Two new Critically Endangered species of *Ditassa* (Apocynaceae) from the threatened cangas of the Iron Quadrangle, Minas Gerais, Brazil

Cássia Bitencourt¹, Moabe Ferreira Fernandes¹,², Fábio da Silva do Espírito Santo³ & Alessandro Rapini¹,*

¹Programa de Pós-Graduação em Botânica, Universidade Estadual de Feira de Santana, Av. Transnordestina, s/n, Novo Horizonte, 44036-900, Feira de Santana, Bahia, Brazil
²Departamento de Biologia, Centro de Ciências, Universidade Federal do Ceará, Av. Mister Hull s/n, campus do Pici, 60440-900, Fortaleza, Ceará, Brazil
³Centro de Formação em Tecnociências e Inovação, Universidade Federal do Sul da Bahia, Rua Itabuna, s/n, Rod. Ilhéus – Vitória da Conquista, km 39, BR 415, Ferradas, 45613-204, Itabuna Bahia, Brazil
*Corresponding author: rapinibot@yahoo.com.br

REGULAR PAPER

**Background and aims** – Vegetation on ironstone outcrops is highly threatened, particularly due to the impact of mining. In this study, two new species of *Ditassa* (Metastelmatinae, Asclepiadoideae, Apocynaceae) from the cangas of the Iron Quadrangle (Minas Gerais, Brazil) are described and illustrated, and their conservation status is discussed.

**Material and methods** – Species recognition is based on a morphological and molecular study of recent and historical collections, including a survey of the main herbaria of Brazil, Europe and the United States. Conservation status assessments are based on the evaluation of areas of occupancy and the impact of iron mining in the region.

**Key results** – The two new species are morphologically similar to species in the “Hemipogon from the Espinhaço” clade, which includes *Morilloa*. Nevertheless, they exhibit flowers with a double corona and are described in *Ditassa* here, following preliminary phylogenetic analyses with 73 plastid-coding regions. These species are known from only two highly disturbed locations each and are Critically Endangered. A key to identify the 14 species of Metastelmatinae currently recorded in cangas of the Iron Quadrangle is provided.

**Conclusion** – The Critically Endangered *Ditassa cangae* and *D. ferricola* are examples of poorly known, nearly extinct species under strong anthropogenic pressure caused by intense mining activities and the lack of adequate legislation for the protection of canga landscapes.

**Keywords** – Asclepiadoideae; campos rupestres; conservation; Espinhaço Range; Hemipogon; iron outcrops; Metastelmatinae; mining; threatened species.

INTRODUCTION

The Iron Quadrangle (IQ) geosystem (Quadrilátero Ferrifero), in the southern Espinhaço Range (Minas Gerais, Brazil), comprises an area of approximately 7000 km² (Dorr 1964) between two biodiversity hotspots, Atlantic Rainforest and Cerrado (Myers et al. 2000; Mittermeier et al. 2005). It comprises the largest reserves of high-grade iron ore in the world (Dorr 1964; Jacobi & Carmo 2012; Skirycz et al. 2014) and has been intensively mined since the beginning of the 20th century. Additionally, the privatization policy by the Brazilian government at the end of the 20th century has boosted the mineral production leading to an increased growth of the iron ore sector (IBRAM 2018). Mineral mining is an impor-
tant part of the Brazilian economy. It accounted for approximately 8.5% (~50 billion dollars) of the gross domestic product 20 years ago (https://www.ingeoweb.com.br/minerao) and around 1.1% in the last decade (OECD 2017; https://oec.world/en/profile/country/bra). In 2017, iron ore represented more than half (62%) of the value of minerals exported by Brazil and was one of the most important export products, second only to soybean (IBRAM 2018).

The IQ is a conglomerate of geological formations and types of vegetation marked by ferruginous soils, heterogeneous topography and water deficit (e.g., Dorr 1964). “Canga” is a typical landscape dispersed over mountaintops along the IQ that is directly associated with ironstone soil. This term was originally applied in geology to the ferruginous hard layer on superimposed banded iron formations, re-formed by weathering events approximately 65 million years ago (Dorr 1964; Shuster et al. 2012; Conceição et al. 2016; Vasconcelos & Carmo 2018; Gagen et al. 2019). It occupies almost 2% of the IQ and is distributed in patches along two hydrological basins: the Paráopeba sub-basin (São Francisco basin) to the west and the Doce River sub-basin (Atlantic East basin) to the east (Salles et al. 2018). Characterised by herbs and subshrubs growing on rocky outcrops (Silva 1991; Jacobi & Carmo 2012), the canga vegetation is under strong abiotic stress and most species are adapted to high levels of heavy metals (Baker 1981; Boyd 2012; Skirycz et al. 2014).

