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Borreria krapocarmeniana, a New Cryptic Species Recovered Through Taxonomic Analyses of *Borreria scabiosoides* and *Borreria linoides* (Spermacoceae, Rubiaceae)

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Abstract—The new species ***Borreria krapocarmeniana*** (Rubiaceae) is described and illustrated. The taxonomic identity of *Borreria linoides* and *Borreria scabiosoides* are discussed. *Borreria organensis* and *Borreria rubricaulis* are proposed as new synonyms of *B. scabiosoides*. Seed micromorphology and pollen grains of the three species are analyzed and a map with the distribution of these species is presented. Additionally, a table featuring diagnostic characters to distinguish between species is provided.

Keywords—Comparison table, distribution map, pollen grain, seed morphology.

Borreria G. Mey. is a pantropical genus of Rubiaceae, including 100 species in the Americas. *Borreria* belongs to tribe Spermacoceae and is characterized by a history of taxonomic changes involving the entire tribe. In the following, we provide an overview of the taxonomic debate currently existing at the tribal and generic level, and then focus on American *Borreria* species, outlining the goals of the present study.

Tribe Spermacoceae was classically characterized by the fimbriate stipules, uniovulate locules, dry fruits, seeds with a ventral groove, and pluriaperturate pollen grains (Hooker 1873; Robbrecht 1988). This tribal concept, known as Spermacoceae s.s., was expanded by recent phylogenetic studies that included members of the former tribes Hedyotideae and Mannettieae into Spermacoceae, forming the current circumscription Spermacoceae s.l. (Andersson and Rova 1999; Dessein et al. 2005; Robbrecht and Manen 2006; Kårehed et al. 2008; Groeninckx et al. 2009). Spermacoceae s.l. displays considerable morphological variation, but no clear morphological synapomorphies exist to support the expanded circumscription (Groeninckx et al. 2009).

The lack of synapomorphies to circumscribe taxa in Spermacoceae has been a problem also at the generic and the species level. For instance, the generic status of *Borreria* has been the subject of debate, because of its morphological similarity with the close relative *Spermacoce* L. The African, Australian and Asian species of *Borreria* were relegated as synonyms of *Spermacoce* (Verdcourt 1976; Sivarajan et al. 1987; Dessein et al. 2002, 2003; Harwood and Dessein 2005). In America, there are divergent opinions regarding the generic circumscription. On one hand, Delprete and collaborators have applied the old world concept of *Spermacoce* to all Neotropical species in treatments of the genus for some specific geographical area of South America (Delprete 2007, 2010; Delprete et al. 2005; Delprete and Cortés 2006). On the other hand, recent studies on American taxa considered the close similarity with *Spermacoce*, but maintained the generic status of *Borreria*, based on inflorescence, pollen, fruit, and seed characters (Bacigalupo and Cabral 1996, 2007; Bacigalupo et al. 2010; Cabral et al. 2010, 2011, 2012a, 2012b; Salas et al. 2011).

Available molecular phylogenetic studies offer no resolution with respect to the relationship between *Borreria* and *Spermacoce.* Based on analyses of both chloroplast and nuclear genes, Kårehed et al. (2008) pointed out that merging *Borreria* species into *Spermacoce* is not supported, because the broader concept of *Spermacoce* (i.e. including *Borreria*) is paraphyletic. Several smaller and morphologically well-defined genera, such as *Diodia* L., *Mitracarpus* Zucc., *Richardia* L., and *Psyllocarpus* Mart. & Zucc., appear in fact intermingled with *Spermacoce* species. Also, Kårehed et al. (2008) and other available molecular phylogenetic studies include only a small number of species representing the American flora (nine *Borreria* spp. in Dessein, 2003; five species in Kårehed et al. 2008; four species in Groeninckx et al. 2009), and phylogenetic relationships among these few American *Borreria* and *Spermacoce* species is unclear.

Due to this debate and the uncertainty in current molecular phylogenies, in the present study we consider these genera as a *Borreria-Spermacoce* alliance, instead of massively including all species of *Borreria* under *Spermacoce* [i.e. in our opinion the following taxa should not be relegated to synonyms of *Spermacoce*, *Borreria* subsect. *Borreria*, *Borreria* subsect. *Latifoliae* (K. Schum.) Bacigalupo & E. L. Cabral, and *Borreria* subgen. *Dasycephala* (DC.) Bacigalupo & Cabral]. Further molecular studies and a revision of American species of *Borreria* are necessary to assess whether these genera should be considered separate genera or merged into one large genus, *Spermacoce*. Therefore, in this paper we follow the generic circumscription proposed by Bacigalupo and Cabral (1996) and consider that the three American species studied in this paper, *Borreria linoides* DC., ***Borreria krapocarmeniana*** E. L. Cabral & L. M. Miguel and *Borreria scabiosoides* Cham. & Schltdl., belong to *Borreria* sect. *Borreria*. Species of section *Borreria* are easily distinguished from *Spermacoce* species by bilateral glomerules, exserted stamens and styles, and capsular fruits with both mericarps dehiscing septicidally from the apex (see Table 1 for a full list of differences).

