

Dioscorea compacta (Dioscoreaceae), a new endangered dwarf species from the Jalapão region, Tocantins, Brazil

Diogo Araújo¹, Guilherme Medeiros Antar² & Julio A. Lombardi¹

Summary. The Jalapão region located in the east of the state of Tocantins, central Brazil is the largest continuous area of protected cerrado, a hotspot of biodiversity. Here we present a new species of *Dioscorea*, found in dry soils in sandy open cerrado vegetation within the limits of two protected areas. This species differs from other similar species by its combination of dwarf habit, staminate flowers with three stamens plus three staminodes, compact pistillate inflorescences and spheroid unwinged seeds.

Key Words. cerrado, endemic species, grasslands, taxonomy.

Introduction

Dioscoreaceae comprises four genera and c. 650 species distributed mainly in tropical and subtropical regions (E-monocot 2015). Among the genera, *Dioscorea* L. (including *Rajania* L.) has the largest number of species and widest distribution. Most of the genus is Neotropical, with Brazil having the greatest number of species of any country in the world, at 139 (Kirizawa *et al.* 2015). These are distributed throughout the country, especially in seasonally dry environments, e.g. in the cerrado and semideciduous forests, and c. 75% of the species are endemic.

Dioscorea species are mostly dioecious, stem-climbing plants, with an underground system that is perennial at least in part. Their leaves are mostly alternate; petiole with a pulvinus at each end; inflorescences axillary racemes, panicles, spikes or combinations of these, flowers unisexual, with 6 sepaloïd tepals, pistillodium or staminodium sometimes present, 3 – 6 stamens, free, connate to tepals or into a staminal column; style 3-fid, 3-lobed, sometimes with bifid ends, ovary 3-locular. Fruit a 3-winged capsule or rarely a berry, usually with two winged seeds per loculus (Caddick *et al.* 2002).

Knuth (1924) divided the genus based mainly on the characters of the fruit and seed wing. Thus, subgenus *Dioscorea* (*Eudioscorea*) was comprised of species with a circular wing around the seed, and species of the subgenus *Helmia* (Kunth) R. Knuth characterised by an oblong wing directed towards the base of the seed. The subgenera were subdivided into sections, 17 for *Helmia* and 39 for *Dioscorea*, based

mainly on inflorescence and staminate flower morphology, but with unclear and arbitrary definitions, in contrast to the monophyly of the genus, as stated by Wilkin *et al.* (2005) based on molecular phylogenetic studies.

As the majority of *Dioscorea* species have winged seeds for wind dispersal (Burkill 1960), taxonomists have used the absence of this trait to justify different genera: *Epipetrum* Phil., *Tamus* L., *Borderea* Miégev., *Nanarepenta* Matuda and *Rajania* L. (Viruel *et al.* 2010). Although these taxa are now considered among *Dioscorea*, there is morphological and biogeographical evidence that wingless seeds have arisen more than once within the genus: the Mediterranean-Macaronesian *D. communis* (L.) Caddick & Wilkin with its berry fruit, instead of capsule; the Caribbean species of *Rajania* with samaroid fruits; the dwarfs, *D. gillettii* Milne-Redh. and *D. kituensis* Wilkin & Muasya from east Africa; *D. pyrenaica* Bubani & Bordère ex Gren. and *D. chopardii* Gausson from the French and Spanish Pyrenees; and *Epipetrum* species from the Chilean Andes (Wilkin *et al.* 2009).

Dwarf species are short, usually less than 50 cm, entirely or occasionally missing a climbing stem, appearing as self-supported or prostrate herbs. This habit has developed in a great number of species in African savannah, with no parallel evolution in Asia, but some in the New World (Burkill 1960). Besides *Epipetrum*, the Mexican *Dioscorea minima* B. L. Rob. & Seaton and *D. multinervis* Benth. (Sosa & Valdivieso 2013), once treated as genus *Nanarepenta*. In Brazil, most of them occur in high altitude open vegetation

Accepted for publication 6 April 2016. Published online 27 April 2016

¹ Instituto de Biociências de Rio Claro, Departamento de Botânica, Universidade Estadual Paulista - UNESP, Av. 24 A 1515, Bela Vista, 13506-900, Caixa Postal 199, Rio Claro, São Paulo, Brazil. e-mail: diogoambientais@gmail.com

² Departamento de Botânica, Instituto de Biociências, Universidade de São Paulo, Herbário SPF, Rua do Matão 277, 05508-090, São Paulo, SP, Brazil.