In the IQ, an estimated 1109 species of vascular plants, including several rare and endemic species, occur in cangas (Viana & Lombardi 2007; Jacobi & Carmo 2008; Giulietti et al. 2009). Although this region has been floristically studied for centuries, a recent inventory (Jacobi & Carmo 2012) reported nearly 100 undescribed species of plants from cangas and several others have been described since then (e.g., Versieux 2011; Versieux & Machado 2012; Knapp et al. 2015). An inventory of the Amazonian cangas in the Serra dos Carajás, State of Pará, reported 856 species of seed plants; approximately 60% of them were new occurrences for the area (Mota et al. 2018). Although cangas in IQ and Carajás are both highly diverse (amounting to approximately 1700 species combined), only about 5% of this diversity (96 species) is shared between the two regions (Mota et al. 2018; Zappi et al. 2019). Currently, more than half of the area originally covered by cangas in the IQ has been lost (Salles et al. 2018) and large areas are already reserved for ore extraction (Villén-Pérez et al. 2017). In Carajás, the cangas cover an area larger than in the IQ and almost 20% of it has already been affected by mining activities since the 1980s (Souza-Filho et al. 2019). Therefore, mining may represent a negative impact on plant diversity and some have argued that the biodiversity in the cangas is not sufficiently protected by legislation (e.g., Miola et al. 2019).

The Apocynaceae are one of the ten largest families of angiosperms in the IQ cangas with 29 species (Rapini 2012). Only two species, Blepharodon pictum (Vahl) W.D.Stevens and Mandevilla tenuifolia (J.C.Mikan) Woodson, are shared with the Amazonian cangas in Carajás (Fernandes et al. 2018). Most species of Apocynaceae in the IQ cangas are Asclepiadoideae (21 vs. only 6 of the 22 species of Apocynaceae in the Carajás cangas), including two rare undescribed species, listed as “Hemipogon aff. carassensis” (Malme) Rapini” and “Hemipogon aff. hemipogonoides” (Malme) Rapini” in Rapini (2012). Rarity is common in Asclepiadoideae: some species of asclepiads are known only from the type material and others have not been collected for decades (e.g., Rapini et al. 2002; Rapini 2010, 2012; Biodiversitas 2011). Nonetheless, only three species of Asclepiadoideae from these cangas, Ditassa laevis Mart., D. longisepala (Hua) Fontella & E.A.Schwarz and Minaria monocoronata (Rapi) T.U.P.Konno & Rapini, are listed as threatened in the official Brazilian Red List (Brazilian Ministry of the Environment 2014).

Here, we describe and illustrate the undescribed “Hemipogon aff. carassensis” and “Hemipogon aff. hemipogonoides” (Rapini 2012) as two new microendemic species (sensu Silva et al. 2019) of Ditassa R.Br. (D. cangae Bitencourt & Rapini and D. ferricola Bitencourt & Rapini, respectively), and discuss their conservation status within the context of the mining impact in the region. This seems to be a remarkable example of convergence. Morphologically, the two new species resemble species from the “Hemipogon from the Espinhaço” clade, a cohesive lineage, well supported by molecular data from both nuclear and plastid regions (Silva et al. 2012), though partially (i.e., the four twinning species) segregated to Morilloa Fontella, Goes & S.Cáceres (Fontella-Pereira et al. 2014). However, phylogenetic analyses using 73 plastid-coding regions (Bitencourt et al. 2019) strongly supported them as sister species, nested in a clade consisting predominantly of species endemic to the Espinhaço Range, but classified primarily in Ditassa R.Br. (fig. 1). The unexpected position of these two species puts into question the taxonomic classification of other species endemic to the IQ cangas classified due to their morphology but that have not yet been phylogenetically analysed with molecular data, such as Minaria monocoronata (Konno et al. 2006; Ribeiro et al. 2014). The current circumscription of Ditassa is not monophyletic (e.g., Silva et al. 2012; Liede-Schumann et al. 2014), but the placement of the two novelties in this genus seems most appropriate at this time. To facilitate the recognition of the new species, a key to identify the 14 species of Metastelmatinae (for subtribe circumscription, see Endress et al. 2018) recorded in the cangas of the Iron Quadrangle (Rapini 2012) is provided.

