Biota Neotropica 18(4): e20180544, 2018
www.scielo.br/bn

biotaneotropica
ISSN 1676-0611 (online edition)
Article

Endemic angiosperms in Bahia Coastal Forests, Brazil: an update using a newly delimited area

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OSTROSKI, P., SAITER, F. Z., AMORIM, A. M., FIASCHI, P. **Endemic angiosperms in Bahia Coastal Forests, Brazil: an update using a newly delimited área**. Biota Neotropica. 18(4): e20180544. http://dx.doi.org/10.1590/1676-0611-BN-2018-0544

Abstract: The forest along the coast of Bahia state, in northeastern Brazil, has been acknowledged as an area of endemism for several groups of organisms. The first study concerning endemic angiosperm species in this region, through which 395 taxa were registered, was conducted 15 years ago. However, this number is probably underrated. In this article, we present an updated checklist of angiosperm taxa in Bahia Coastal Forests (BCF) based on geographic distribution data available from the Brazilian Plant List (Flora do Brasil 2020). The records were checked in herbaria, recent taxonomic literature, and, when necessary, reviewed by experts. The final checklist consists of 547 taxa endemic to BCF, distributed in 69 families, with seven endemic genera: *Bahiella* (Apocynaceae), *Santosia* (Asteraceae), *Harleyodendron* (Fabaceae), *Cubitanthus* (Linderniaceae), *Anomochloa* and *Parianella* (Poaceae), and *Andreadoxa* (Rutaceae). The families with highest richness in endemic taxa were Bromeliaceae (108 spp.), Fabaceae (41 spp.) and Myrtaceae (32 spp.). This updated checklist shares only 143 taxa with a previous list published about 15 years ago. Those two lists differ mostly due to slightly different area limits, and to the large number of additional endemic species described since then. We hope our list will be used as a resource in future studies and contributes to the conservation of the highly diverse Bahia Coastal Forest.
Keywords: *Atlantic Forest, checklist, conservation, endemism, hotspot.*

Angiospermas endêmicas da Floresta Costeira da Bahia, Brasil: uma atualização utilizando uma nova delimitação de área

Resumo: A floresta costeira do estado da Bahia, no nordeste do Brasil, tem sido apontada como área de endemismo para diversos grupos de organismos. O primeiro levantamento de espécies de angiospermas endêmicas dessa região foi realizado há cerca de 15 anos e revelou a ocorrência de 395 táxons. Entretanto, esse número provavelmente está subestimado. Neste trabalho apresentamos uma lista atualizada de táxons de angiospermas endêmicas da Floresta Costeira da Bahia (FCB), tendo como base as informações de distribuição geográfica disponíveis na lista da Flora do Brasil. Estas informações foram posteriormente checadas em registros de herbários, estudos taxonômicos recentes e, quando necessário, revisadas por especialistas. A lista final de espécies é constituída por 547 táxons endêmicos da Floresta Costeira da Bahia, distribuídos em 69 famílias e incluindo sete gêneros endêmicos: *Bahiella* (Apocynaceae), *Santosia* (Asteraceae), *Harleyodendron* (Fabaceae), *Cubitanthus* (Linderniaceae), *Anomochloa* e *Parianella* (Poaceae), and *Andreadoxa* (Rutaceae). As famílias mais ricas em táxons endêmicos são Bromeliaceae (108 spp.), Fabaceae (41 spp.) e Myrtaceae (32 spp.). Apenas 143 táxons são compartilhados por esta lista atualizada e uma lista preliminar publicada há cerca de 15 anos. As duas listas diferem especialmente por ligeiras diferenças nos limites da área de estudo e também pelo acréscimo de novas espécies endêmicas descritas desde então. Espera-se que a lista seja usada como ferramenta para estudos futuros e para a conservação da rica flora costeira da Bahia.
Palavras-chave: *Checklist, conservação, endemismo, hotspot, Mata Atlântica.*

Introduction

The Atlantic Forest is considered a biodiversity hotspot due to the occurrence of a high number of endemic and threatened species (Myers et al. 2000). The natural distribution of the Atlantic Forest was originally continuous along the Brazilian coast and extended to some areas in Argentina and Paraguay (Fundação SOS Mata Atlântica 2013). Nowadays, it is one of the eight most critically endangered hotspots, as only 12,5% of the original forest remains (Fundação SOS Mata Atlântica 2014). Nevertheless, it is the richest Brazilian phytogeographic domain in plant diversity, with 8,728 endemic species of angiosperms (Flora do Brasil 2020, under construction).

Some studies have emphasized the division of the Atlantic Forest in northern and southern regions (Cracraft 1985, Colombi et al. 2010, Martins 2011) with a limit along the Doce river, in the north of Espírito Santo state. The floristic differences between these two regions were highlighted by Oliveira-Filho & Fontes (2000) and Oliveira-Filho et al. (2005), who observed several taxa with Amazonian affinities occuring in the northern region, while taxa with subtropical Andean affinities are mostly found in the southern region (Berry et al. 2004, Santos et al. 2007, Menini Neto et al. 2016). Other authors recognize three main centers of endemism in the Atlantic Forest: northern (Pernambuco and Alagoas states), southern (from Rio de Janeiro to Santa Catarina states), and central (southern Bahia and Espírito Santo states) (Murray-Smith et al. 2009, Thomas et al. 1998).

Recently, Saiter et al. (2016a) divided the central region of the Atlantic Forest in three subregions based on the composition of tree species, indicating the most important abiotic factors affecting that division. Contrary to previous knowledge, the rivers did not play an important role in this division, which lies about 100 km north of the Doce river and is best explained by climatic factors, such as moisture, elevation and temperature (Saiter et al. 2016a). One of the regions, referred to as Bahia Coastal Forests (BCF) by Saiter et al. (2016a), encompasses the northern extreme of Espírito Santo and most of the coast of the state of Bahia. Due to high biodiversity and the incidence of endemic and threatened species, this region has been designated as a hot-point within the Atlantic Forest hotspot (Martini et al. 2007). Many studies to this date on different groups of organisms support this claim, as the region is considered an area of endemism for frogs (Carnaval et al. 2009), birds (Silva et al. 2004), Myrtaceae (Murray-Smith et al. 2009) and trees in general (Thomas et al. 2003).

An estimate of endemic vascular plant species present in two protected areas in southern Bahia showed that the distribution of 59% of the species is restricted to Bahia and Espírito Santo states (Thomas et al. 1998). These results motivated the compilation of a preliminary list of endemic angiosperm species in the region comprising Espírito Santo to the north of the Doce river and the south of Bahia, including inland Seasonal Dry Forests (Thomas et al. 2003) (Figure 1a). This list consisted of 395 endemic species of angiosperms in the region (Thomas et al. 2003), among which several are known to occur only in dry forests, such as *Chrysophyllum subspinosum* Monach. (Sapotaceae) and *Colicodendron bahianum* Cornejo & Ilts (Capparaceae). That study reported eight endemic genera in this area: *Arapatiella* R.S.Cowan, *Brodriguesia* R.S.Cowan and *Harleyodendron* R.S.Cowan (Fabaceae), *Atractantha* McClure, *Anomochloa* Brogn., *Alvimia* Calderón ex Soderstr. & Londoño, and *Sucrea* Soderstr. (Poaceae), and *Trigoniodendron* E.F.Guim & Miguel (Trigoniaceae) (Thomas et al, 2003).

