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Revisiting *Psyllocarpus goiasensis* (Rubiaceae: Spermacoceae): a new synonym, notes on type specimens, and conservation status assessment of this endemic species from the campo rupestre of Goiás state, central Brazil

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Summary. *Psyllocarpus goiasensis* J. H. Kirkbr. is an endemic species from the campo rupestre of Goiás. *Psyllocarpus laricoides* Mart. & Zucc. var. γ *longicornu* K. Schum., formerly under the synonymy of *P. laricoides*, is treated here as a new synonym of *P. goiasensis*. A second-step lectotype is designated for this variety. The first illustration and photographs of *P. goiasensis*, as well as a distribution map and comments on its ecology are presented. This species is assessed as Endangered (EN) under the range size (B) criterion of the IUCN.

Key Words. Chapada dos Veadeiros, Pohl, *Spermacoce* clade, taxonomy.

Introduction

Psyllocarpus Mart. & Zucc. is distinguished from other genera of the *Spermacoce* clade in the tribe Spermacoceae by its compressed capsule parallel to the septum (Martius & Zuccarini 1824; Kirkbride 1979; Kårehed *et al.* 2008; Salas *et al.* 2015). It is endemic to Brazil and as currently circumscribed comprises 12 species, occurring in the Cerrado, campo rupestre, and white-sand Amazonian campina (Kirkbride 1979; Cabral & Bacigalupo 1997; Zappi *et al.* 2014; BFG 2015; Carmo *et al.* 2018). Despite being considered a morphologically well-defined genus, *Psyllocarpus* has never been the subject of a comprehensive phylogenetic study to test its monophyly and how it relates to other genera in the *Spermacoce* clade, as well as the relationships between its species. However, according to an analysis based on two species and two nuclear DNA regions, *P. asparagoides* Mart. ex Mart. & Zucc. and *P. phyllocephalus* K. Schum. and ITS and ETS, respectively, Salas *et al.* (2015) recovered the genus as sister group of a clade composed of some *Spermacoce* L. species.

Psyllocarpus goiasensis J. H. Kirkbr. is endemic to the state of Goiás, occurring in the Chapada dos Veadeiros and Serra Geral do Paranã, growing on soils composed of quartz sands (Kirkbride 1979; Delprete 2010). Kirkbride (1979) compared it with the supposedly closely related *Psyllocarpus laricoides* Mart. & Zucc., since both taxa have leaf axils with brachyblasts and indeterminate flowering branches with axillary inflorescences in 1-flowered cymes. The author distinguished *P. goiasensis* from *P. laricoides* by its hypanthium and capsule puberulous above the middle (vs glabrous) and the absence of a calyx tube (vs calyx tube present).

Psyllocarpus laricoides var. γ *longicornu* K. Schum. was described based on the collection "Prope Ouro fino: *Pohl* n. 1317 (d. 851)". Schumann (1888) segregated this variety from the typical *P. laricoides* based on the following morphological traits: "internodiis abbreviatis, foliis longioribus, inflorescentia elongata, sepalis majoribus tubo corollae vix brevioribus, capsulae aequilongis". Some of these features, such as the elongate flowering branches and the calyx lobes relatively longer, are diagnostic for the identification of *P. goiasensis*. Kirkbride (1979) transferred *P. laricoides* var. γ *longicornu* to the synonymy of *P. laricoides*, an endemic species from high elevation areas of the Espinhaço Range in the states of Minas Gerais and Bahia, without further explanation. He also designated a lectotype for this variety, in W, with two isolectotypes, in W and K, and annotated that it was collected by Pohl in 1820, in "Ouro fino", Minas Gerais.

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In the present study, we propose that *Psyllocarpus laricoides* var. γ *longicornu* should be treated as a synonym of *P. goiasensis*, based on morphology and geographical distribution here clarified by consulting Pohl's travel book (Pohl 1976). Since there are two type specimens of this variety deposited in W, and no specification is provided by Kirkbride (1979) as to which one is the lectotype, a second-step lectotype designation is here proposed, according to Art. 9.17 of the ICN (McNeill *et al.* 2012). We provide the first illustration and photographs of *P. goiasensis*, along with a distribution map, comments on its ecology, and conservation status assessment.