(Couto *et al.* 2014) from central-northern to south-eastern cerrado (Kirizawa *et al.* 2015). *D. anomala* Griseb., *D. maianthemoides* Uline ex. R. Knuth and *D. stenophylla* Uline, in the Espinhaço Mountains of Goiás and Minas Gerais; *D. perdicum* Taub. in the Serra do Mar highlands of Minas Gerais and Rio de Janeiro (Pedralli 2002); and *D. sphaeroidea* R. Couto & J. M. A. Braga, from high altitude grasslands in Rio de Janeiro.

The Jalapão region, located in the far east of the state of Tocantins, is the largest continuous area of protected Cerrado in Brazil (Silva & Bates 2002), a domain with high endemism (Forzza *et al.* 2012) and threats from human activities (Klink & Machado 2005). The principal conservation units in this area are Parque Estadual do Jalapão, Estação Ecológica Serra Geral do Tocantins, Parque Nacional das Nascentes do Parnaíba and Área de Proteção Ambiental do Jalapão (Schmidt *et al.* 2007), all these herein called Jalapão Protected Areas (JPA), where vegetation is well conserved and mostly composed of swamp forests, (locally called “veredas”), and open cerrado vegetation on nutrient-poor sandy soils (Sampaio *et al.* 2008). The weather is distinctly seasonal, a characteristic of the Cerrado domain (Ratter *et al.* 1997), the mean precipitation is approximately 1500 mm/year, and mean temperature is around 26°C, with a rainy season from October to March and a dry season from April to September (Seplan 2012), when human-induced burns usually happen in the area (Schmidt *et al.* 2007). Despite this level of protection and its recognised importance for conservation, few botanical expeditions have taken place there, and so the flora is poorly known (Proença *et al.* 2007).

Material and Methods

During examination of *Dioscorea* collections currently deposited in the SPF herbarium (for the masters thesis of the second author), we found two samples of a new species. This was confirmed by bibliographic survey and comparison with specimens from ASE, B, BHCB, CEPEC, CESJ, CGMS, CEN, CONC, EAC, HPL, HRCB, HST, HUESB, HVASF, HXBH, IAC, IEF, INPA, IPA, JPB, K, LP, LPB, M, MAC, MBML, MG, MVA, MVFA, NY, OUPR, PAMG, PEUFR, RB, SGO, SI, SP, SPF, TANG, UB, UEC, UFMT, UFP, UFPI, UFRN, VIC and VIES. Duplicates were sent to K and HRCB (herbaria acronyms follow Thiers, continuously updated). Accepted plant names follow Kirizawa *et al.* (2015).

The new species was described and drawn from herbarium specimens. Morphological analysis, photographs and measurements of the rehydrated reproductive structures were undertaken using Leica IC80 camera coupled to a Leica M60 stereomicroscope. For Conservation Status, Extant of Occurrence (EOO) and Area of Occupancy (AOO), the Land-cover change map

layer between January 2004 to December 2014 was assessed using the GeoCat tool (Bachman *et al.* 2011), and standard cell size as proposed by IUCN (2012). The distribution map was produced with QGIS version 2.8.1 (Quantum GIS Development Team 2015).

Taxonomic Treatment

Dioscorea compacta D. Araújo **sp. nov.** Type: Brazil, Tocantins: Mateiros: Estação Ecológica Serra Geral do Tocantins, caminho para o rio Verdinho, G. Antar, H. Antar & Nascimento 731 (holotype SPF; isotype K).