American species of *Borreria* have been the focus of various taxonomic studies. Cabral (1983) expanded the geographic distribution of *B. scabiosoides* to northeastern Argentina (Corrientes and Misiones), southern Brazil (Río Grande do Sul and Santa Catarina), and eastern Paraguay (Canindeyú, Guairá and Itapúa). These specimens were identified using the original description and compared with the phototype F 884. Recently, while analyzing numerous specimens of American and European herbaria and herbarium collections from northern Brazil identified as *B. scabiosoides*, we noticed these specimens differed from specimens cited by Cabral (1983), leading to the conclusion that they were all misidentified as *B. scabiosoides*, but represented in fact a different

Table 1. Morphological differences between *Spermacoce* (sensu Cabral et al. 2010) and *Borreria* sect. *Borreria* (sensu Bacigalupo and Cabral 1996)

Character	*Spermacoce*	*Borreria* sect. *Borreria*
Inflorescence	Glomerules unilateral	Glomerules bilateral
Internal surface of corolla	Tube without a ring of moniliform hairs, lobes entirely pilose	Tube with a ring of moniliform hairs near the middle, lobes glabrous or pubescent
Corolla shape	Urceolate or campanulate	Infundibuliform
Corolla lobes/ corolla tube ratio	Longer than the tube	Equal or shorter than the tube
Stamens	Stamens included, fixed near the base of the corolla tube or at the interlobular sinuses	Stamens exserted, fixed at the interlobular sinuses
Style/ stigma	Styles very short, included. Stigma capitate-bilobate	Styles long, exserted. Stigma capitate-bilobate or bifid
Fruit dehiscence	Capsule indehiscent or with septicidal dehiscence in only one mericarp	Fruits capsular dehiscing septicidal from the apex, both mericarps dehiscent
Seed characters	Flat ventral side. Never seeds with elaiosome or transversally sulcate are present	Ventral side with longitudinally groove. Some species have seeds with elaiosome or transversally sulcate
Pollen grains	Zonocolporate, ectocolpi long and endoapertures joined, forming an endocingulum with a well-defined boundary observed with light microscopy. Ectocolpi surrounded by a margin of granules. Exine psilate at the apocolpium and spinulate at the mesocolpium	Pantoporate or zonocolporate, ectocolpi short or medium. Endocingulum are barely discernible. Ectocolpi without margin of granules. Exine uniformly spinulate

entity. As we analyzed the misidentified specimens, we observed that part of the material from Río Grande do Sul (Brazil), deposited in PACA, had been identified as *B. linoides* by Rambo (Rambo 1962). This name, however, had been reduced to *B. tenella* var. *linoides* (DC.) K. Schum by Schumann (1888), and later to *B. scabiosoides* G. Mey. var. *linoides* (DC.) Standl. by Standley (1936). In order to clarify the identity of specimens seen by Rambo, we analyzed the holotype of *B. linoides* deposited in G-DC and classical material identified by Schummann and deposited in BR, M and W. We concluded that the two species can actually be distinguished by their stipules, the size of the leaves, and the shape of the seeds, and are different from the entity represented by the specimens identified as *B. scabiosoides* by Cabral (1983).

Based on this conclusion, we here describe and illustrate the new species ***Borreria krapocarmeniana*** to rename Cabral's specimens from northeastern Argentina, southern Brazil and eastern Paraguay. *Borreria scabiosoides* and *B. linoides* are here described and illustrated for the first time, and the latter is also reinstated as a valid species name. In addition, we carried out a comparative analysis of micromorphological seed and pollen characters of the three species. We also provide a map with the respective geographic distributions and a table with diagnostic characters for each species.

Materials and Methods

This study is based on literature revisions and analysis of collections and images of the three species of *Borreria* from the herbaria AS, B, BAB, BHCB, BM, BR, CEN, CEPEC, CTES, F, G, G-DC, HUEFS, HUVA, IAN, INPA, IPA, K, LIL, LP, LPB, M, MA, MG, MO, P, PACA, PY, R, RB, S, SI, USZ, and W (Holmgren et al. 1990). We used conventional taxonomic methods. To describe pollen and seed morphology of each species, we sampled material from dried herbarium material of the following specimens: *Borreria scabiosoides: E. B. Souza 687* (CTES); *R. Guillén & S. Coria 1569* (CTES); *D. Sucre 3710* (CTES)*; *J. A. Lombardi et al. 4814*; *Borreria linoides: J. E. Pohl 1263*(W)*; *Borreria krapocarmeniana: J. E. Montes 16163* (CTES), *B. Rambo 40516* (CTES)*, *L. M. Miguel et al. 28* (CTES)*, *S. G. Tressens 1234* (CTES)*. All these specimens were used for pollen micromorphological studies, and those marked with an asterisk were used also for seed micromorphological studies.

Pollen grains were acetolyzed according to Erdtman (1966) before subsequent treatments. For analyses with light microscopy (LM), grains were mounted in glycerin jelly, and slides deposited at the Palynological Laboratory of the Universidad Nacional del Nordeste (PAL-CTES), Corrientes, Argentina. For SEM analyses, grains were sputter-coated with gold, and examined and photographed using a Jeol 5800 LV SEM at the Universidad Nacional del Nordeste. Seeds were examined untreated using the SEM.

The terminology of pollen follows Punt et al. (2007) and that of seeds follows Stearn (1986).

Results

Pollen and seed morphological data allows us to clarify the identity of *B. scabiosoides*, redefine *B. linoides*, and describe the new species ***Borreria krapocarmeniana***. This means that we identified three different species that were intermingled under *B. scabiosoides*. Our results on seed and pollen micromorphology are presented below. Pollen of *B. scabiosoides* and *B. linoides* is described here for the first time. A list of other morphological characters distinguishing the three recognized species is found in Table 2.