MATERIAL AND METHODS

This study is part of a forthcoming systematic work on Metastelmatinae (Bitencourt 2019, Bitencourt et al. unpubl. res.). We analysed approximately 1200 specimens deposited at the main herbaria in Brazil (e.g., BHCB, CEN, DIAM, HRB, HUEFS, IBGE, MMN, R, RB, SP, SPF, UB) and outside Brazil (e.g., B, BR, C, F, K, LPB, M, MO, NY, P, S, USZ, W) (acronyms according to Thiers continuously updated). Morphological terms follow Beentje (2016) and location data, such as population data, their conservation status is inferred based mainly on the IUCN’s (2017) criteria for area of occupancy (AOO), calculated using 2 × 2 km cells in the GeoCAT Tool (Bachman et al. 2011).
TAXONOMIC TREATMENT

**Ditassa cangae** Bitencourt & Rapini, sp. nov.

Figs 2, 3

**Diagnosis** – *Ditassa cangae* differs from the morphologically similar *Morilloa carassensis* (Malme) Fontella, Goes & S. Cáceres and *M. piranii* (Fontella) Fontella, Goes & S. Cáceres by the subcampanulate, adaxially puberulent corolla (vs. urceolate, adaxially bearded corolla in *M. carassensis* and *M. piranii*), gynostegial double corona (vs. absent), anthers with triangular wings (vs. laterally falcate in *M. carassensis* and recurved in *M. piranii*) and colleters obreniform (vs. linear).


**Description** – Herb twining; stems cylindrical, puberulous (non-glandular trichomes), sometimes only along a pair of longitudinal lines. Leaves opposite, ascendant; petiole 2–7 mm long; blade linear to narrowly elliptic, 1.1–3.5 × 0.1–0.2 cm, base and apex attenuate, margins entire, revolute, membranous, glabrescent; colleters intrapetiolar. Cymes, 4- or 5-flowered, subaxillary; bracts lanceolate, c. 1 × 0.5 mm, glabrous; peduncle c. 1 mm long. Flowers with pedicel 1–3 mm long; sepals ovate, c. 1.3 × 1 mm, apex acute, involute, glabrescent, axillary colleters alternisepalous; corolla subcampanulate, probably creamy, abaxially glabrescent, adaxially puberulent, tube 0.3–0.5 × 1.1–1.2 mm, lobes triangular, 2–2.5 × 1.3–1.5 mm, apex attenuate, involute; corona gynostegial, double, 5-lobeb, lobes shorter than the gynostegium, outer lobes ovate, 1–1.2 × 0.6–0.8 mm, apex caudate, inner lobes lanceolate, c. 1 × 0.4 mm, apex acute; anthers 0.8–1 × 0.3–0.4 mm, quadrangular, M-shaped, wings triangular, c. 0.5 × 0.25 mm, apical membranous appendix quadrangular, c. 0.2 mm long; corpusculum ovate, 0.2–0.23 × 0.15–0.17 mm; caudicles obreniform, horizontal, c. 0.06 mm long; pollinia ovate-elliptic, 0.3–0.35 × c. 0.2 mm; style head apically mammillated, exserted from the corolla tube. Follicles obclavate, 1.9–3.7 × 0.3–0.4 cm, glabrous, striate, apex sometimes curved.

**Distribution** – *Ditassa cangae* is restricted to the Chapada de Canga, in Catas Altas, and Serra de Gandarela, in Santa Bárbara, both in the Doce River basin, east sector of the Iron Quadrangle, southern Espinhaço Range, state of Minas Gerais, Brazil (fig. 3).

**Habitat and ecology** – The species occurs in canga, growing on ironstone soils, between 910–1637 m a.s.l.

**Phenology** – Collected with flowers in December and May, and fruits in May.

**Etymology** – The epithet refers to canga, a landscape associated with ferruginous substrates where the species is found.

**IUCN conservation assessment** – *Ditassa cangae* is known only from two locations, both close to the Caraça Sanctuary, in the most preserved sector of the Iron Quadrangle (Salles et al. 2018). The two collections lack population and environmental data, and the species is rare. Its area of occupancy is less than 8 km² and, despite frequent fieldwork in the Iron Quadrangle, the species has not been recollected in the last decade; we also tried to find it without success three times. The Doce River basin has become unpopular because of the dam collapse in Mariana (2015) and Brumadinho (2019) and the locations of *D. cangae* are seriously threatened and declining, one of them is highly mined (fig. 3E) and the other is close to the pit of the Gongo Soco mine (Barão de Cocais municipality, fig. 3G), which is under threat of imminent collapse. A National Park covers part of the Serra de Gandarela, but most patches of canga were not included in the park due to their high value for mining (Salles et al. 2018). From our *in situ* observation and the satellite image (fig. 3E), we conclude that one of the two locations of this species (the Chapada de Canga, Catas Altas) is destroyed. The small area of occupancy, the lack of collections after 2008, the high disturbance caused by mining activities in the region and the reduction of the number of locations to only one suggest that *D. cangae* is Critically Endangered [CR B2ab(i, ii, iii, iv, v)].