Materials and Methods

We analysed collections deposited at CTES, F, HUEFS, MBM, MO, NY, RB, SPF, UB, UEC, and US herbaria; digital images of type specimens deposited at K, MO, NY, US, W, WAG, and WIS available at JSTOR, the New York Botanical Garden's Virtual Herbarium, Smithsonian National Museum of Natural History, Tropicos, and the Virtual Herbaria (Naturhistorisches Museum Wien) websites; and photographs of type specimens, not yet digitised, deposited at W. Acronyms are presented according to Thiers (continuously updated). Links for digital images available online are provided in Appendix 1. A population in the Serra do Tombador, Goiás, Brazil, was sampled and photographed in the field. Conservation status was assessed by range size (B) criterion, following IUCN (2014) recommendations. We used coordinates from municipalities, when their names were given on the labels, as proxies for the specimens which were not georeferenced. Extent of occurrence (EOO) and area of occupancy (AOO) were estimated using GeoCAT (Bachman *et al.* 2011).

Taxonomic Treatment

Psyllocarpus goiasensis *J. H. Kirkbr.* (Kirkbride 1979: 41; 17, fig. 5). Type: Brazil, Goiás, Chapada dos Veadeiros, Cerrado on outcrops with adjacent wet campo (brejo), c. 10 km N of Alto Paraíso do Goiás, c. 1100 m, 24 March 1971, *H. S. Irwin et al.* 33082 (holotype UB!; isotypes MO2575309!, NY00133029!, US00130113 [negative and digital image]!, WAG0003052 [digital image]!, WIS0004269 [digital image]!, WIS0004270 [digital image]!) (Figs 1 and 2).

Psyllocarpus laricoides var. γ *longicornu* K. Schum. (Schumann 1888: 6 (6); 33), **synon. nov.** Type: Brazil, Goiás, Ouro Fino, 1819 [annotated as "Minas Gerais, Ouro fino, 1820" by Kirkbride (1979)], *J. B. E. Pohl* 1317 (lectotype W ["*29a W – W46*" handwritten on herbarium sheet, annotated as lectotype by Joseph H. Kirkbride, Jr.]!, first-step selected by Kirkbride (1979: 16); isolectotypes BR0000005325986 [digital image]!, K000470420 [digital image]!, M0189211 [digital image]!, W ["*29a W – W45*" handwritten on herbarium sheet, annotated as isotype by Joseph H. Kirkbride, Jr.]!; lectotype W ["*29a W – W46*" handwritten on herbarium sheet, annotated as lectotype by Joseph H. Kirkbride, Jr.,]!, second-step selected here).

DISTRIBUTION. *Psyllocarpus goiasensis* is endemic to the state of Goiás, central Brazil (Map 1). From north to south, this species occurs in the Serra do Tombador, Chapada dos Veadeiros, and Serra Geral do Paranã, in the municipalities of Alto Paraíso de Goiás, Cavalcante, Formosa, and São João d'Aliança. However, most of the analysed specimens were collected in the region of the Chapada dos Veadeiros.

SPECIMENS EXAMINED. BRAZIL. Goiás: c. 30 km N of Formosa, 2 May 1966, *H. S. Irwin et al.* 15531 (paratypes F!, NY!, UB!, W [digital image]!), Chapada dos Veadeiros, 18 July 1964, *G. T. Prance & N. T. Silva* 58197 (paratypes NY!, UB!, US!), 15 Feb. 1966, *H. S. Irwin et al.* 12870 (paratypes F!, NY!, UB!, W [digital image]!), 6 March 1973, *W. R. Anderson* 6437 (paratypes NY!, RB!, UB!, US!), 16 March 1973, *W. R. Anderson* 7161 (paratypes MBM!, MO!, NY!, UB!), Estrada Alto Paraíso a Campo Belo, km 8, 28 Nov. 1976, *G. J. Shepherd et al.* 3714 (UEC!), Hilly campo c. 16 km S of Alto Paraíso (formerly Veadeiros), 20 March 1969, *H. S. Irwin et al.* 24745 (paratypes F!, NY!, RB!, UB!), Region of the Chapada dos Veadeiros, 14°30'S, 47°30'W, 24 May 1956, *E. Y. Dawson* 14619 (paratype F!), Rod. GO-118, 10-20 km S de São João da Aliança, 11 Feb. 1990, *G. Hatschbach & V. Nicolack* 53810 (MBM!, US!), Serra do Tombador, 13°32'20"S, 47°31'46"W, 14 April 2015, *J. A. M. Carmo & A. V. Scatigna* 352 (CTES, UEC!), Alto Paraíso de Goiás, Chapada dos Veadeiros, 20 Feb. 1975, *G. Hatschbach et al.* 36340 (paratypes CTES!, MBM!, MO!, NY!, US!, W [digital image]!), Fazenda São Bento, próximo a Cachoeira Almecégas II, 14°10'44"S, 47°34'59"W, 16 April 2009, *G. Martinelli et al.* 16535 (MO!, RB!), Parque Nacional da Chapada dos Veadeiros, 17 Oct. 2006, *J. P. Souza et al.* 8677 (SPF!), Cavalcante, Parque Nacional da Chapada dos Veadeiros, 1320 m, 13°56'38"S, 47°41'46"W, 15 April 2009, *G. Martinelli et al.* 16512 (RB!), Serra do Tombador, 1128 m, 13°32'22"S, 47°31'47"W, 19 April 2013, *J. Cordeiro et al.* 4966 (HUEFS!, MBM!), Formosa, Rio Tiquiri, 25 May 1967, *E. P. Heringer* 11451 (RB!).