***Seeds*—**In *B. scabiosoides*, seeds are oblong ellipsoid with rounded ends, dark brown, 2.3–2.84 × 1–1.03 mm; the dorsal surface is convex; the ventral surface is slightly sunken with a longitudinal deep groove, the margin of the groove is entire and forms a straight line from one end of the seed to the other. The strophiole, a parenchymatic tissue, is observed in the groove, and the hilum is located in the lower third, like a small swelling. Also, numerous raphide bundles can be observed on the strophiole using a stereomicroscope. The testa surface is reticulate foveate and the cells of the testa are tetragonal and generally isodiametrical, but elongated in the center, the anticlinal wall is raised and slightly undulating, the periclinal wall is smooth and cleaved. Figure 1 A–C.

In *B. linoides*, seeds are linear ellipsoid, dark brown, 1.60 × 0.33 mm, the dorsal surface is convex and a longitudinal deep groove is distinguished in the ventral surface. The strophiole covers this groove, and in the upper third there is an apical white elaiosome, extending over the seed apex like a cone. In stereomicroscope analyses, the testa surface appears finely reticulate foveate, whereas in SEM analyses, papillae are observed in the cells of the testa, but neither the anticlinal nor the periclinal wall are clearly observed. Figure 1 D–F.

In *B. krapocarmeniana*, seeds are oblong ellipsoid with rounded ends, brownish, 1.7–2.2 × 0.6–1 mm, the dorsal surface is convex, the ventral surface is slightly sunken; this

Table 2. Comparison of the morphological features of the three species of *Borreria*

Morphological character	*Borreria scabiosoides*	*Borreria linoides*	*Borreria krapocarmeniana*
Habit growth	Perennial, prostrate or decumbent subshrub	Annual, erect herb	Perennial, erect subshrub
Stems	Stems cylindrical	Stems quadrangular with ribs darker	Stems quadrangular
Length of leaves and leaflet form	Leaves 40–140 × 2.5–20 mm, linear to narrowly elliptic	Leaves 21–45 × 1–2.5 mm, linear	Leaves 40–120 × 5–8 mm, narrowly elliptic
Number and length of bristles in stipular sheaths	Stipular sheaths with 3–5 bristles. Bristles 1.5–4 mm long	Stipular sheaths with 1–3 bristles, the medial wider at the base. Bristles 1.2–2.5 mm long	Stipular sheaths with 5–8 bristles. Bristles 3–5 mm long
Number of involucral bracts	Involucral bracts 2–4 (–6)	Involucral bracts 2	Involucral bracts 2–4
Calyx	Calyx 4-lobed	Calyx 4-lobed with linear teeth between the lobes	Calyx 4-lobed
Seed	Seed without elaiosome	Seed with elaiosome located in the upper third, exceeding the apex, like a cone	Seed with elaiosome located from the half to the upper third of the seed without exceeding the apex
Pollen grain	Pollen grain 8-zonocolporate (rarely 7, 9 or 10-zonocolporate)	Pollen grain 6-pantoporate (rarely 7–8-9-pantoporate)	Pollen grain 8-pantoporate (rarely 6–7-pantoporate)

face has a longitudinal deep groove, the margin of the groove is entire and forms a straight line from one end of the seed to the other. The strophiole and the elaiosome cover the groove; the latter is found from the half to the upper third of the ventral groove, not exceeding the apex of the seed. This elaiosome is white and sections of the seed reveal that the strophiole and the elaiosome represent different structures (Fig. 1 J). The hilum is located below the elaiosome as a small swelling. In stereomicroscope analyses, some raphide bundles can be observed on the strophiole. The testa surface is reticulate foveate, and cells of the testa are tetragonal and elongated, their anticlinal wall is raised and straight, and their periclinal wall is smooth and slightly cleaved. Figure 1 G–K.

***Pollen Grains*—**In *B. scabiosoides*, pollen grains are medium and oblate-spheroidal (P = 26.32–29.64μm, E = 29.4–31.42 μm). The outline is circular, 8-zonocolporate (rarely 7, 9, or 10-zonocolporate). The apertures are compound; the ectoaperture is a colpus, 8.51–9.20 μm long. In light microscope analyses, the endoaperture is observed like a pore, whereas SEM analysis revealed that it is an endocingulum with additional lolongate thinnings. The exine is tectate-perforate, uniformly spinulate, 2.10 μm thick. The perforations are circular, 0.18–0.83 μm. The nano-spinules are 0.21–0.31 μm long. In broken grains, the inner surface is observed, the nexine is finely granular, and broad endocracks are present. Figure 2 A–F.

In *B. linoides*, pollen grains are medium and spheroidal (P= 17.6–23.1 μm), 6- pantoporate (rarely 7-, 8-, or 9-pantoporate), have pores 1.21–2.01 μm in diameter. An operculum covers the whole pore. The exine is tectate-perforate, uniformly spinulate, 1.3–2 μm thick. The perforations are elongated comma-like, less commonly circular, 0.21–0.61 μm. The nano-spinules are 0.26 μm long. Figure 2 G–H.