Checklists of endemic taxa are critical to overcome issues that hinder conservation strategies in highly biodiverse regions, such as: 1) basic taxonomic information (Linnean shortfall, or "which species are there?"), and 2) lack of geographic information (Wallacean shortfall, or "where do these species occur?") (Whittaker et al. 2005). Both shortfalls are part of reality in Bahia Coastal Forests, world-renowned as one of the highest diversity areas in tree species (Thomas et al. 1998, Martini et al. 2007, Murray-Smith et al. 2009).

We aimed to provide a list of endemic species of angiosperms in Bahia Coastal Forest following Saiter et al. (2016a) to verify whether the current list agrees with the preliminary checklist by Thomas et al. (2003). We expect this updated list to further highlight the importance of BCF as a critical area for biodiversity conservation in the Brazilian Atlantic forest.

Material and Methods

1. *Study area*

To delimit the study area we used the BCF *sensu* Saiter et al. (2016a) (Figure 1b) with a slight modification to include the municipalities whose territory was at least 50% inside that perimeter. Municipalities were used as a base for the retrieval of taxonomic information from online datasets (see data collection). To remove the arbitrary northern limit from Saiter et al. (2016a) (Figure 1b), the study area was expanded to include seven municipalities complying with the 50% territory criterion (Figure 1c). Municipal limits were defined based on data from the Brazilian Institute for Geography and Statistics (IBGE 1993) (Figure 1c).

The resulting area comprised 156 municipalities, which account for approximately 99,000 km^2 (Figure 1c) at southern Bahia state, and a small fraction from northern Espírito Santo state and northeastern Minas Gerais state, contrasting with an area of about 119,000 km^2 at southern Bahia which included more inland areas, and northen Espírito Santo with a southern limit at the Doce River (Thomas et al. 2003) (Figure 1a).

2. *Data collection*

To compile the checklist of endemic species of angiosperms in BCF, we started by performing a data search in the Brazilian Plant List (Flora do Brasil 2020) on March 9, 2017, using the following filters simultaneously: "group: angiosperms", "endemism: only endemic to Brazil", "origin: native", "state: Bahia", and "phytogeographic domain: Atlantic Forest". We decided not to search only for species endemic to the Atlantic Forest in Bahia to avoid excluding species that could also occur in the north of Espírito Santo and in a small area in northeastern Minas Gerais (Figure 1c). The initial search resulted in 3,338 species, 59 subspecies and 154 varieties (3,551 taxa). These records were then checked in the SpeciesLink database (splink.cria.org.br). Each taxon map generated by the SpeciesLink website was visually checked, first to remove taxa that were clearly not endemic to BCF, i.e. those with several records outside the study area. Each of the 1,336 remaining taxa were then mapped with QGis 2.14 (Quantum GIS Development Team 2016) and we verified whether the points of occurrence were enclosed in the limits of the study area, which resulted in the further removal of 701 taxa.

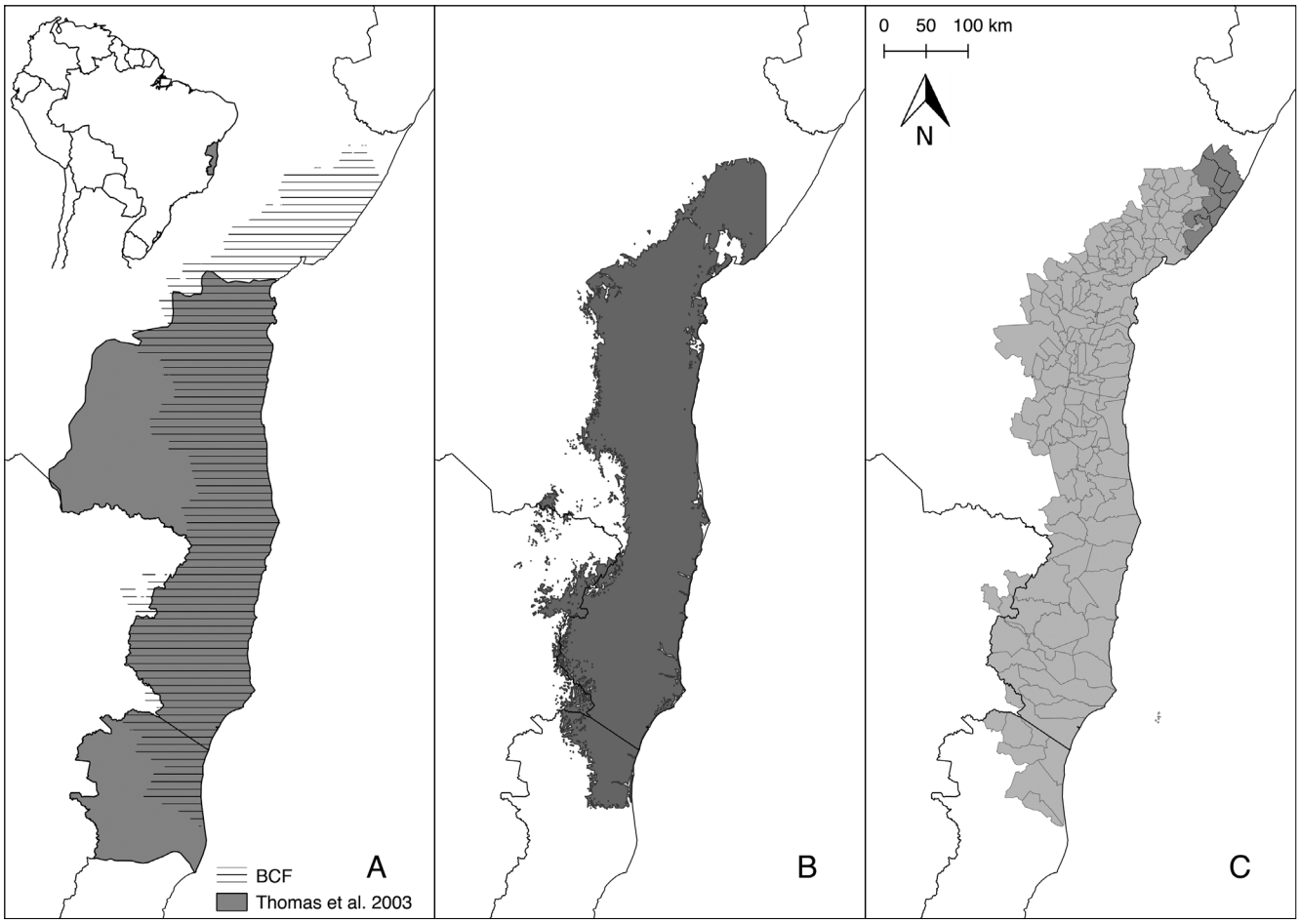

Figure 1. a) Study area in which Thomas et al. (2003) based their list of endemic species. b) Bahia Coastal Forest (BCF) according to Saiter et al. (2016a). c) Municipalities with at least 50% of its area within the BCF (light grey), and those added to the study area based on IBGE (1993) (dark grey). Coordinates: UTM. Datum WGS 84.

From the 635 taxa left, the records with incongruent data were verified by experts or checked using recent taxonomic studies (Appendix 1). This step resulted in 30 additional non-endemic species discarded from the list. The taxa for which no scientific records were found in Google Scholar (scholar.google.com), Biodiversity Heritage Library (biodiversitylibrary.com), SpeciesLink (splink.cria.org.br), and the Brazilian Plant List (Flora do Brasil 2020) were complemented by a search for location records in the CEPEC herbarium. Once this verification was completed, 53 species from the list had to be removed because no records were available and a further five species were removed due to lack of precise geographic information.