<http://www.ipni.org/urn:lsid:ipni.org:names:60471722-2>

Underground system an ovoid-conical tuber 1.5 × 1.0 cm, with a single aerial stem, light brownish periderm and white inside. Stems, to 40 cm long, slender, initially erect, then prostrate, sometimes climbing, dextrorse. *Leaves* alternate, entire; petiole to 0.5 cm long; blade 3 – 4.5 × 0.8 – 2.5 cm, bright green above, pale green below, membranaceous, ovate to lanceolate, base cordate, apex acute, veins 3 – 7, prominent on abaxial surface. *Staminate inflorescences* to 6.5 cm long, branched main axis bearing cymes with highly reduced internodes, 1 – 7 flowers per node, bracts 2.5 – 3 mm long, lanceolate, right curved, mucronulate; flowers sessile, bracteoles 1.5 – 2.5 × 0.5 – 0.8 mm, ovate, apex rounded, mucronulate, perianth tubular, 3 mm long, green, white at apex, tepals free at the middle, 1.3 – 1.5 × 0.5 – 0.8 mm, oblong; stamens 3, base connate, inserted at the base of the perianth, filaments c. 1 mm long, anthers basifixed, extrorse, staminodes 3, alternate with stamens; pistillode 0.2 – 0.3 mm, terete, columnar, apically 3-lobed. *Pistillate inflorescence* to 0.5 cm long, simple, compact, one per node; bearing up to 7 sessile flowers, 4 mm long, one per node of the rachis, bracts two, 2 – 3 × 0.5 – 0.7 mm, narrowly ovate; perianth campanulate, tepals free, 1 × 0.5 mm, mostly whitish, ovate, acute, ovary 3-carpellate, style c. 1 mm long, columnar, trifid at the apex, each branch 2-lobed; staminodes 3, c. 0.1 mm long, antheriform; ovary 3-angled, carpels fusion conspicuous. *Capsules* 8 – 9 × 6.8 – 7 mm, light green when immature, brownish when mature, rounded-obovate in outline, 3-winged, two seeds per locule; seeds spheroidal, wings absent, testa dark brown, colliculate. Figs 1, 2.

RECOGNITION. A dwarf species, similar to *D. sphaeroidea* R. Couto & J. M. A. Braga based on dimensions and fruit/seed morphology, but differing on filament length, 0.5 mm in *D. sphaeroidea* and 1 mm in *D. compacta*; pistillode shape, flattened and columnar; style length, 0.5 mm and 1 mm, respectively.

DISTRIBUTION. Only known from Jalapão region, central Brazil. (Map 1).