In *B. krapocarmeniana*, pollen grains are medium and spheroidal (P= 20–22 μm), 8-pantoporate (rarely 6- or 7-pantoporate), and have pores 1.61–2.46 μm in diameter. An operculum covers the whole pore. The exine is tectate-perforate, uniformly spinulate, 1.10 μm thick. The perforations are elongated comma-like, less commonly circular, 0.18–0.57μm. The nano-spinules are 0.16–0.24 μm long. Pollen grains of this species were described previously by Cabral (1985) and Pire (1996) under the name *B. scabiosoides* based on samples from Argentinean specimens. In this work, we additionally analyzed pollen grains of samples from Brazilian and Paraguayan specimens. Figure 2 I–K.

Discussion

The three species here analyzed are herbs with sparse branches, linear to narrowly elliptic leaves and apical, rarely subapical glomerules, subtended by long involucral bracts. Although they look superficially similar, possibly explaining the confusion in specimen identifications, we identified several diagnostic traits that distinguish them from one another (Table 2).

Borreria krapocarmeniana is morphologically more similar to *B. scabiosoides* than *B. linoides.* Both species share the same habitat, low fields or around water bodies, have fistulous stems and subtriangular stipular sheaths with more than three stipular bristles. However, *B. krapocarmeniana* has quadrangular stems (vs. subcylindrical stems in *B. scabiosoides*), seeds with a white apical elaiosome (vs. seeds without elaiosome), and pantoporate pollen grains (vs. zonocolporate pollen grains).

Based on seed and pollen morphology, *B. krapocarmeniana* appears more closely related to *B. linoides*. However, in *B. krapocarmeniana,* the elaiosome is located between the middle and upper third of the seed, without exceeding the apex (vs. it is located only in the upper third of the seed and exceeding the apex, like a cone, in *B. linoides*), pollen grains are 8-pantoporate (vs. 6-pantoporate), and the stipular sheaths possess 6–8 bristles (vs. 1–3 bristles, the medial wider at the base).

Finally, based on our analyses, we exclude *B. scabiosoides* from the flora of Argentina and Paraguay, and propose two new synonyms, *B. organensis* and *B. rubricaulis*, for this species. We describe *B. krapocarmeniana* for the flora of Argentina, Brazil and Paraguay, and rehabilitate *B. linoides* at the species level for the flora of Brazil (known to occur only in the type locality). Figure 3.

Taxonomic Treatment

Borreria scabiosoides Cham. & Schltdl., Linnaea 3: 318. 1828. *Spermacoce scabiosoides* (Cham. & Schltdl.) Kuntze, Revis. Gen. Pl. 3(3): 123. 1898.—TYPE: BRAZIL. Rio de Janeiro,