Results

The final checklist consisted of 547 angiosperm taxa endemic to BCF (535 species, six subspecies, and six varieties) in 69 families (none endemic) and 230 genera (Table 1). Seven genera are endemic to BCF: *Bahiella* J.F.Morales (Apocynaceae), *Santosia* R.M.King & H.Rob. (Asteraceae), *Harleyodendron* (Fabaceae, Figure 2f), *Cubitanthus* Barringer (Linderniaceae), *Anomochloa* and *Parianella* Hollowell, F.M.Ferreira & R.P.Oliveira (Poaceae), and *Andreadoxa* Kallunki (Rutaceae). The genera with the highest number of endemic species in the BCF were *Aechmea* Ruiz & Pav. (Bromeliaceae) (33 spp.), *Pavonia* Cav. (Malvaceae) and *Myrcia* DC. (Myrtaceae), each with 16 species. The three families with the highest numbers of endemic taxa (species + infraspecific taxa) were Bromeliaceae (108), Fabaceae (41) and Myrtaceae (32).

Discussion

The families with the highest numbers of endemic taxa in BCF are also among the ten richest angiosperm families in Brazil and in the Atlantic Forest (BFG 2015). Thomas et al. (2003) reported Fabaceae (53 spp.) as the richest family of a total of 65 families in the previous list. Compared with the BFG (2015), it is remarkable that Orchidaceae, one of the three richest families in Brazil and in the Atlantic Forest, was not among the richest families in this study, with only 25 taxa. This may be due to the lack of geographic records for 14 species in this family, which had to be discarded.

Among the 20 richest angiosperm genera in Brazil (BFG 2015), *Aechmea* and *Myrcia* are also among the genera with the highest number of endemic species in the BCF. In a preliminary list of the endemic angiosperm species from southern Bahia and northern Espírito Santo, Thomas et al. (2003) cited *Conchocarpus* J.C.Mikan (Rutaceae) (19 spp.) as the richest genus, followed by *Pavonia* Cav. (Malvaceae) (13 spp.), *Couepia* Aubl., and *Erythroxylum* P.Browne (seven spp. each).

Table 1. Checklist of angiosperms endemic to Bahia Coastal Forest *sensu* Saiter et al. (2016a). * Taxon also in Thomas et al. (2003).

Acanthaceae

Aphelandra ignea Nees ex Steud.

Clistax bahiensis Profice & Leitman

Harpochilus phaeocarpus Nees

Herpetacanthus magnobracteolatus Indriunas & Kameyama

Herpetacanthus strongyloides Indriunas & Kameyama

Herpetacanthus tetrandrus (Nees & Mart.) Herter

Justicia antirrhina Nees & Mart.

Justicia physogaster Lindau

Lepidagathis cuneiformis Kameyama

Mendoncia bahiensis Profice

Mendoncia blanchetiana Profice

Pseuderanthemum albiflorum (Hook.) Radlk.

Pseuderanthemum verbenaceum (Nees & Mart.) Radlk.

Ruellia sessilifolia (Nees) Lindau

Schaueria gonyostachya (Nees & Mart.) Nees

Schaueria hirsuta Nees

Schaueria marginata Nees

Schaueria pyramidalis A.L.A.Côrtes

Achariaceae

Kuhlmanniodendron macrocarpum Groppo, Favaretto & Fiaschi

Amaranthaceae

Lecosia formicarum Pedersen

Amaryllidaceae

Griffinia arifolia Ravenna

Griffinia parviflora Ker Gawl.

Griffinia paubrasilica Ravenna

Annonaceae

Annona bahiensis (Maas & Westra) H.Rainer *

Duguetia magnolioidea Maas *

Duguetia restingae Maas *

Duguetia reticulata Maas *

Guatteria stenocarpa Lobão, Maas & Mello-Silva

Hornschuchia cauliflora Maas & Setten *

Hornschuchia leptandra D.M.Johnson *

Hornschuchia obliqua Maas & Setten *

Hornschuchia polyantha Maas *

Hornschuchia santosii D.M.Johnson *

Malmea obovata R.E.Fr. *

Pseudoxandra bahiensis Maas *

Unonopsis bahiensis Maas & Orava

Xylopia involucrata M.C.Dias & Kinoshita *

Apocynaceae

Aspidosperma thomasii Marc.-Ferr. *

Bahiella blanchetii (A.DC.) J.F.Morales

Bahiella infundibuliflora J.F.Morales

Continuation Table 1.

Lacmellea bahiensis J.F.Morales

Marsdenia carvalhoi Morillo & Carnevali

Matelea riparia Morillo

Matelea santosii Morillo & Fontella

Oxypetalum laciniatum Rapini & Farinaccio

Rauvolfia atlantica Emygdio

Araceae

Anthurium bromelicola subsp. *bahiense* Mayo et al. *

Anthurium illepidum Schott

Anthurium molle E.G.Gonç. & J.G.Jardim

Anthurium teimosoanum E.G.Gonç. & J.G.Jardim

Asterostigma riedelianum (Schott) Kuntze

Dracontioides salvianii E.G.Gonç.

Philodendron aemulum Schott

Zomicarpa steigeriana Maxim. ex Schott

Araliaceae

Schefflera aurata Fiaschi

Arecaceae

Bactris soeiroana Noblick ex A.J.Hend.

Geonoma pohliana subsp. *rubescens* (Wendland ex Drude) Henderson

Geonoma pohliana subsp. *unaensis* Henderson

Syagrus × *camposportoana* (Bondar) Glassman

Syagrus itapebiensis (Noblick & Lorenzi) Noblick & Meerow

Syagrus santosii K. Soares & C.A.Guim.

Aristolochiaceae

Aristolochia brunneomaculata I.Abreu & Giul.

Aristolochia longispathulata F.González *

Asparagaceae

Hagenbachia brasiliensis Nees & Mart.

Asteraceae

Acmella paniculata (Wall. ex DC.) R.K.Jansen

Austroeupatorium morii R.M.King & H.Rob.

Barrosoa atlantica R.M.King & H.Rob. *

Diacranthera hebeclinia H.Rob.

Litothamnus ellipticus R.M.King & H.Rob. *

Mikania amorimii Borges & Forzza

Mikania kubitzkii R.M.King & H.Rob. *

Mikania mattos-silvae R.M.King & H.Rob. *

Mikania santosii R.M.King & H.Rob. *

Piptocarpha riedelii (Sch.Bip.) Baker

Santosia talmonii R.M.King & H.Rob. *

Vernonanthura vinhae (H.Rob.) H.Rob. *

Begoniaceae

Begonia delicata Gregório & J.A.S.Costa

Begonia elianeae Gregório & J.A.S.Costa

Begonia epibaterium Mart. ex A.DC.

 http://dx.doi.org/10.1590/1676-0611-BN-2018-0544

Continuation Table 1.