**Taxonomic notes** – *Ditassa cangae* is morphologically similar to *Morilloa carassensis* and *M. piranii*, two twining species of the “Hemipogon from the Espinhaço” clade.
Figure 3 – Distribution of plants threatened by mining companies showing areas affected by iron ore exploitation in the Iron Quadrangle, Minas Gerais, Brazil. A. Distribution of vulnerable (yellow circles), endangered (orange), and critically endangered (red) species of vascular plants and density of mining companies (low to high: purple – red – white) (database from Instituto Prístino: https://www.institutopristino.org.br/atlas/geossistemas-ferruginosos-do-brasil/quadrilatero-ferrifero/baixe-os-arquivos-shp-e-kml/, accessed 28 Aug. 2019); red lines show river basin borders; phytogeographic domains in the map, light brown = Cerrado and green = Atlantic Forest. B–G. Details of areas affected by mining, with the type locality of Ditassa ferricola (green star in D); and Ditassa cangae (orange stars) in Chapada de Canga, Catas Altas (E) and Serra de Gandarela, Santa Bárbara (F) just south of Gongo Soco mine, Barão de Cocais (G). Satellite images and distribution maps were built and exported using ArcGIS online (https://www.arcgis.com). © Esri and its licensors, all rights reserved. This image is not distributed under the terms of the Creative Commons license of this publication. For permission to reuse, please contact the rights holder.
(sensu Silva et al. 2012) because of the shared habit, lanceolate leaves, and 4–7-flowered cymes. Nevertheless, it can be easily distinguished from both species by the flowers with subcampanulate, adaxially puberulent corolla (vs. urceolate, bearded corolla) and double corona, with caudate outer lobes (vs. without corona). Although morphologically similar to species of Morilhoa, it is described in Ditassa because phylogenetic analyses with plastid-coding regions (Bitencourt 2019) show that it is closer to Ditassa banksii R.Br. ex Schult. than to Morilhoa lutea (E.Fourn.) Fontella, Goes & S.Cáceres, the type species of the respective genera (fig. 1).

Ditassa cangae is nested in a clade that consists of species classified primarily in Ditassa and also having a double corona, a feature traditionally used to define this genus. Thus, the similarities between Ditassa cangae and species of Morilhoa, in particular concerning their vegetative morphology, are possibly convergences due to their occurrence in rupetrian grasslands.

Ditassa ferricola Bitencourt & Rapini, sp. nov.

Figs 3, 4

Diagnosis — Ditassa ferricola is morphologically similar to the erect species of the “Hemipogon from the Espinhaço” clade, in particular to Hemipogon hemipogonoides (Malme) Rapini, and also to the two sister species Ditassa auriflora Rapini and D. cordeiroana Fontella. However, they all differ in habit: D. ferricola is a subshrub whereas H. hemipogonoides is an erect herb, D. cordeiroana is a twining herb, and D. auriflora is a shrub. The corolla is adaxially densely pilose on the middle third and puberulent on the upper third (vs. barbate at the base of lobes and sericeo-tomentulose upwards in H. hemipogonoides and barbellate at the base of lobes and papillo-puberulent upwards in D. auriflora and D. cordeiroana). The new species exhibits a gynostegial double corona, similar to the two species of Ditassa, whereas H. hemipogonoides exhibits a gynostegial corona with a single whorl of lobes. The corpusculum is subelliptic in D. ferricola (vs. obovate in H. hemipogonoides and oblong to elliptic in D. auriflora and D. cordeiroana).

Type — Brazil: Minas Gerais, Mun. Igarapé, Pico do Itaitiaçu, 20°07′17″S, 44°21′43.7″W, 1340 m a.s.l., 10 Feb. 2009, fl., fr., Carmo 4296 (holotype: BHCB).