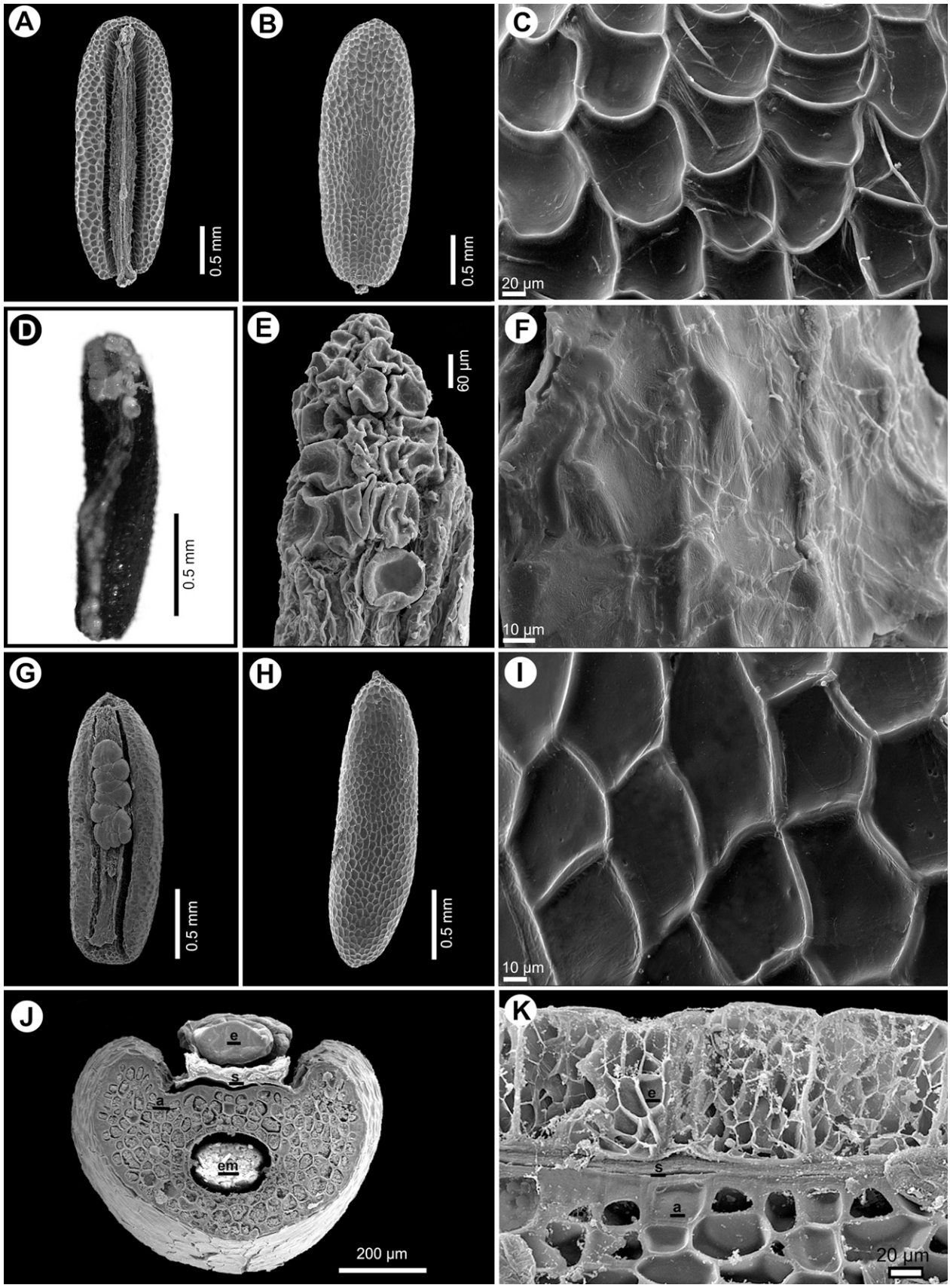

FIG. 1. Photographs of seeds with SEM and stereomicroscope. A.–C. *Borreria scabiosoides*. A. Ventral side of seed. B. Dorsal side of seed. C. Detail of the testa surface. D.–F. *Borreria linoides*. D. Ventral side of seed on stereomicroscope. E. Detail of the elaiosome. F. Detail of the testa surface. G.–K. *Borreria krapocarmeniana*. G. Ventral side of seed. H. Dorsal side of seed. I. Detail of the testa surface. J. Transverse section of seed. K. Detail of the longitudinal section of seed. a. Albumen. e. Elaiosome. em. Embryo. s. Strophiole. A.–C. from *D. Sucre 3710* (CTES); D.–F. from *J. E. Pohl 1263* (W); G. and J. from *S. G. Tressens 1234* (CTES); H. and I. from *B. Rambo 40561* (CTES); K. from *L. M. Miguel et al. 28* (CTES). Credits: photograph D. by Roberto M. Salas.