HABITAT. *Psyllocarpus goiasensis* occurs in montane areas at elevations from 1000 to 1400 m, in campo rupestre vegetation (sensu Silveira *et al.* 2016), growing on sandy soils.

CONSERVATION STATUS. This is the first conservation status assessment for *Psyllocarpus goiasensis*. Its EOO and

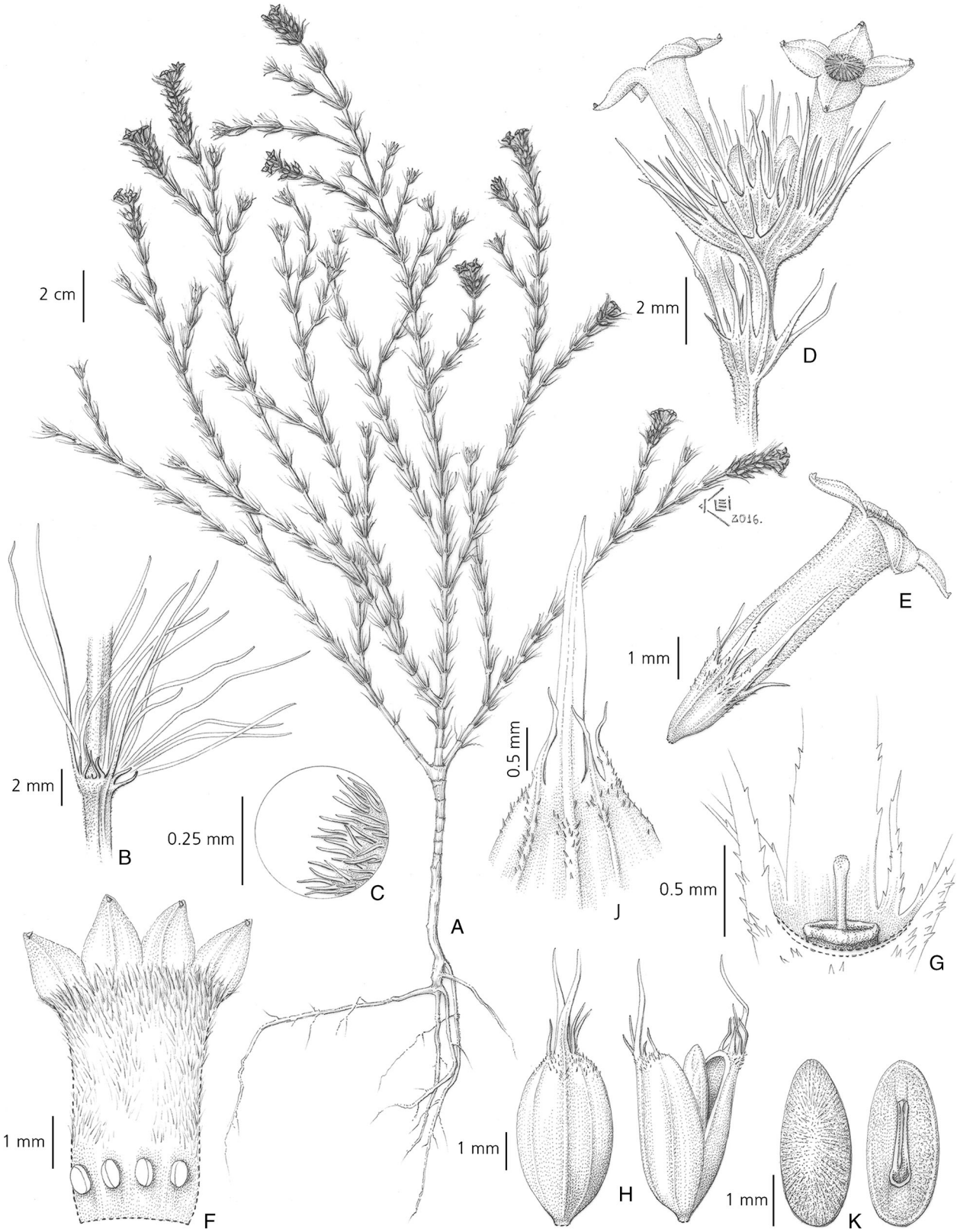
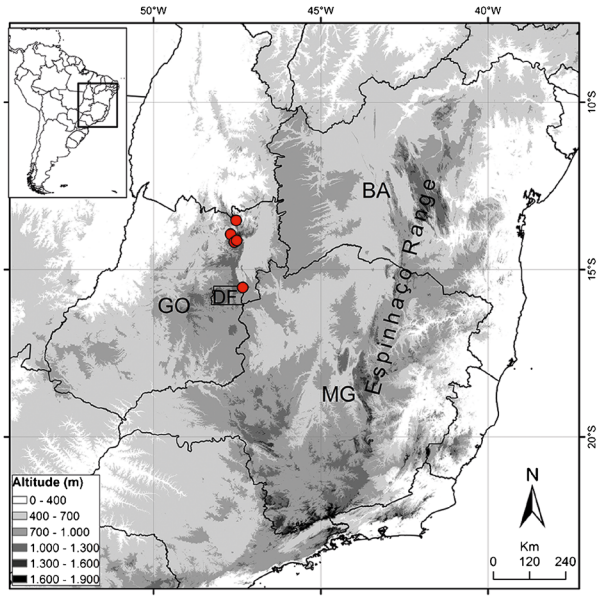