Description — Subshrub, 30–40 cm tall; stems cylindrical, pubescent (non-glandular trichomes), sometimes only along a pair of longitudinal lines. Leaves opposite, ascendant to erect; petiole 1–2 mm long; blade acuminate, 1–3.5 × 0.1–0.15 cm, coriaceous, base and apex attenuate, margins entire, revolute, sparsely ciliate; colleters intrapetiolar. Cymes 2–4-flowered, subaxillary; bracts lanceolate, 0.8–1.4 × 0.25–0.3 mm, glabrous; peduncle 1.5–2 mm long, puberulous. Flowers with pedicel 0.8–1.2 mm long, puberulous; sepals ovate, c. 1.2 × 0.5 mm, apex attenuate, margins entire, in-volute, pubescent, axillary colleters alterneispelous; corolla subcampanulate, probably brownish creamy, abaxially glabrous, adaxially glabrous on the basal third, densely pilose on the medium third and puberulent on the upper third, tube 0.5–0.6 × 0.7–0.8 mm, lobes lanceolate, 0.8–1.0 × 0.7–0.8 mm, apex attenuate, involute; corona gynostegial, double, 5-lobed, outer lobes lanceolate, c. 1.2 × 0.4 mm, acuminate, protruding above the gynostegium, inner lobes lanceolate, c. 0.8 × 0.2 mm, acuminate, as high as the gynostegium; anthers subcuneiform, c. 0.5 × 0.4 mm, wings cuneiform, c. 0.5 × 0.2 mm, apical membranous appendix subcuneiform, c. 0.3 mm long; corpusculum subelliptic, c. 0.1 × 0.05 mm; caudicles c. 0.03 mm long, subtriangular, horizontal; pollinia oblong, c. 0.15 × 0.08 mm; style head apically globose. Follicles turbinate, 3–3.5 × 0.5–0.8 cm, striate, puberulous, apex attenuate.

Distribution — Ditassa ferricola is known from two locations, the Pico do Itatiaiaçu and Serra Azul, along the Serra do Curral, in the northern portion of the Iron Quadrangle, southern Espinhaço Range and south of Belo Horizonte, state of Minas Gerais, Brazil (fig. 3).

Habitat and ecology — The species occurs on ironstone soil of a canga outcrop, ca. 1340 m a.s.l.

Phenology — Collected with flowers and fruits in January and February.

Etymology — The epithet is a reference to the ferruginous habitat in which the species is found.

IUCN conservation assessment — Ditassa ferricola has been collected only twice, both times in mining areas. Although we do not have the precise locality of the collection in Serra Azul, we know that it is located in the main mining area of IQ (fig. 3B). We did not have permission to access these areas and the two attempts to find the species nearby were not successful. However, from our in situ observation and the satellite image (fig. 3D), the type location (but probably both locations) is completely destroyed by mining. Specimen labels provide no information about population density and environmental conditions, but since the species is known from only two, highly mined locations (AOO < 8 km²), one or both of them completely destroyed, surrounded by urban landscapes near the capital of Minas Gerais, it should be classified as Critically Endangered [CR B2ab(i, ii, iii, iv, v)].


Taxonomic notes — Morphologically, Ditassa ferricola is very similar to (1) Hemipogon hemipogonoides, an erect perennial plant of the “Hemipogon from the Espinhaço” clade (sensu Silva et al. 2012), and (2) D. auriflora, because of the erect habit and the opposite linear leaves. The species can be distinguished from both by the characters provided in the diagnosis. Ditassa ferricola is a subshrub with aciculate leaves and flowers with corolla lobes internally densely pilose on the middle portion and double corona, with ovate outer lobes and lanceolate inner lobes. It is phylogenetically sister to D. cangae (fig. 1; Bitencourt 2019) and is therefore described in Ditassa for the same reasons mentioned for D. cangae.