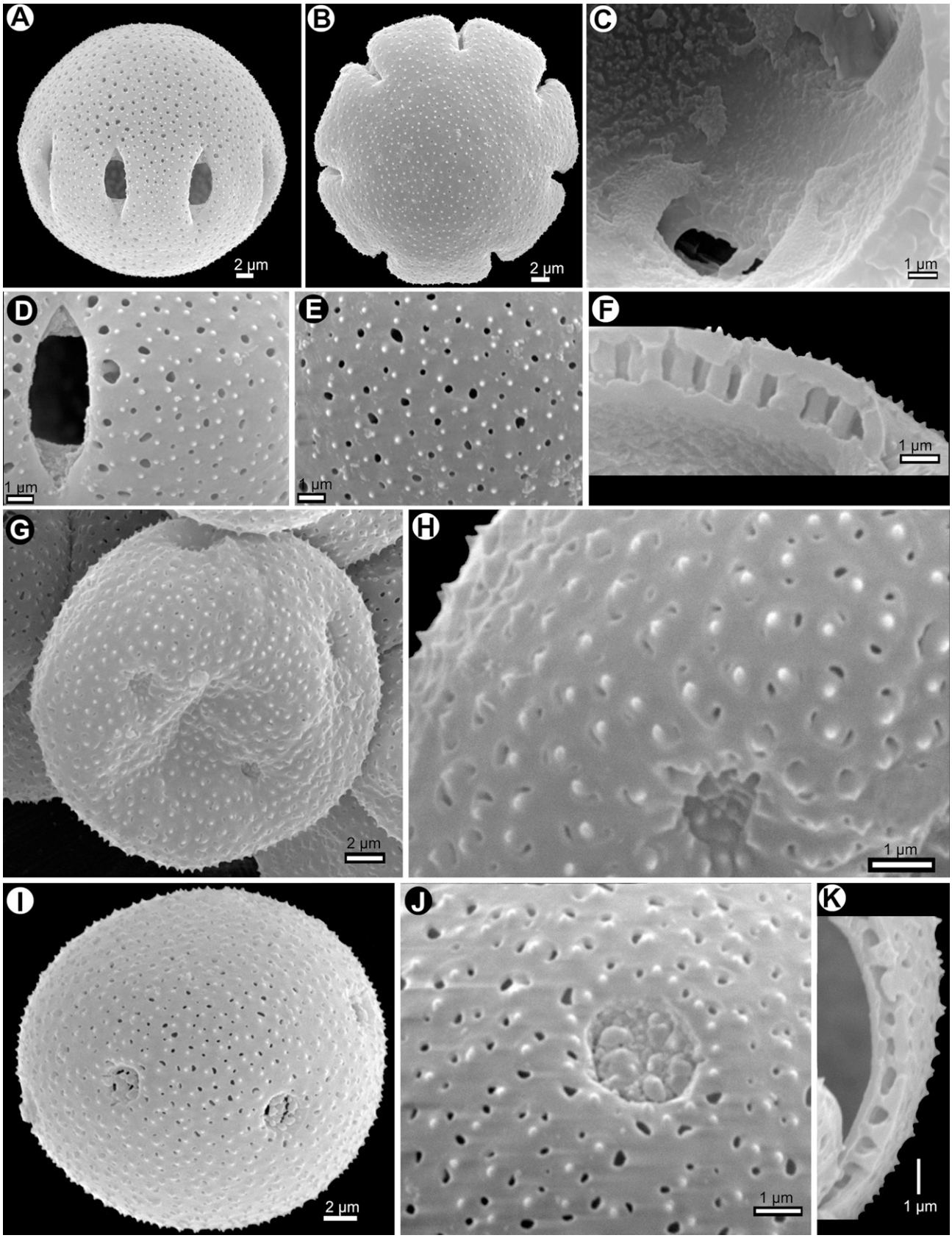

FIG. 2. Scanning electron photomicrographs of pollen grain. A.–F. *Borreria scabiosoides.* A. Polar view of pollen grain. B. Equatorial view of pollen grain. C. Inside of pollen fragment with an endocingulum; nexine surface granular with endocracks. D. Detail of an ectoaperture and exine at the mesocolpium. E. Detail of the exine at the apocolpium. F. Wall stratification. G.–H. *Borreria linoides.* G. Pollen grain. H. Detail of an ectoaperture and the exine. I.–K. *Borreria krapocarmeniana.* I. Pollen grain. J. Detail of an ectoaperture and the exine. K. Wall stratification. A. and F. from *R. Guillén & S. Coria 1569* (CTES); B. from *D. Sucre 3710* (CTES); C. from *E. B. Souza 617* (CTES); D. and E. from *J. A. Lombardi 4814* (CTES); G.–H from *J. E. Pohl 1263* (W); I.–K from *B. Rambo 40561* (CTES).

FIG. 3. Distribution map of *Borreria linoides*, *Borreria krapocarmeniana* and *Borreria scabiosoides*.

F. Sellow s .n. (holotype: B, destroyed; Photo F 884). EPITYPE: selected by Cabral et al. 2011: BRAZIL. Bahia: Barreiras, Prainha, margem do Rio das Ondas, 12° 08′48″S, 45°00′55″W, 456 m, 1 May 2009, *D. Cardoso, R. M. Salas & A. A. Cabaña-Fader 2626* (HUEFS!, CTES!, K!, SI!).

Borreria scabiosoides var. *glabrescens* Huber, Bull. Soc. Bot. Genève Sér. 2 6: 211. 1914. — TYPE: BRAZIL. Arumanduba: campo alagade, 3 May 1903, *J. Huber 3556* (holotype: MG!).

Borreria anderssonii Standl., Field Mus. Nat. Hist., Bot. Ser. 7: 245. 1931. *Borreria scabiosoides* Cham. & Schltdl. var. *anderssonii* (Standl.) Steyerm., Acta Bot. Venez. 6: 194.1971. — TYPE: ECUADOR. Puna Island near Guayaquil (Guayas), 1852, *N. J. Andersson 71* (holotype: S!; isotype: F!).

Borreria organensis Gardner, London J. Bot. 4: 111. 1845, ***nov. syn.*** — TYPE: BRAZIL. Organ Mountains (= Serra dos Orgãos), s. d., *G. Gardner 442* n.v.

Spermacoce rubricaulis C. Wright., Anales Acad. Ci. Med. Habana 6: 149–150. 1869, ***nov. syn.*** *Borreria rubricaulis* (C. Wright) Urb., Symb. Antill. 7: 550.1913.— TYPE: CUBA. Guanímar, s. d., *C. Wright 3590* [lectotype: here designated: NY (00004534)!; isolectotypes: NY (00004533)!, GH (digital JSTOR-image)!, US (digital JSTOR-image)!].

Perennial, sub-aquatic, submerged or marshy subshrub, 35–100 cm tall; stems cylindrical, simple or sparsely branched, fistulose, rooting at the basal nodes, prostrate or decumbent, glabrous, reddish green to nigrescent green when dry, internodes 2.5–9 cm long. Leaves opposite, pseudo-petiolate, leaf blades 40–140 × 2.5–20 mm, linear to narrowly elliptic, glabrous, apex acute or acuminate; base attenuate, margins scaberulous, 4–5 pairs of secondary nerves conspicuous on the lower surface. Stipular sheath, hyaline-white, subtriangular, glabrous or hispidulous on the upper nodes, with 3–5 bristles; bristles 1.5–4 mm long, glabrous. Inflorescence terminal and axillary glomerules, 10–20 mm wide; involucral bracts 2–4(–6), narrowly elliptic, three times longer than the glomerule. Flower sessile; hypanthium 2.3–3 mm long, glabrescent to pilose on the upper part; calyx 4-lobed, lobes 1.6–1.8 mm long, narrowly triangular; corolla 4 mm long, infundibuliform, white or lilacinus on the lobes, external surface puberulous with papillae on the apex of the lobes, internal surface with a ring of the moniliform hairs near the middle of the tube and sparse hairs on the lobes; stamens exserted, filaments 2.5 mm long, anthers 1.2 mm long, blue; style 5 mm long, stigma 2-lobed; nectariferous disk entire. Capsule 5–6 mm long, obovate-oblong, glabrous to pilose in the upper third. Seeds 2.3–2.8 mm long, oblong ellipsoid, brown; ventral surface with a longitudinal groove covered by a strophiole with numerous raphides; testa reticulate-foveate. Figures 4 A–B, 5.

Phenology—This species flowers and fruits throughout the year, with peak flowering from December to May.