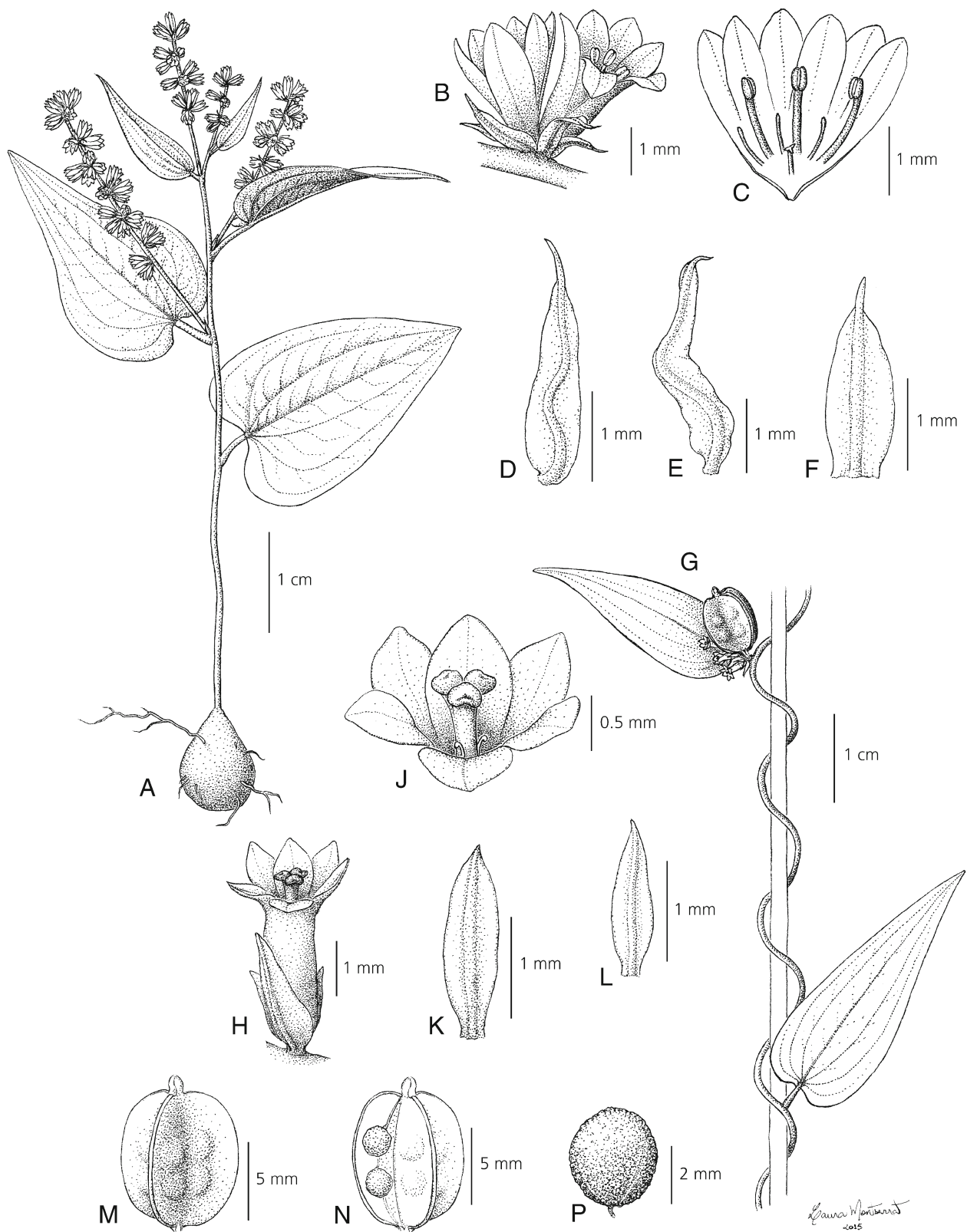


Fig. 1. *Dioscorea compacta*. **A** habit, staminate plant; **B** secondary axis of staminate flower; **C** dissected staminate flower; **D**–**E** bracts of staminate inflorescence; **F** bracteole of staminate flower; **G** right-twining stem, pistillate plant; **H** pistillate flower, frontal view; **J** pistillate flower, apical view; **K** bract of pistillate inflorescence; **L** bracteole of pistillate flower; **M**–**N** fruit; **P** seed. DRAWN BY LAURA MONTSERRAT.



Fig. 2. *Dioscorea compacta*. A habitat; B habit; C fruits; D twining up sedges; E tuber. PHOTOS BY: GUILHERME MEDEIROS ANTAR

SPECIMENS EXAMINED. BRAZIL. Tocantins: Mateiros: Estação Ecológica Serra Geral do Tocantins, caminho para o rio Verdinho, G. Antar, H. Antar & Nascimento 731 (holotype SPF; isotype K); Estrada entre Mateiros e Coaceral, 13 Nov. 2011, J. B. Bringel *et al.* 883 (UB); Área de Proteção Ambiental do Jalapão, campo próximo a Fazenda Lua Cheia, acessado pela antiga estrada São Felix-Mateiros, 23 Jan. 2014, G. Antar & L. F. Nascimento 374 (SPF); Parque Estadual do Jalapão, próximo à sede do Parque Estadual do Jalapão, 3 Feb. 2015, G. Antar & H. P. Antar 801 (HRCB, SPF).

HABITAT. Between 500 and 600 m a.s.l. in dry soils of sandy open cerrado vegetation. Its known populations are currently under protection of JPA. According to collectors and published literature (Schmidt *et al.* 2007), dry season fires are very common in the Jalapão region and is hard to find areas unburned for more than 3 years. Thus, *Dioscorea compacta* may be resistant to fires, surviving due to its underground system.