Fig. 1. *Psyllocarpus goiasensis*. **A** habit; **B** stipule; **C** indumentum on the stipule; **D** apex of flowering branch; **E** flower; **F** corolla, opened out; **G** nectariferous disc, style, and stigma; **H** capsules, dorsal and lateral views; **J** apex of the capsule, dorsal view; **K** seeds, dorsal and ventral views. From *Carmo & Scatigna* 352 (CTES, UEC)]. DRAWN BY KLEI SOUSA.

Fig. 2. *Psyllocarpus goiasensis*. **A** individual plants; **B** flowering branch; **C** flowers. Serra do Tombador, Goiás, Brazil, 14 April 2015. PHOTOS: JOÃO CARMO.

AOO account for 2,475.228 km^2 and 20 km^2, respectively (.kml file available at https://figshare.com/articles/Extent_of_Occurrence_and_Area_of_Occupancy_of_Psylocarpus_goiasensis/4216356), and it was recorded in three locations: Serra do Tombador; Chapada dos Veadeiros, including records within the limits of the Parque Nacional da Chapada dos Veadeiros; and Serra Geral do Paranã. Therefore, *P. goiasensis* should be considered as an Endangered (EN) species under the B1ab(iii) + 2ab(iii) criteria, based on its EOO < 5000 km^2 and AOO < 500 km^2, number of locations ≤ 5, and continuing decline in area, extent and quality of habitat, due to major current disturbances in the campo rupestre, which are opencast mining, annual anthropogenic fires to support the cattle industry, wood extraction, invasive species, ornamental plant



Map 1. Distribution map of *Psyllocarpus goiasensis* in the state of Goiás, Brazil, and its relative position to the Espinhaço Range, in the states of Minas Gerais and Bahia, where *Psyllocarpus laricoides* occurs. BA: Bahia; DF: Distrito Federal; GO: Goiás; MG: Minas Gerais.

indiscriminate collection, road construction and uncontrolled urbanisation, especially linked to tourism expansion and eucalypt plantations (Silveira *et al.* 2016).

PHENOLOGY. Specimens were collected with flowers and fruits from October to April, and only fruits until July.

NOTES. The type specimens of *Psyllocarpus laricoides* var. γ *longicornu* present morphological traits coincident to *P. goiasensis*, such as the monopodial branching pattern (Fig. 1A; vs sympodial in *P. laricoides*), no calyx tube (Fig. 1E; vs calyx tube), and calyx lobes triangular to subulate (Fig. 1E, J; vs narrowly triangular to linear) and longer (2.3 – 3 mm long) than those of *P. laricoides* (1 – 1.4 mm long, from syntype M0189221!). Capsules of *P. laricoides* var. γ *longicornu* seem glabrescent, as is the case for some specimens of *P. goiasensis*, but we were not able to analyse the indumentum on the apex of the hypanthium and fruit in detail.