Distribution and Ecology—This species is known from Bolivia, Brazil, Colombia, Costa Rica, Cuba, Ecuador, Guatemala, Guayana, Nicaragua, Panama, Peru, and Venezuela. It inhabits permanent or temporary flooded areas, within or around lentic or lotic water bodies. Figure 3.

Conservation status—*Borreria scabiosoides* is a widespread species, relatively abundant in areas where it occurs. Therefore its conservation status is of least concern (LC) (IUCN 2001).

Remarks—We consider *B. organensis* Gardner a new synonym of *B. scabiosoides.* Gardner (1845) mentioned affinities with *B. scabiosoides*, but differentiated both species, because of a "pilose capsule and the want of long hairs on the involucral leaves" in *B. organensis.* However, based on the specimens available to date, these characters actually do not clearly separate the species. The type of *B. organensis* could not be located in this study. In the database of the herbarium K, the specimen stored under *Gardner 442* is identified as *Oncidium gardnerii* Lindl. This is probably due to a misinterpretation of the collector number, because the correct collector number for this *Oncidium* specimen is *Gardner 642*.

Borreria rubricaulis (C. Wright) Urb. is also treated here as a new synonym. In the original description, Wright (1869) mentioned *B. organensis* and *B. scabiosoides* as related to *B. rubicaulis*, but did not explain the differences between them. We analyzed two isotypes [NY (00004533) and NY (00004534)] and noticed that *B. rubricaulis* agrees with the features of *B. scabiosoides*. We actually could find no significant differences between them, and thus designated the more complete isotype as the lectotype, i.e. NY (00004534). Additionally, we looked for other extant specimens of the type collection in GH and US (through the JSTOR database) and other specimens identified as *B. rubricaulis* of the same collector *C. Wright s.n.*, deposited in P and K (000470215).

Steyermark (1972) recognized three varieties for this species, differentiating them by the glomerules and corolla size, the indument, and length of the involucral bracts. In this study, we consider that these morphological differences reflect the range of morphological variation over the wide geographic distribution of this species rather than discrete morphological entities.

Notes—*Borreria scabiosoides* is considered a rice weed, facilitated by the strategy of spreading by seeds and rooting stems (Chitty and Ramia 2001).

Representative Specimens Examined—BOLIVIA. Beni: Valle Quiquibey, camino a San Borja, 765 m, ladera en la zona del barranco de inundación del río Quiquibey, 21 Aug 1986, *S. Beck 12709* (CTES, LPB, MO). Cochabamba: Chapare, 16°33′36″ S, 65°57′36″ W, 13 May 2002, *Zarate 1303* (MO). La Paz: Sud Yungas, Alto Beni, orillas del río Alto Beni, zona inundable, 450 m, 31 Dec 1987, *R. Seidel & M. Schulte 2295* (CTES, LPB). Santa Cruz: Velasco, Campamento El Refugio, en bajo, anegado temporalmente, matorral ribereño, 27 May 1994, *R. Guillén & S. Coria 1569* (CTES, MA, MO, USZ).

BRAZIL. Amapá: Rio Oiapoque, 3°36′ N, 51°19′ W, 16 Oct 1960, *H. S. Irwin 48771* (IAN). Amazonas: s. l., 25 Nov 1985, *Junk 1027* (INPA). Bahia: Caetité, ca. 14 km na estrada de Caetité para Brumado, 19 Feb 1992, *A. M. Carvalho et al. 3769* (CEPEC, CTES). Ceará: Aracaty, s. d., *G. Gardner 1703* (IPA); Campo de sub-estacao experimental de Barbalhas, 11 Aug 1948, *A. Duarte & Paixao 1399* (CTES, RB). Maranhão, Mun. Arari, 29 Apr 1998, *R. S. Secco & N. A. Rosa 892* (IAN). Minas Gerais: Januária, distrito de Tejuco, margens do Rio Pandeiros, 15°39′59.5″ S, 44°37′58.2″W, 18 May 2002, *J. A. Lombardi et al. 4814* (BHCB, CTES); Serra do Espinhaço, 14 Feb 1969, *H. S. Irwin et al. 23302* (RB). Pará: Jacarenim, caminho para serra de Almeirim, 29 Mar 1963, *E. Oliveira 2420* (IAN); Almeirim, 3 May 1903, *W. Ducke 15484* (RB); Marajó, 2 Jul 1896, *J. Huber 218* (MG). Paraíba: Patos, 16 May 1984, *M. Agra 466* (JPB). Pernambuco: Caruaru, Distrito de Murici, Brejo dos Carvalos, 8°18′ 36″S, 36°0′0″W, 4 Apr 1995, 1100 m, *F. M. Villarouco et al. 31* (CTES, PEUFR). Piauí: Mun. Campo Maior, Fazenda Sol Poente (EMBRAPA), 12 May 2001, *E. B. Souza 617* (CTES, HUVA). Rio de Janeiro: restinga de Cabo Frio, 18 Sep 1968, *D. Sucre 3710* (CTES, RB). Tocantins: Dianopolis, Lagoa Bonita, 11°40′24″S, 46°39′22″W, 590 m, 30 Sep 2003, *T. B. Cavalcanti et al. 3400* (CEN, CTES).

COLOMBIA. Valdivia: 8 km de Puerto Valdivia, 7°25′ N, 75°26′ W, 14 May 1987, *R. Callejas et al. 3474* (CTES).