DISCUSSION

The Espinhaço Range harbours one of the highest levels of plant diversity and endemism in Brazil (e.g., Rapini et al. 2008; Silveira et al. 2016). While its biodiversity is possibly less threatened by climate change in the southern part (Biten-
The IQ produces more than 75% of the Brazilian iron ore (Jacobi & Carmo 2008; ANM 2018). The region is almost completely (96%) under prospecting licenses for private initiative (Jacobi & Carmo 2012; ANM 2019) and more than 22,500 mining projects are planned within protected areas (Villén-Pérez et al. 2017). The situation is alarming but might become worse as the Brazilian government is treating environmental laws as obstacles for national economic development (e.g., Abessa et al. 2019; Ferrante & Fearnside 2016), the species endemic to this region are most threatened by anthropogenic pressure caused by the long history of mining (Ribeiro et al. 2012). This is particularly worrisome because disturbances in old landscapes, such as the cangas (on ironstone) and the associated campos rupestres s. str. (on quartzite), are irreversible: once environmental conditions have changed, the original state is not recovered and their communities move to other, less complex states (Miola et al. 2019).
2019). Regardless of the huge socioeconomic and ecological impact caused by the rupture of two dams in the IQ in less than four years (e.g., Fernandes et al. 2016), the government openly supports a set of bills that will reduce the need for environmental licenses and may allow mining activities in protected areas (e.g., Carmo et al. 2017; Villén-Pérez et al. 2017; Abessa et al. 2019; Câmara et al. 2019; Campos-Silva & Peres 2019). If passed, these changes in legislation will greatly increase the area affected by mining in a short time, enhancing the threat to canga biodiversity even more (Villén-Pérez et al. 2017).

* Ditass a cangae and *D. ferricola* are only two of the 116 species endemics to the Iron Quadrangle, 25% of which are also restricted to the threatened cangas (Jacobi & Carmo 2012; fig. 3A). Exhaustive fieldwork in the region did not locate these species, suggesting that both are examples of poorly known, nearly extinct species in areas under high anthropogenic pressure. The number of still undescribed species in a similar situation is however higher (Jacobi & Carmo 2012). While the number of extinct species will probably increase rapidly in the IQ, the discussion about economic development and biodiversity conservation does not seem to advance in a compatible rhythm. Rather than relaxing the environmental legislation, strategies to monitor mining activities and their impact on biodiversity and landscape should be implemented urgently. The use of remote sensing (e.g., Buchanan et al. 2008; Tracewski et al. 2016; Santini et al. 2019), with particular attention to areas with threatened species, may signal the initial stages of landscape transformation to inspection authorities, contributing to reducing the decline of biodiversity in the IQ canga caused by mining and associate activities.

**ACKNOWLEDGEMENTS**

This work is part of the Ph.D. thesis of CB, developed at PPG-Bot-UEFS with a fellowship from the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code #1514632 (DS) and #88881.135731/2016-01 (PDSE), and supported by the project Universal (CNPq #485468/2013-1). CB acknowledges the International Association of Plant Taxonomy (IAPT, 2016) grant, Neotropical Grasslands Conservancy memorial (NGC, 2016) and Shirley A. Graham (Missouri Botanical Garden, 2018) Fellowships. MFF acknowledges the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq, #141560/2015-0) and CAPES (PDSE #88881.133545/2016-01). AR is a CNPq researcher. We are grateful to an anonymous reviewer and André Olmos Simões for important contributions and to Petra de Block for suggestions about the conservation assessments.

**REFERENCES**


les, Gentianales (except Rubiaceae): 207–411. Cham, Springer. https://doi.org/10.1007/978-3-319-39605-5_3


Ferrante L., Fearnside P.M. (2019) Brazil’s new president and ‘ru-


IBRAM – Instituto Brasileiro de Mineração (2018) Relatório anu-


vers%C3%A7%C3%85o.web.pdf [accessed 29 May 2019].


tions Sub-Committee. Available at https://www.iucnredlist.org/


Cobri.13279


Jacobi C.M., Meve U., Middleton D.J., Liede-Schumann S. (2018) Phylogenetics and biogeogra-

phy of the genus *Metastelma* (Apocynaceae-Asclepiadoideae-


Mota N.O.F., Watanabe M.T.C., Zappi D.C., Hiura A.L., Pal-


OECD – Organization for Economic Co-Operation and Devel-

opment (2017) Local content policies in minerals-exporting coun-

tries: The case of Brazil. Available at https://www.oecd.org/

trade/topics/trade-in-raw-materials/documents/trade-raw-materials-

brazil-country-note.pdf [accessed 12 May 2020].


9052.v28i2p97-123


Rapini A., Mello-Silva R., Kawasaki M.L. (2002) Richness and endemism in Asclepiadoideae (Apocynaceae) from the Espi-


.2012.705356


versification in the Espinhaço Range: Insights from the bioge-


Salles D.M., Carmo F.F., Jacobi C.M. (2018) Habitat loss challeng-

es the conservation of endemic plants in mining-targeted Bra-


coibi.13279


matite and goethite from Brazilian “canga” duricrust demon-


Communicating Editor: André O. Simões.

Submission date: 29 Aug. 2019
Acceptance date: 12 May 2020
Publication date: 8 Jul. 2020