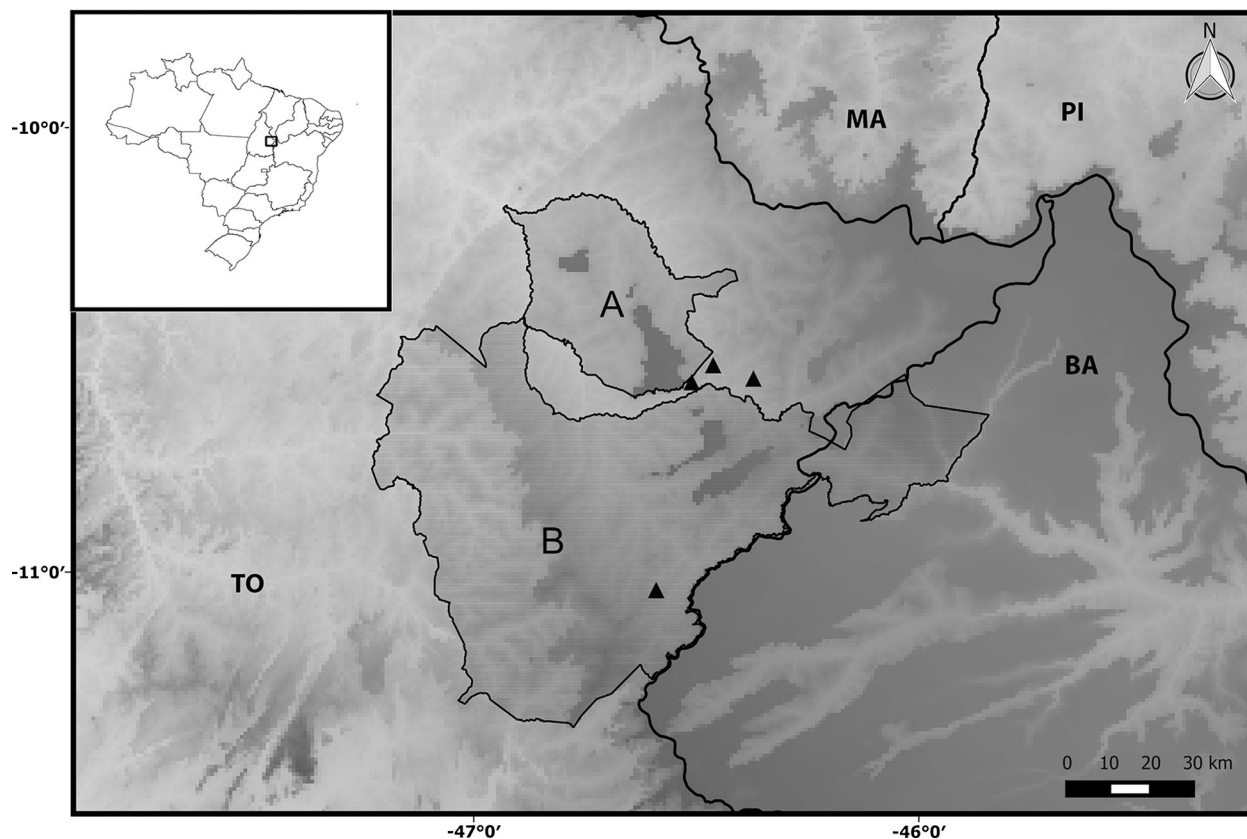
CONSERVATION STATUS. There are few known populations of *Dioscorea compacta*, three registered inside a perimeter of 15 km and another 60 km away. They cover an EOO of 314 km², with an AOO of 16 km²

(cell size of 4 km²); both values are below the threshold for Endangered in the IUCN (2012) conservation status assessment, 5000 km² and 500 km², criteria B1 and B2 respectively. The cerrado of Jalapão is under the increasing threat of burning where the surrounding areas are turned into cattle ranches or grain plantations. Most of the threats come from less than 100 km to the east, in the northwestern state of Bahia.

PHENOLOGY. Flowering and fruiting during the wet season, between November and February.

ETYMOLOGY. We named this species “*compacta*” for its compact growth and inflorescences, especially the pistillate ones.

NOTES. At first sight, *Dioscorea compacta* resembles the dwarf occasional climbers *D. anomala*, *D. maianthemoides* and *D. stenophylla*, herein called *D. anomala* complex, but is clearly distinct by the number of stamens, number of staminodia in the pistillate flower and the seed shape, characters summarised in Table 1. Another dwarf, *D. perdicum* is similar because of its short inflorescences and 3-staminate flowers, but distinct because of the absence of either pistillodia or staminodia in staminate and pistillate flowers, respectively. Besides *D. compacta*, the



Map 1. Geographic distribution of *Dioscorea compacta* (▲). A Protected Area of Parque Estadual do Jalapão. B Protected Area of Estação Ecológica da Serra Geral do Tocantins. States: BA Bahia; MA Maranhão; PI Piauí; TO Tocantins.

only Brazilian species that combine dwarf growing and spherical unwinged seeds in 3-winged capsules — as appear in some *Epipetrum* — is the recently discovered *D. sphaeroidea*. In Mexico, *D. minima* and *D. multinervis* are very similar to *D. compacta* due to its short pistillate inflorescences and spheroid rugose seeds, but distinct by the absence of staminodia in the staminate flower. The tubers of neotropical dwarf species are perennial and the aerial stem is dextrorse, so this may place them in the

second of two New World clades as shown by Wilkin *et al.* (2005). A more focused phylogenetic approach is necessary to understand the rise of dwarf *Dioscorea* in the Neotropics.