Begonia goldingiana L.Kollmann & A.P.Fontana
Begonia mattos-silvae L.B.Sm. ex S.F.Sm. & Wassh. *
Begonia pinheironis L.B.Sm. ex S.F.Sm. & Wassh. *
Begonia russelliana L.B.Sm. ex S.F.Sm. & Wassh. *
Begonia saxifraga A.DC.
Begonia subacida Irmsch.
Begonia sylvatica Meisn. ex A.DC.
Bignoniaceae
Handroanthus parviflorus Espírito-Santo & M.M. Silva-Castro
Bromeliaceae
Aechmea amicorum B.R.Silva & H.Luther
Aechmea amorimii Leme *
Aechmea ampla L.B.Sm.
Aechmea andersoniana Leme & H.Luther
Aechmea andersonii H.Luther & Leme
Aechmea carvalhoi E.Pereira & Leme
Aechmea correia-araujoi E.Pereira & Moutinho
Aechmea curranii (L.B.Sm.) L.B.Sm. & M.A.Spencer
Aechmea digitata L.B.Sm. & R.W.Read
Aechmea discordiae Leme
Aechmea disjuncta (L.B.Sm.) Leme & J.A.Siqueira
Aechmea echinata (Leme) Leme *
Aechmea farinosa (Regel) L.B.Sm.
Aechmea glandulosa Leme
Aechmea gregaria Leme & L.Kollmann
Aechmea guaratingensis Leme & L.Kollmann
Aechmea heterosepala Leme
Aechmea incompta Leme & H.Luther
Aechmea ituberaensis Leme & L.Kollmann
Aechmea laevigata Leme
Aechmea lanata (L.B.Sm.) L.B.Sm. & M.A.Spencer
Aechmea limae Leme
Aechmea lymanii W.Weber
Aechmea miniata Beer ex Baker
Aechmea mira Leme & H.Luther
Aechmea mollis L.B.Sm.
Aechmea pendulispica Leme & L.Kollmann
Aechmea ramusculosa Leme
Aechmea tentaculifera Leme, Amorim & J.A. Siqueira
Aechmea turbinocalyx Mez
Aechmea viridipetala A.F.Costa & Amorim
Aechmea viridostigma Leme & H.Luther
Aechmea weberi (E.Pereira & Leme) Leme
Alcantarea cerosa Leme, A.P.Fontana & O.A.B.Ribeiro
Alcantarea pataxoana Versieux
Araeococcus montanus Leme

Continuation Table 1.

Araeococcus nigropurpureus Leme & J.A.Siqueira
Araeococcus sessiliflorus Leme & J.A.Siqueira
Billbergia fosteriana L.B.Sm.
Billbergia macrocalyx Hook.
Canistrum fosterianum L.B.Sm.
Canistrum guzmanioides Leme
Canistrum lanigerum H.Luther & Leme
Canistrum sandrae Leme
Canistrum seidelianum W.Weber
Cryptanthus colnagoi Rauh & Leme
Cryptanthus coriaceus Leme
Cryptanthus ilhanus Leme
Cryptanthus lyman-smithii Leme
Cryptanthus pseudopetiolatus Philcox *
Cryptanthus ruthiae Philcox
Cryptanthus ubairensis I.Ramírez
Cryptanthus vexatus Leme
Cryptanthus viridovinosus Leme
Cryptanthus walkerianus Leme & L.Kollmann
Hohenbergia barbarespina Leme & Fraga
Hohenbergia brachycephala L.B.Sm.
Hohenbergia burle-marxii Leme & W.Till
Hohenbergia capitata Schult. & Schult.f.
Hohenbergia castellanosii L.B.Sm. & Read
Hohenbergia correia-araujoi E.Pereira & Moutinho
Hohenbergia flava Leme & C.C.Paula
Hohenbergia hatschbachii Leme *
Hohenbergia itamarajuensis Leme & Baracho
Hohenbergia littoralis L.B.Sm.
Hohenbergia pabstii L.B.Sm. & Read
Hohenbergia reconcavensis Leme & Fraga
Hohenbergia sandrae Leme
Lymania alvimii (L.B.Sm. & R.W.Read) R.W.Read *
Lymania azurea Leme
Lymania brachycaulis (E.Morren ex Baker) L.F.Sousa
Lymania corallina (Brong. ex Beer) R.W.Read
Lymania globosa Leme
Lymania languida Leme
Lymania marantoides (L.B.Sm.) R.W.Read
Lymania spiculata Leme & Forzza *
Neoregelia azevedoi Leme
Neoregelia crispata Leme *
Neoregelia longisepala E.Pereira & I.A.Penna *
Neoregelia rothinessa Leme, H.Luther & W.Till
Neoregelia silvomontana Leme & J.A.Siqueira
Neoregelia viridolineata Leme

Continuation Table 1.

Neoregelia wilsoniana M.B.Foster
Orthophytum buranhense Leme & A.P.Fontana
Orthophytum guaratingense Leme & L.Kollmann
Orthophytum rubrum L.B.Sm.
Portea alatisepala Philcox *
Portea filifera L.B.Sm.
Portea grandiflora Philcox *
Portea kermesina K.Koch
Portea nana Leme & H.Luther
Quesnelia alborosea A.F.Costa & T.Fontoura
Quesnelia clavata Amorim & Leme
Quesnelia dubia Leme
Quesnelia koltesii Amorim & Leme
Ronnbergia brasiliensis E.Pereira & I.A.Penna *
Ronnbergia carvalhoi Martinelli & Leme *
Ronnbergia neoregelioides Leme
Ronnbergia silvana Leme
Vriesea dictyographa Leme
Vriesea graciliscapa W.Weber
Vriesea longisepala A.F.Costa
Vriesea minuta Leme
Vriesea minutiflora Leme
Vriesea roberto-seidelii W.Weber
Vriesea ruschii L.B.Sm. subsp. ruschii
Vriesea sandrae Leme
Vriesea silvana Leme

Burseraceae

Protium icicariba var. *talmonii* Daly *
Trattinnickia lorenziana Daly & M.F.F.Melo

Cactaceae

Rhipsalis hileiabaiana (N.P.Taylor & Barthlott) N.Korotkova & Barthlott *

Calophyllaceae

Kielmeyera itacarensis Saddi
Kielmeyera marauensis Saddi

Capparaceae

Colicodendron martianum Cornejo

Caryocaraceae

Caryocar edule Casar.

Chrysobalanaceae

Couepia bondarii Prance *
Couepia coarctata Prance *
Couepia impressa subsp. *cabraliae* Prance *
Couepia longipetiolata Prance *
Licania bahiensis Prance
Licania lamentanda Prance *

Continuation Table 1.

Licania littoralis Warm. var. *littoralis*
Licania santosii Prance *
Licania turbinata Benth.
Parinari alvimii Prance *

Clusiaceae

Tovomita iaspidis L.Marinho & Amorim
Tovomita megantha L.Marinho & Amorim

Commelinaceae

Dichorisandra jardimii Aona & M.C.E.Amaral
Dichorisandra leucophthalmos Hook.
Dichorisandra leucosepala Aona & M.C.E.Amaral
Dichorisandra marantoides Aona & Faden
Dichorisandra ordinatiflora Aona & Faden
Dichorisandra radicalis Nees & Mart.
Dichorisandra subtilis Aona & M.C.E.Amaral

Connaraceae

Connarus blanchetii var. *laurifolius* (Baker) Forero
Connarus cuneifolius Baker
Connarus portosegurensis Forero
Rourea bahiensis Forero *
Rourea carvalhoi Forero et al. *
Rourea discolor Baker
Rourea macrocalyx Carbonó et al. *
Rourea tenuis G.Schellenb.

Cucurbitaceae

Cayaponia nitida Gomes-Klein & Pirani
Fevillea bahiensis G.Rob. & Wunderlin
Gurania wawrei Cogn.