According to Pohl's travel book (Pohl 1976) he travelled in Goiás from 1818 to 1820. The locality Ouro Fino was a small village in the so-called captaincy of Goiás, which he passed by with his entourage on his way from Paracatu do Príncipe, Minas Gerais, to Vila Boa, Goiás, in 1819. Therefore, the distribution of *Psyllocarpus laricoides* var. γ *longicornu* in Goiás also corroborates its synonymy with *P. goiasensis*, since *P. laricoides* is an endemic species from the Espinhaço Range (Map 1) in Minas Gerais and Bahia (Kirkbride 1979). Furthermore, other species have been described based on Pohl's collections at the same locality. Bentham (1839: 429) described *Crotalaria divergens* Benth. and *C. vespertilio* Benth., for which he listed the localities "Ouro fino" and Santa Cruz for the former and only "Ouro fino" for the latter, both in "Goyaz" [Goiás]. The information "Ad Ouro fino & S. Cruz in C. Goyaz" is written on the labels of two type specimens of *C. vespertilio* from the collection *Pohl* 1634 (isotypes NY00006697 [digital image]!, W0031489[digital image]!). There is a municipality in southern Minas Gerais also called Ouro Fino, but the village that originated it received its current name only in 1868 (IBGE 2016), after Pohl left Brazil.

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Appendix 1

Digital images of MO, NY, WAG, and WIS isotypes of *Psyllocarpus goiasensis* J. H. Kirkbr. available at http://www.tropicos.org/Image/51125, http://sweetgum.nybg.org/science/vh/specimen_details.php?irn=303767, http://plants.jstor.org/stable/10.5555/al.ap.specimen.wag0003052?searchUri=plantName%3D%2522Psyllocarpus%2Bgoiasensis%2522%26syn%3D1, http://plants.jstor.org/stable/10.5555/al.ap.specimen.wisv0004269wis?searchUri=plantName%3D%2522Psyllocarpus%2Bgoiasensis%2522%26syn%3D1, and http://plants.jstor.org/stable/10.5555/al.ap.specimen.wisv0004270wis?searchUri=plantName%3D%2522Psyllocarpus%2Bgoiasensis%2522%26syn%3D1.

Digital images of BR, K, and M isolectotypes of *Psyllocarpus laricoides* Mart. & Zucc. var. γ *longicornu* K. Schum. available at http://plants.jstor.org/stable/10.5555/al.ap.specimen.br0000005325986?searchUri=plantName%3D%2522Psyllocarpus%2Blaricoides%2Bvar.%2Blongicornu%2522%26syn%3D1, http://plants.jstor.org/stable/10.5555/al.ap.specimen.k000470420?searchUri=plantName%3-

D%2522Psyllocarpus%2Blaricoides%2Bvar.%2Blongicornu%2522%26syn%3D1, and http://plants.jstor.org/stable/10.5555/al.ap.specimen.m0189211?searchUri=plantName%3D%2522Psyllocarpus%2Blaricoides%2Bvar.%2Blongicornu%2522%26syn%3D1.

Digital images of W paratypes of *Psyllocarpus goiasensis* J. H. Kirkbr. available at http://herbarium.univie.ac.at/database/detail.php?ID=1056921, http://herbarium.univie.ac.at/database/detail.php?ID=1056920, and http://herbarium.univie.ac.at/database/detail.php?ID=219632.

Digital image of M syntype of *Psyllocarpus laricoides* Mart. & Zucc. available at http://plants.jstor.org/stable/10.5555/al.ap.specimen.m0189221?searchUri=si%3D1%26plantName%3D%2522Psyllocarpus%2Blaricoides%2522%26syn%3D1.

Digital images of NY and W isotypes of *Crotalaria vespertilio* Benth. available at http://plants.jstor.org/stable/10.5555/al.ap.specimen.ny00006697?searchUri=filter%3Dname%26so%3Dps_group_by_genus_species%2Basc%26Query%3Dcrotalaria%2Bvespertilio and http://plants.jstor.org/stable/10.5555/al.ap.specimen.w0031489?searchUri=filter%3Dname%26so%3Dps_group_by_genus_species%2Basc%26Query%3Dcrotalaria%2Bvespertilio.

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