According to Burkill (1960), dwarf species from open vegetation tend to have lost the seed wings. In contrast, the *Dioscorea anomala* complex and *D. perdicum* have circular wings in their flattened seeds. However, the same author stated that seeds with such

Table 1. Comparison of morphological characters of Brazilian dwarf *Dioscorea* species similar to *D. compacta*.

		<i>D. compacta</i>	<i>D. sphaeroidea</i>	<i>D. maianthemoides</i>	<i>D. stenophylla</i>	<i>D. perdicum</i>	<i>D. anomala</i>
Habit		sometimes climbing	sometimes climbing	sometimes climbing	sometimes climbing	non-climbing	non-climbing
Leaf	Shape	wider than long	wider than long	longer than wide	longer than wide	longer than wide	longer than wide
	Texture	membranaceous	membranaceous	coriaceous	coriaceous	coriaceous	coriaceous
Estaminate Flowers	No of stamens	6	3	6	6	3	6
	Pistillode Shape	columnar	flattened	conical	conical	flattened	conical
Pistillate Flowers	Style Length	1 mm	0.5 mm	1 mm	1 mm	0.5 mm	1 mm
	Staminodes	3	3	6	6	3	6
Seeds	Shape	rounded	rounded	flattened	flattened	flattened	flattened
	Wings	absent	absent	present	present	present	present

wings can glide in very light air but are less effective in strong wind, which is the prevailing condition in those environments. Non South American wingless seeded species are zoochoric (Wilkin pers. comm.) and the carunculate seeds of *Epipetrum* (Viruel *et al.* 2010) in South America are suggested to be the same. On the other hand, once *D. compacta* is fruiting in the last month of the rainy season, the rounded colliculate light seeds probably still depends on the wind for dispersal, instead of flying, rolling or even being carried by small streams among the bushes. We noticed predation of the staminodes in many staminate flowers, which can be confusing for proper determination but calls attention to an interesting feature for the study of the plant-predator/pollinator relationship.

Acknowledgements

We thank Laura Montserrat for providing the line drawing; Jalapão State Park and Serra Geral do Tocantins Ecological Station crew for field support; Ubiratan Chagas, Lucas Nascimento, Marcela Escaramai, Heloisa Antar, Vera Scatena, Paulo Sano, Rebeca Viana and Marcio Martins for help during field work. Thanks to Dr Paul Wilkin for the attentive personal communication. GMA thanks “Coordenação de Aperfeiçoamento de Pessoal de Nível Superior”, “Fundação de Amparo à Pesquisa do Estado de São Paulo” (2014/01851-7) and Idea Wild, DA thanks to “Conselho Nacional de Desenvolvimento Científico e Tecnológico” (158553/2011-0), for financial support. Special thanks to two anonymous reviewers for their advice.