Cyclanthaceae

Asplundia maximiliani Harling

Cyperaceae

Becquerelia discolor Kunth
Hypolytrum bahiense M.Alves & W.W.Thomas *
Hypolytrum jardimii M.Alves & W.W.Thomas *
Hypolytrum lucennoi M.Alves & W.W.Thomas

Dichapetalaceae

Stephanopodium magnifolium Prance *
Tapura martiniae Amorim & D.Lisboa
Tapura zei-limae Amorim & Fiaschi

Dilleniaceae

Davilla bahiana Aymard
Davilla macrocarpa Eichler

Dioscoreaceae

Dioscorea macrothyrsa Uline

Ebenaceae

Diospyros amabi B.Walln.

http://dx.doi.org/10.1590/1676-0611-BN-2018-0544

Continuation Table 1.

Diospyros riedelii (Hiern) B.Walln.

Diospyros scottmorii B.Walln.

Eriocaulaceae

Actinocephalus ochrocephalus (Körn.) Sano

Erythroxylaceae

Erythroxylum compressum Peyr.

Erythroxylum leal-costae Plowman

Erythroxylum martii Peyr.

Erythroxylum mattos-silvae Plowman *

Erythroxylum membranaceum Plowman *

Erythroxylum santosii Plowman *

Erythroxylum splendidum Plowman *

Euphorbiaceae

Actinostemon lasiocarpus (Müll.Arg.) Baill.

Algernonia bahiensis (Emmerich) G.L.Webster *

Bernardia gambosa Müll.Arg.

Bernardia micrantha Pax & K.Hoffm.

Croton sapiifolius Müll.Arg.

Croton thomasii Riina & P.E.Berry

Dalechampia armbrusteri G.L.Webster

Dalechampia viridissima G.L.Webster *

Gymnanthes gaudichaudii Müll.Arg.

Ophthalmoblapton pedunculare Müll.Arg.

Fabaceae

Andira carvalhoi R.T.Penn. & H.C.Lima *

Andira marauensis N.F.Mattos *

Arapatiella psilophylla (Harms) R.S.Cowan *

Canavalia cassidea G.P.Lewis *

Canavalia dolichothyrsa G.P.Lewis *

Chamaecrista amabilis H.S.Irwin & Barneby *

Chamaecrista amorimii Barneby *

Chamaecrista onusta H.S.Irwin & Barneby *

Chamaecrista salvatoris (H.S.Irwin & Barneby) H.S.Irwin & Barneby

Copaifera majorina Dwyer

Dahlstedtia bahiana (A.M.G.Azevedo) M.J.Silva & A.M.G.Azevedo

Harleyodendron unifoliolatum R.S.Cowan *

Inga aptera (Vinha) T.D.Penn. *

Inga conchifolia L.P.Queiroz

Inga pedunculata (Vinha) T.D.Penn. *

Inga pleiogyna T.D.Penn.

Machaerium aureum Filardi & H.C.Lima

Moldenhawera blanchetiana var. *multijuga* L.P.Queiroz et al.

Moldenhawera intermedia G.P.Lewis & L.P.Queiroz

Moldenhawera luschnathiana Yakovlev

Moldenhawera nutans L.P.Queiroz et al.

Continuation Table 1.

Muellera longiunguiculata (MJ.Silva & AMG.Azevedo) MJ.Silva & AMG.Azevedo

Ormosia lewisii D.B.O.S.Cardoso, C.H.Stirt. & Torke *

Ormosia limae D.B.O.S.Cardoso & L.P.Queiroz

Ormosia timboensis D.B.O.S.Cardoso, Meireles & H.C.Lima

Parapiptadenia ilheusana G.P.Lewis *

Phanera carvalhoi (Vaz) Vaz

Piptadenia killipii var. *cacaophila* G.P.Lewis *

Piptadenia ramosissima Benth.

Piptadenia santosii Barneby ex G.P.Lewis *

Schnella lilacina (Wunderlin & Eilers) Wunderlin

Senegalia amorimii M.J.F.Barros & M.P.Morim

Senegalia olivensana (G.P.Lewis) Seigler & Ebinger

Senegalia piptadenioides (G.P.Lewis) Seigler & Ebinger

Swartzia alternifoliolata Mansano

Swartzia arenophila R.B.Pinto, Torke & Mansano

Swartzia curranii R.S.Cowan

Swartzia pinheiroana R.S.Cowan *

Swartzia riedelii R.S.Cowan

Swartzia thomasii R.B.Pinto, Torke & Mansano

Zollernia magnifica A.M.Carvalho & Barneby *

Gentianaceae

Macrocarpaea atlantica J.R.Grant & V.Trunz

Macrocarpaea dolichophylla J.R.Grant & V.Trunz

Macrocarpaea orbiculata J.R.Grant & V.Trunz

Icacinaceae

Pleurisanthes brasiliensis (Val.) Tiegh.

Iridaceae

Neomarica brachypus (Baker) Sprague

Neomarica floscella A.Gil & M.C.E.Amaral

Neomarica portosecurensis (Ravenna) Chukr *

Neomarica unca (Ravenna) A.Gil

Lauraceae

Nectandra micranthera Rohwer

Ocotea montana (Meisn.) Mez

Ocotea ramosissima L.C.S.Assis e Mello-Silva

Ocotea sperata P.L.R.Moraes et van der Werff

Ocotea thinicola van der Werff et P.L.R.Moraes

Lecythidaceae

Eschweilera complanata S.A.Mori

Eschweilera mattos-silvae S.A.Mori *

Eschweilera sphaerocarpa M.Ribeiro & S.A.Mori

Linderniaceae

Cubitanthus alatus (Cham. & Schltdl.) Barringer

Loganiaceae

Spigelia genuflexa Popovkin & Struwe

Strychnos alvimiana Krukoff & Barneby *

Continuation Table 1.

Strychnos setosa Krukoff & Barneby

Loranthaceae

Psittacanthus excrenulatus Rizzini

Psittacanthus salvadorensis Kuijt

Struthanthus longiflorus Rizzini

Malpighiaceae

Bunchosia itacarensis W.R.Anderson *

Heteropterys sanctorum W.R.Anderson *

Peixotoa sericea C.E.Anderson *

Stigmaphyllon hispidum C.E.Anderson

Stigmaphyllon macropodum A.Juss.

Malvaceae

Byttneria cristobaliana Dorr

Pavonia cauliflora (Nees) Fryxell ex G.L.Esteves

Pavonia ciliata G.L.Esteves & Krapov. *

Pavonia crispa Krapov. *

Pavonia gerleniae Gonçalez & M.C.Duarte

Pavonia goetheoides (Hassl.) Fryxell ex G.L.Esteves

Pavonia latibracteolata Krapov. *

Pavonia longifolia A.St.-Hil.

Pavonia macrobracteolata Gonçalez & M.C.Duarte

Pavonia ovaliphylla G.L.Esteves & Krapov. *

Pavonia paucidentata Fryxell

Pavonia pilifera Krapov.

Pavonia rubriphylla G.L.Esteves

Pavonia sancti Krapov.

Pavonia spectabilis Krapov. *

Pavonia spiciformis Krapov. *

Pavonia stipularis Krapov. *

Marantaceae

Goeppertia fasciata (Linden ex K.Koch) Borchs. & S.Suárez

Goeppertia rufibarba (Fenzl) Borchs. & S.Suárez

Ischnosiphon bahiensis L.Andersson *

Monotagma grallatum Hagberg & R. Erikss. *

Stromanthe bahiensis Yosh.-Arns, Mayo & J.M.A. Braga

Marcgraviaceae

Schwartzia geniculatiflora Gir.-Cañas & Fiaschi

Melastomataceae

Bertolonia alternifolia Baumgratz, Amorim & A.B.Jardim

Bertolonia bullata Baumgratz, Amorim & A.B.Jardim

Huberia carvalhoi Baumgratz

Huberia sessilifolia R. Godenberg & Michelangelo

Meriania inflata Michelangeli & R.Goldenb.

