a high diversity site in Brazil's Atlantic Forest. Biodiversity and Conservation16 (11): 3111–3128. https://doi.org/10.1007/s10531-007-9166-6

Mori SA, Boom BM, de Carvalho AM, dos Santos TS (1983) Southern Bahian Moist Forests. The Botanical Review 49 (2): 155–232. https://doi.org/10.1007/bf02861011

Moura EO, Sousa VF, Soares AS, Versieux LM (2018) Private environmental consultancy reveals five genera and ten species of angiosperms new to Rio Grande do Norte state, northeastern Brazil. Check List 14 (2): 439–451. https://doi.org/10.15560/14.2.439

Murray-Smith C, Brummitt NA, Oliveira-Filho AT, Bachman S, Moat J, Lughadha EMN, Lucas EJ (2009) Plant Diversity Hotspots in the Atlantic Coastal Forests of Brazil. Conservation Biology 23 (1): 151–163. https://doi.org/10.1111/j.1523-1739.2008.01075.x

Ostroski P, Saiter FZ, Amorim AM, Fiaschi P (2020) Angiosperm endemism in a Brazilian Atlantic Forest biodiversity hot-point. Brazilian Journal of Botany 43: 397–404. https://doi.org/10.1007/s40415-020-00603-w

QGIS.org (2023) QGIS Geographic Information System. QGIS Association. http://www.qgis.org. Accessed on: 2023-10-17.

Rezende CL, Scarano FR, Assad ED, Joly CA, Metzger JP, Strassburg BBN, Tabarelli M, Fonseca GA, Mittermeier RA (2018) From hotspot to hopespot: an opportunity for the Brazilian Atlantic Forest. Perspectives in Ecology and Conservation 16 (4): 208–214. https://doi.org/10.1016/j.pecon.2018.10.002

Ribeiro MC, Metzger JP, Martensen AC, Ponzoni FJ, Hirota MM (2009) The Brazilian Atlantic Forest: How much is left, and how is the remaining forest distributed? Implications for conservation. Biological Conservation 142 (6): 1141–1153. https://doi.org/10.1016/j.biocon.2009.02.021

Rodrigues ASL, Pilgrim JD, Lamoreux JF, Hoffmann M, Brooks TM (2006) The value of the IUCN Red List for conservation. Trends in Ecology and Evolution 21 (2): 71–76. https://doi.org/10.1016/j.tree.2005.10.010

Saatchi S, Agosti D, Alger K, Delabie J, Musinsky J (2001) Examining fragmentation and loss of primary forest in the southern Bahian Atlantic Forest of Brazil with Radar Imagery. Conservation Biology 15 (4): 867–875. https://doi.org/10.1046/j.1523-1739.2001.015004867.x

Sousa-Baena MS, Garcia LC, Peterson AT (2014) Completeness of digital accessible knowledge of the plants of Brazil and priorities for survey and inventory. Diversity and Distributions 20 (4): 369–381. https://doi.org/10.1111/ddi.12136

Tabarelli M, Pinto LP, Silva JMC, Hirota M, Bedê L (2005) Challenges and opportunities for biodiversity conservation in the Brazilian Atlantic Forest. Conservation Biology 19 (3): 695–700. https://doi.org/10.1111/j.1523-1739.2005.00694.x

Thomas WW, Carvalho AMVD, Amorim AMA, Garrison J, Arbelaez AL (1998) Plant endemism in two forests in southern Bahia, Brazil. Biodiversity and Conservation 7 (3): 311–322. https://doi.org/10.1023/A:1008825627656

Vercillo UE, Morato RG, Cunha AA, de Marco P, Strier KB, Mittermeier RA, de Franco JLA (2023) Action plans for species conservation are an important tool to meet global and national biodiversity targets—a study case in Brazil. Journal for Nature Conservation 71: 126324. https://doi.org/10.1016/j.jnc.2022.126324

Werneck MS, Sobral M, Rocha CTV, Landau EC, Stehmann JR (2011) Distribution and endemism of angiosperms in the Atlantic Forest. Natureza & Conservação 9 (2): 188–193. https://doi.org/10.4322/natcon.2011.024

Zwiener VP, de Lima RAF, Sánchez-Tapia A, Rocha DSB, Marques MCM (2021) Tree diversity in the Brazilian Atlantic Forest: biases and general patterns using different sources of information. In: Marques MCM, Grelle CEV (Eds.) The Atlantic Forest. Springer, Cham, Switzerland, 115–131. https://doi.org/10.1007/978-3-030-55322-7_6