References

- Bachman, S., Moat, J., Hill, A. W., de la Torre, J. & Scott, B. (2011). Supporting Red List threat assessments with GeoCAT: geospatial conservation assessment tool. *ZooKeys* 150: 117 – 126.
- Burkill, I. H. (1960). The organography and the evolution of Dioscoreaceae, the family of the Yams. *Bot. J. Linn. Soc.* 56: 319 – 412.
- Caddick, L. R., Wilkin, P., Rudall, P. J., Hedderson, T. A. J. & Chase, M. W. (2002). Yams reclassified: a recircumscription of Dioscoreaceae and Dioscoreales. *Taxon* 51: 103 – 114.
- Couto, R. S., Lopes, C. R. & Braga, J. M. A. (2014). *Dioscorea sphaeroidea* (Dioscoreaceae), a threatened new species from the high-altitude grasslands of southeastern Brazil with wingless seeds. *Phytotaxa* 163(4): 229 – 234.
- E-monocot (2015). EMonocot, An online resource for monocot plants <http://e-monocot.org/> (accessed 18 August 2015).
- Forzza, R. C., Baumgratz, J. F. A., *et al.* (2012). New Brazilian floristic list highlights conservation challenges. *BioScience* 62: 39 – 45.
- IUCN (2012). *IUCN Red List Categories and Criteria. Version 3.1* 2nd ed. IUCN, Gland and Cambridge.
- Kirizawa, M., Xifreda, C. C., Couto, R. & Araújo, D. (2015). Dioscoreaceae. *Lista de Espécies da Flora do Brasil*. Jardim Botânico do Rio de Janeiro. <http://floradobrasil.jbrj.gov.br/jabot/floradobrasil/FB7372>. Accessed 20 April 2015.
- Klink, C. A. & Machado, R. B. (2005). Conservation of Brazilian Cerrado. *Conservation Biol.* 19(3): 707 – 713.
- Knuth, R. (1924). Dioscoreaceae. In: H. G. A. Engler (ed.), *Das Pflanzenreich* 4, 43 (87): 1 – 387. Verlag von Wilhelm Engelmann, Leipzig.
- Pedralli, G. (2002). Levantamento florístico das Dioscoreaceae (R. Br.) Lindley da Cadeia do Espinhaço, Minas Gerais e Bahia, Brasil. *Bol. Bot. Univ. São Paulo* 20: 63 – 119.
- Proença, C. E. B., Farias-Singer, R. & Gomes, B. M. (2007). *Pleonotoma orientalis* (Bignoniaceae-Bignoniaceae): Expanded description, distribution and a new variety of a poorly known species. *Edinburgh J. Bot.* 64(1): 17 – 23.
- Quantum GIS Development Team (2015). Quantum GIS Geographic Information System. Open Source Geospatial Foundation Project. <http://qgis.osgeo.org>.
- Ratter, J. A., Ribeiro, J. F. & Bridgewater, S. (1997). The Brazilian cerrado vegetation and threats to its biodiversity. *Ann. Biol.* 80: 223 – 230.
- Sampaio, M. B., Schmidt, I. B. & Figueiredo, I. B. (2008). Harvesting Effects and Population Ecology of the Buriti Palm (*Mauritia flexuosa* L.f., Arecaceae) in the Jalapão Region, Central Brazil. *Econ. Bot.* 62(2): 171 – 181.
- Schmidt, I. B., Figueiredo, I. B. & Scariot, A. (2007). Ethnobotany and Effects of Harvesting on the Population of *Syngonanthus nitens* (Bong.) Ruhland (Eriocaulaceae), a NTFP from Jalapão Region, Central Brazil. *Econ. Bot.* 61(1): 73 – 85.
- SEPLAN — Secretaria do Planejamento e Meio Ambiente do Estado de Tocantins. (2012). *Atlas do Tocantins: Subsídios ao Planejamento da Gestão Territorial*. Seplan, Palmas.
- Silva, J. M. C. & Bates, J. M. (2002). Biogeographic patterns and conservation in the South America Cerrado: A Tropical Savana Hotspot. *BioScience* 52(3): 225 – 233.
- Sosa, V. & Valdivieso, I. G. (2013). Dioscoreaceae. In: G. C. Rzedowski & J. Rzedowski (eds), *Flora del Bajío y de Regiones Adyacentes 177*. Instituto de Ecología, A.C., México.

- Thiers, B. [continuously updated]. *Index Herbariorum: A global directory of public herbaria and associated staff*. New York Botanical Garden's Virtual Herbarium. <http://sweetgum.nybg.org/ih>. Accessed 02 September 2015.
- Viruel, J., Segarra-Moragues, J. G., Pérez-Collazos, E., Villar, L. & Catalán, P. (2010). Systematic Revision of the *Epipetrum* Group of *Dioscorea* (Dioscoreaceae) Endemic to Chile. *Syst. Bot.* 35(1): 40 – 63.
- Wilkin, P., Schols, P., Chase, M. W., Chayamarit, K., Furness, C. A., Huysmans, S., Rakotonasolo, F., Smets, E. & Thapayai, C. (2005). A plastid gene phylogeny of the yam genus, *Dioscorea*: Roots, fruits and Madagascar. *Syst. Bot.* 30: 736 – 749.
- _____, Muasya, A. M., Banks, H., Furness, C. A., Vollesen, K., Weber, O. & Sebsebe, D. (2009). A New Species of Yam from Kenya, *Dioscorea kituiensis*: Pollen Morphology, Conservation Status, and Speciation. *Syst. Bot.* 34(4): 652 – 659.