Miconia lurida Cogn.

Ossaea loligomorpha R.Goldenb. & Reginato

Ossaea sulbahiensis D´El Rei Souza

Continuation Table 1.

Physeterostemon aonae Amorim, Michelangeli & R.Goldenb.

Physeterostemon fiaschii R.Goldenb. & Amorim

Physeterostemon jardimii R.Goldenb. & Amorim

Physeterostemon thomasii Amorim, Michelangeli & R.Goldenb.

Pleiochiton amorimii Reginato & R.Goldenb.

Tibouchina bahiensis Wurdack *

Tibouchina bradeana Renner

Tibouchina paulo-alvinii Guimarães da Vinha *

Tibouchina stipulacea Vinha *

Tibouchina taperoensis Wurdack *

Tibouchina tomentulosa Wurdack

Meliaceae

Guarea anomala T.D.Penn

Trichilia florbranca T.D.Penn. *

Trichilia magnifoliola T.D.Penn. *

Menispermaceae

Curarea crassa Barneby *

Moraceae

Dorstenia setosa Moric.

Myrtaceae

Calyptranthes blanchetiana O.Berg

Eugenia barrana Sobral

Eugenia beruttii (Mattos) Mattos

Eugenia fissurata Mattos

Eugenia itacarensis Mattos *

Eugenia longifolia DC.

Eugenia serraegrandis Sobral

Eugenia sessilifolia DC.

Eugenia unana Sobral

Marlierea lealcostae G.M.Barroso & Peixoto

Marlierea verticillaris O.Berg

Myrcia abrantea (O.Berg) E.Lucas & Sobral

Myrcia cataphyllata M.F.Santos

Myrcia felisbertii (DC.) O.Berg

Myrcia gigantea (O.Berg) Nied.

Myrcia grazielae NicLugh.

Myrcia marianae Staggemeier & E.Lucas

Myrcia monoclada Sobral

Myrcia pendula Sobral

Myrcia pseudomarlierea Sobral

Myrcia raminfinita L.Marinho & E.Lucas

Myrcia spathulifolia Proença

Myrcia stigmatosa O.Berg

Myrcia teimosa Sobral

Myrcia tetraphylla Sobral

Myrcia thomasii B.S.Amorim & A.R.Lourenço

http://dx.doi.org/10.1590/1676-0611-BN-2018-0544

Continuation Table 1.

Myrcia truncata Sobral
Plinia callosa Sobral *
Plinia longiacuminata Sobral
Plinia muricata Sobral *
Plinia rara Sobral *
Plinia spiciflora (Nees & Mart.) Sobral

Nyctaginaceae

Neea alumnorum M.Pignal, Soares Filho & Romaniuc
Neea duckei (Huber) Furlan

Ochnaceae

Ouratea bahiensis Sastre *
Ouratea gigantophylla (Erhard) Engl.
Ouratea longipes Sastre *
Ouratea papulosa Sastre
Ouratea platicaulis Sastre *

Orchidaceae

Anathallis velvetina Luer & Toscano
Aspasia silvana F.Barros *
Bifrenaria silvana V.P.Castro *
Brassavola reginae Pabst
Bulbophyllum teimosense E.C.Smidt & Borba
Cattleya alaorii (Brieger & Bicalho) Van den Berg
Cattleya grandis (Lindl. & Paxton) A.A.Chadwick
Cattleya kerrii Brieger & Bicalho *
Cirrhaea silvana V.P.Castro & Campacci *
Coryanthes bahiensis Marçal & Chiron
Coryanthes buerarenensis Campacci & Bohnke
Elleanthus hymenophorus (Rchb.f.) Rchb.f.
Encyclia fimbriata C.A.Bastos, Van den Berg & Meneguzzo
Epidendrum garciae Pabst
Gomesa silvana (V.P.Castro & Campacci) M.W.Chase & N.H.Williams
Gongora meneziana V.P.Castro & G.Gerlach
Koellensteinia abaetana L.P.Queiroz
Leptotes bohnkiana Campacci
Masdevallia sururuana Campacci
Pabstiella dasilvae Chiron & Xim.Bols.
Promenaea silvana F.Barros & Cath. *
Prosthechea bohnkiana V.P.Castro & G.F.Carr
Prosthechea buerarenensis (Campacci) Campacci
Stanhopea buerarenensis Campacci & Marçal
Stenia bohnkiana V.P.Castro & G.F.Carr

Oxalidaceae

Oxalis alata var. *hirta* Lourteig *
Oxalis bela-vitoriae Lourteig *
Oxalis kuhlmannii var. *adpressipila* Lourteig

Continuation Table 1.

Passifloraceae

Passiflora igrapiunensis T.S.Nunes & L.P.Queiroz

Phyllanthaceae

Discocarpus pedicellatus Fiaschi & Cordeiro
Phyllanthus carvalhoi G.L.Webster

Picramniaceae

Picramnia coccinea W.W.Thomas *

Piperaceae

Peperomia epipremnifolia D.Monteiro & Leitman
Peperomia riparia Yunck.
Peperomia serpentarioides Miq.
Peperomia sulbahiensis D.Monteiro & M.Coelho
Piper bahianum Yunck.
Piper robustipedunculum Yunck.
Piper vellosoi Yunck.

Poaceae

Alvimia auriculata Soderstr. & Londoño *
Alvimia gracilis Soderstr. & Londoño *
Anomochloa marantoidea Brongn. *
Arberella bahiensis Soderstr. & Zuloaga *
Atractantha cardinalis Judz. *
Atractantha radiata McClure *
Chusquea clemirae A.C.Mota, R.P.Oliveira & L.G.Clark
Diandrolyra pygmaea Soderstr. & Zuloaga ex R.P.Oliveira & L.G.Clark
Digitaria doellii Mez *
Eremetis robusta Hollowell, F.M.Ferreira & R.P.Oliveira
Eremocaulon aureofimbriatum Soderstr. & Londoño *
Ichnanthus longhi-wagnerae A.C.Mota & R.P.Oliveira
Merostachys annulifera Send.
Merostachys argentea Send.
Merostachys lanata Send.
Merostachys magnispicula Send.
Merostachys medullosa Send.
Merostachys ramosissima Send.
Olyra bahiensis R.P.Oliveira & Longhi-Wagner
Olyra filiformis Trin.
Olyra latispicula Soderstr. & Zuloaga *
Parianella carvalhoi (R.P.Oliveira & Longhi-Wagner) F.M.Ferreira & R.P. Oliveira
Parianella lanceolata (Trin.) F.M.Ferreira & R.P.Oliveira
Paspalum restingense Renvoize *
Paspalum strigosum Döll
Piresia palmula M.L.S.Carvalho & R.P.Oliveira
Raddia distichophylla (Schrad. ex Nees) Chase *
Raddia stolonifera R.P.Oliveira & Longhi-Wagner

Continuation Table 1.

Polygalaceae
Caamembeca martinelli (Marques & E.F.Guim.) J.F.B.Pastore *
Caamembeca martinelli var. *carnosa* (Marques & E.F.Guim.) J.F.B.Pastore
Securidaca revoluta (A.W.Benn.) Marques
Primulaceae
Cybianthus nemoralis (Mez) G.Agostini
Rubiaceae
Chomelia bahiae J.H.Kirkbr.
Denscantia andrei (E.L.Cabral & Bacigalupo) E.L.Cabral & Bacigalupo *
Denscantia macrobracteata (E.L.Cabral & Bacigalupo) E.L.Cabral & Bacigalupo *
Faramea bicolor J.G.Jardim & Zappi
Faramea nocturna J.G.Jardim & Zappi
Ixora bahiensis Benth.
Ixora cabraliensis Di Maio et Peixoto
Malanea harleyi J.H.Kirkbr. *
Mitracarpus anthospermoides K.Schum.
Posoqueria bahiensis Macias & Kin.-Gouv.
Psychotria martiusii Müll.Arg.
Psychotria megalocalyx Müll.Arg.
Psychotria salzmanniana Müll.Arg.
Psychotria silvicola Müll.Arg.
Psychotria strigosa Müll.Arg.
Psychotria wawrana Müll.Arg.
Rudgea hileiabaiana Zappi & Bruniera
Rudgea ilheotica Müll.Arg.
Rudgea involucrata Müll.Arg.
Rudgea malpighiacea Standl.
Rudgea mouririoides Standl.
Salzmannia arborea J.G. Jardim
Sphinctanthus insignis Steyerm.
Rutaceae
Andreadoxa flava Kallunki *
Conchocarpus concinnus Kallunki *
Conchocarpus dasyanthus Kallunki *
Conchocarpus fissicalyx Pirani *
Conchocarpus gaudichaudianus subsp. *bahiensis* Kallunki *
Conchocarpus hirsutus Pirani *
Conchocarpus inopinatus Pirani *
Conchocarpus longipes Kallunki *
Conchocarpus mastigophorus Kallunki *
Conchocarpus modestus Kallunki *
Conchocarpus punctatus Kallunki *
Conchocarpus racemosus (Nees & Mart.) Kallunki & Pirani

Continuation Table 1.

Conchocarpus santosii Pirani & Kallunki *
Ertela bahiensis (Engl.) Kuntze
Galipea revoluta Pirani
Neoraputia calliantha Kallunki
Neoraputia micrantha Kallunki
Zanthoxylum nemorale Mart.
Zanthoxylum retusum (Albuq.) P.G.Waterman
Sapindaceae
Cardiospermum integerrimum Radlk. *
Paullinia livescens Radlk.
Paullinia unifoliolata Perdiz & Ferrucci
Serjania morii Acev.-Rodr.
Serjania scopulifera Radlk.
Sapotaceae
Chromolucuma apiculata Alves-Araújo & M.Alves
Pouteria atlantica Alves-Araújo & M.Alves
Pouteria glauca T.D.Penn.
Pouteria synsepala Popovkin & A.D.Faria
Pouteria trifida Alves-Araújo & M.Alves
Pradosia longipedicellata Alves-Araújo & M.Alves
Verbenaceae
Citharexylum obtusifolium Kuhlm.
Stachytarpheta hirsutissima Link
Vochysiaceae
Vochysia talmonii M.C.Vianna et al.

The occurrence of only 12 endemic species of *Conchocarpus* in the present checklist probably indicates that several endemic species of this genus are exclusively found at more inland seasonally dry forests (Kallunki & Pirani 1998).

Among the endemic genera from southern Bahia and northern Espírito Santo reported by Thomas et al. (2003), such as *Arapatiella* and *Brodriguesia* (Fabaceae), *Atractantha*, *Alvimia* and *Sucrea* (Poaceae), and *Trigoniodendron* (Trigoniaceae), several are not endemic to BCF. For example, *Brodriguesia*, *Atractantha* and *Trigoniodendron* have been recorded outside our study area, respectively, in Sergipe, Amazonas, and near the Doce River. Similarly, *Physeterostemon* R.Goldenb. & Amorim (Melastomataceae), a recently described endemic genus from the Atlantic Forest of Bahia state (Amorim et al. 2014, Goldenberg et al. 2016, Goldenberg & Amorim 2006), was not considered endemic to BCF in this checklist, as among its species *P. gomesii* Amorim & R.Goldenb. occurs in the municipality of Boa Nova (Amorim et al. 2014), which lies slightly outside our study area.

In comparison with the preliminary list of Thomas et al. (2003), which included 395 endemic angiosperm taxa from an area that covered a larger part of northern Espírito Santo state, as far as the Doce River, and the southern Bahia Atlantic Forest, including more inland areas, and almost reaching the municipality of Salvador (i.e., an area ca. 20% larger than ours) (Figure 1a), the list presented here surprisingly

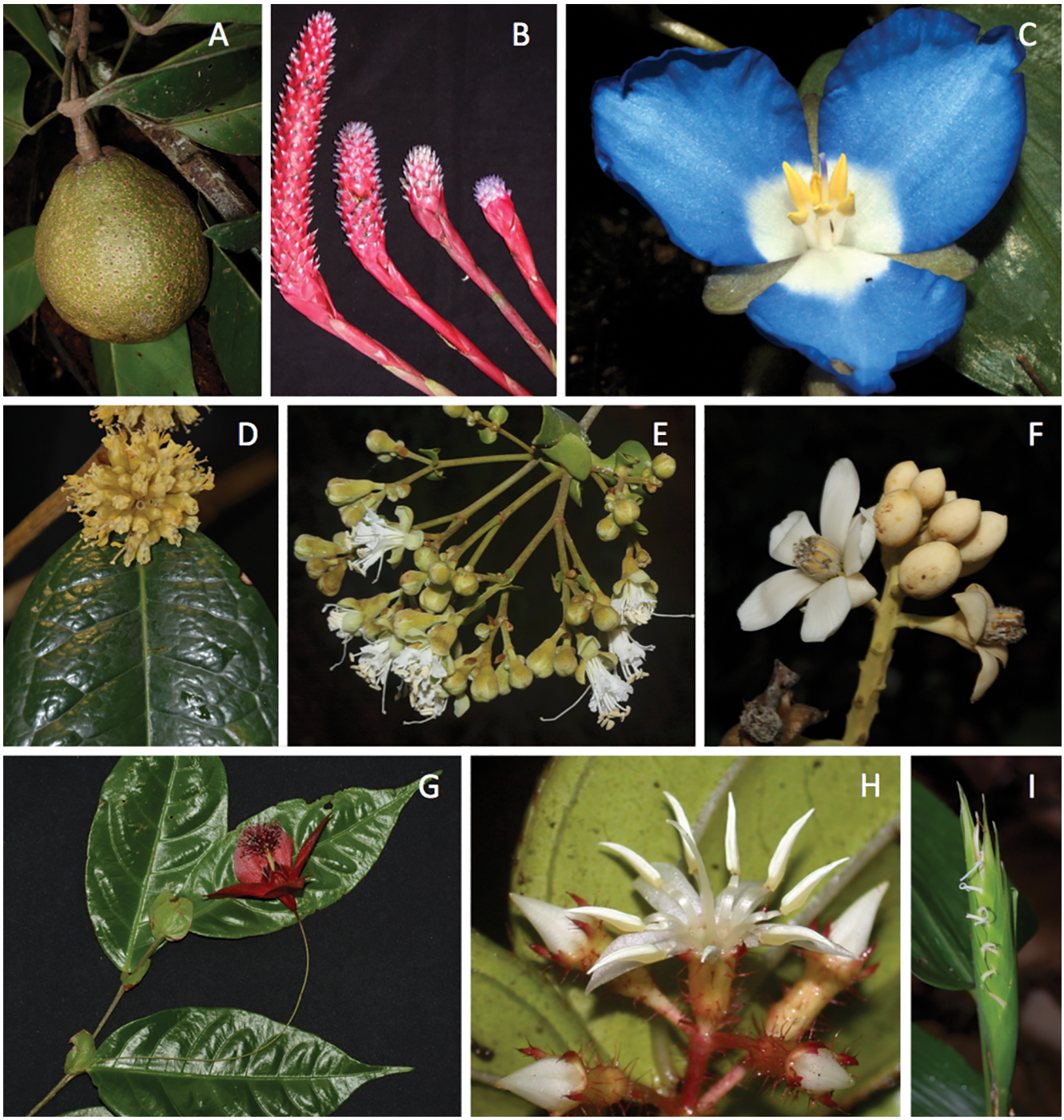

Figure 2. Some species found in the checklist of endemic angiosperms of BCF: a) *Kuhlmanniodendron macrocarpum* (Achariaceae). b) *Quesnelia koltesii* (Bromeliaceae). c) *Dichorisandra leucophtalmos* (Commelinaceae). d) *Tapura zei-limae* (Dichapetalaceae). e) *Arapatiella psilophylla* (Fabaceae). f) *Harleyodendron unifoliolatum* (Fabaceae). g) *Pavonia goetheoides* (Malvaceae). h) *Pleiochiton amorimii* (Melastomataceae). i) *Anomochloa marantoidea* (Poaceae). Photos: a, b, d, g, h) A.Amorim; c) L.Aona; e, f) D.Cardoso; i) J.Jardim.

shares only 143 taxa (Table 1). If we had used the Doce River as our area southern limit, it would have included at least 45 additional species restricted to the Linhares region, such as *Cryptanthus beuckeri* E.Morren (Bromeliaceae), *Rourea luizalbertoi* Forero, L.A.Vidal & Carbonó (Connaraceae), *Simira eliezeriana* Peixoto (Rubiaceae) and the endemic genus *Riodocea* Delprete (Thomas et al. 2003, Rolim et al. 2016). Despite being geographically close and having several species in common (Saiter et al. 2016b), the vegetation of Linhares and the Doce River floodplain are ecologically different from the BCF (Rolim et al. 2005, 2006). In floristic terms, the Linhares region may be more similar to northern Rio de Janeiro, southern Espírito Santo (Silva & Nascimento 2001, Saiter et al. 2016b) and eastern Minas Gerais states (see Krenák-Waitaká Forests *sensu* Saiter et al. 2016a).

Another difference between the two checklists is due to the time gap of about 15 years between studies. A total of 174 species in our checklist were described after 2003, probably due to increased efforts

in collecting and studying plants in the Atlantic Forest in Bahia. For instance, about 41.5% of all new angiosperms in the Brazilian flora described between 1990 and 2006 are endemic to the Atlantic Forest (Sobral & Stehmann 2009). Moreover, 23 species of angiosperms endemic to BCF were described between 2015 and 2017 (e.g., Araújo et al. 2015, Santos et al. 2015, Abreu & Giulietti 2016, Amorim et al. 2016, Côrtes et al. 2016, Ferreira et al. 2016, Marinho & Lucas 2016, Popovkin et al. 2016, Ribeiro et al. 2016, Terra-Araujo et al. 2016, Daly & Melo 2017, Gonçalez et al. 2017).

Compared to the results of a search in the Brazilian Plant List (Flora do Brasil 2020, under construction) using the following filters: "group: angiosperms", "endemism: only endemic to Brazil", "occurrence: only occurs in", "origin: native", "state: Bahia", and "phytogeographic domain: Atlantic Forest", the number of species in our checklist (547 spp.) was much smaller than the 795 species identified by the search engine. Among the reasons for this large difference (248 spp.) it is worth mentioning that a) more than 50 taxa from our list had to be removed due to lack of precise geospatial data, such as the municipality name, which precluded us from citing them as endemic to BCF; b) among the taxa exclusive to the Brazilian Plant List (Flora do Brasil 2020, under construction) that are not restricted to BCF, several occur in more inland seasonally dry forests in the Atlantic Forest, such as *Chrysophyllum subspinosum* Monach. (Sapotaceae) and *Colicodendron bahianum* Cornejo & Iltis (Capparaceae); and c) at least 29 species exclusive to the Brazilian Plant List search occur close to, but outside the study area, such as *Canistrum camacaense* Martinelli & Leme (Bromeliaceae), *Inga grazielae* (Vinha) T.D.Penn. (Fabaceae), and *Bertolonia carmoi* Baumgratz (Melastomataceae), all from the municipality of Boa Nova, and *Aechmea bicolor* L.B.Sm. (Bromeliaceae), *Heteropterys jardimii* Amorim (Malpighiaceae), and *Passiflora timboensis* T.S.Nunes & L.P.Queiroz (Passifloraceae), from the municipality of Santa Teresinha.

There are additional reasons to anticipate that the difference in species numbers between the Brazilian Plant List and our list could be even greater, as the list presented here includes 84 taxa that also occur in northern Espírito Santo and in a small area in northeastern Minas Gerais (Figure 1c). Moreover, the Brazilian Plant List (Flora do Brasil 2020, under construction) is an ongoing project on which new taxa can be continuously added and identified as endemic, what could bring the total number of endemic angiosperm species using the same filters even larger. Alternatively, if the native distribution of several taxa is shown to extend beyond the Atlantic Forest domain in Bahia, the difference between the lists could decrease, as fewer species from the Brazilian Plant List would appear as endemic while applying the same search filters.

Developing knowledge on patterns of endemism for plant species is extremely important and must be taken into account in conservation strategies. This information is relevant for the establishment of new protected areas (Kerr 1997), restoration policies (Chazdon 2008) and in directing additional studies (Francisco-Ortega et al. 2010). Considering the key role of endemic species in the design of conservation policies (Myers et al. 2000, Van Der Werff & Consiglio 2004, Moraes et al. 2005, Lamoreux et al. 2006, Martinelli et al. 2008, Essl et al. 2009, Nowak & Nobis 2010), we expect this checklist could guide future studies and conservation strategies, as well as emphasize the importance of the BCF region as a key area for plant conservation.

Supplementary material

The following online material is available for this article:

Appendix 1 – Taxonomic studies and specialists consulted by family.

Acknowledgements

The authors thank Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for awarding a Master Fellowship to POB, Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for the Research Productivity Fellowship to AMA (grant # 310717/2015-9), and PF (grant # 306228/2016-5), and all specialists that provided updated information on endemic species distribution.

Author Contributions

Piera Ostroski: substantial contribution in the concept and design of the study; contribution to data collection; contribution to data analysis and interpretation; contribution to manuscript preparation; contribution to critical revision augmenting intellectual content.

Felipe Saiter: substantial contribution in the concept and design of the study; contribution to data analysis and interpretation; contribution to manuscript preparation; contribution to critical revision augmenting intellectual content.

André Amorim: substantial contribution in the concept and design of the study; contribution to data analysis and interpretation; contribution to manuscript preparation; contribution to critical revision augmenting intellectual content.

Pedro Fiaschi: substantial contribution in the concept and design of the study; contribution to data analysis and interpretation; contribution to manuscript preparation; contribution to critical revision augmenting intellectual content.

Conflicts of interest

The authors declare that there is no conflict of interest related to the publication of the data in this article.

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Received: 29/03/2018
Revised: 11/07/2018
Accepted: 12/07/2018
Published online: 16/08/2018