COSTA RICA. Guanacaste: Bagaces, 10°32′00″ N, 85°19′00″ W, 9 Jul 1972, *P. A. Opler 923* (MO).

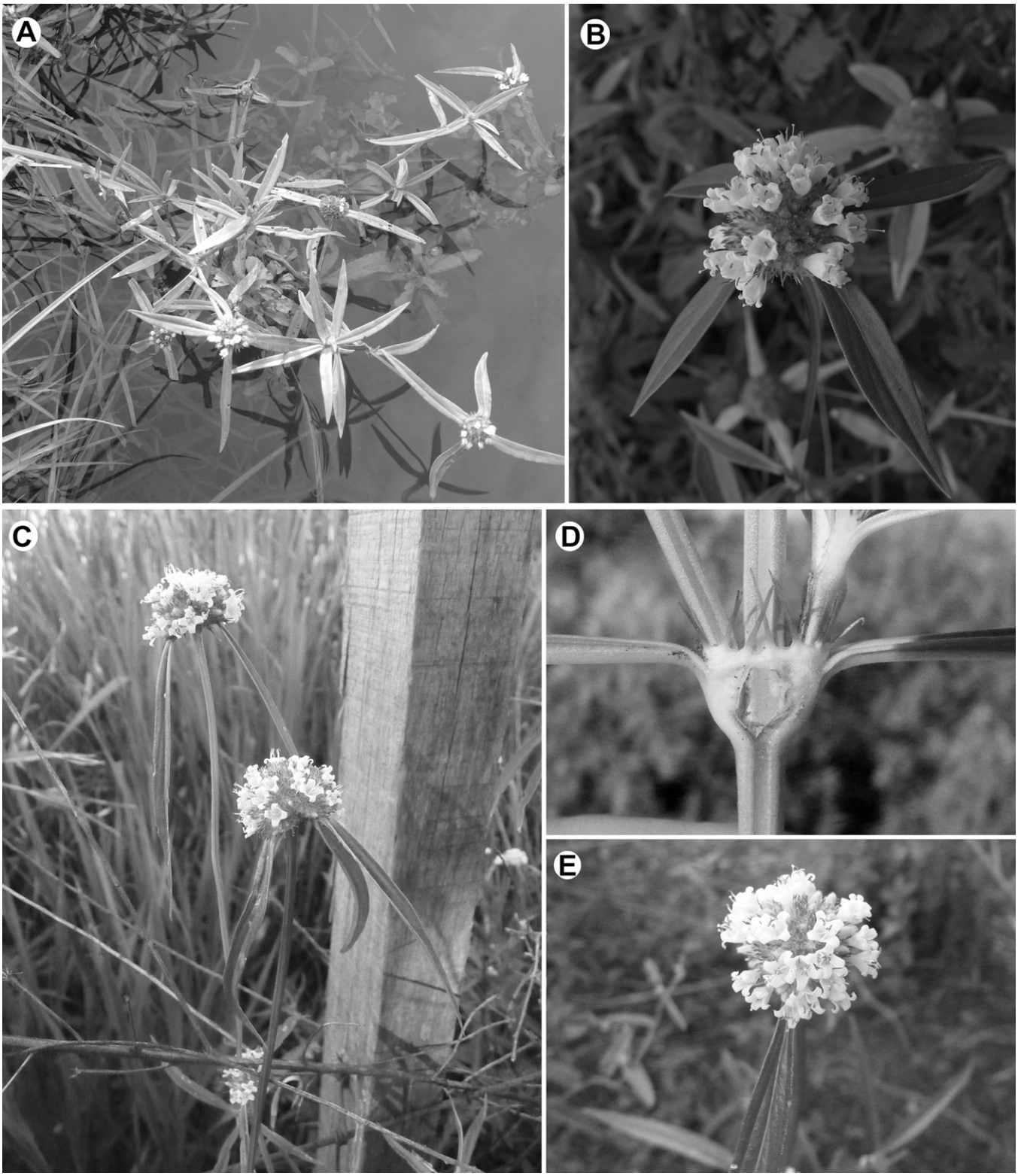

Fig. 4. *Borreria scabiosoides.* A. Habit. B. Glomerule. *Borreria krapocarmeniana.* C. Habit. D. Stipular sheath. E. Glomerule. Credits: photographs by Andrea Cabaña Fader (A.), Elnatan Bezerra de Souza (B.), Roberto M. Salas (C.–E.).

CUBA. S. l., s. d., *C. Wright s.n.* (P, K); Habana, Hoyo Colorado, 3 Nov 1921, *E. L. Ekman 13411* (G); idem, Rincon, 1905, *H. A. van Hermann 666* (P).

ECUADOR. Prov. Guayas: Chongón, 4 Mar 1939, *E. Asplund 5183* (BR, G, P); Guayaquil, 4 May 1956, *E. Asplund 20425* (G, P); Santa Lucía, edge of marsh, 4 Mar 1955, *E. Asplund 15606* (B, R).

NICARAGUA. Río San Juan: 28–30 Jul 1972, *F. C. Seymour 6159* (ENAG, GH, MO, SMU).

PANAMÁ. Colón: 09°18′00″ N, 79°39′00″ W, 4 Sep 1973, *M. Nee 6785* (MO).

PERÚ. Loreto: Maynas, 29 Aug 1988, *M. Rimachi 8747* (MO).

VENEZUELA. Apure: 8 Nov 1973, *G. Davidse 3838* (MO).

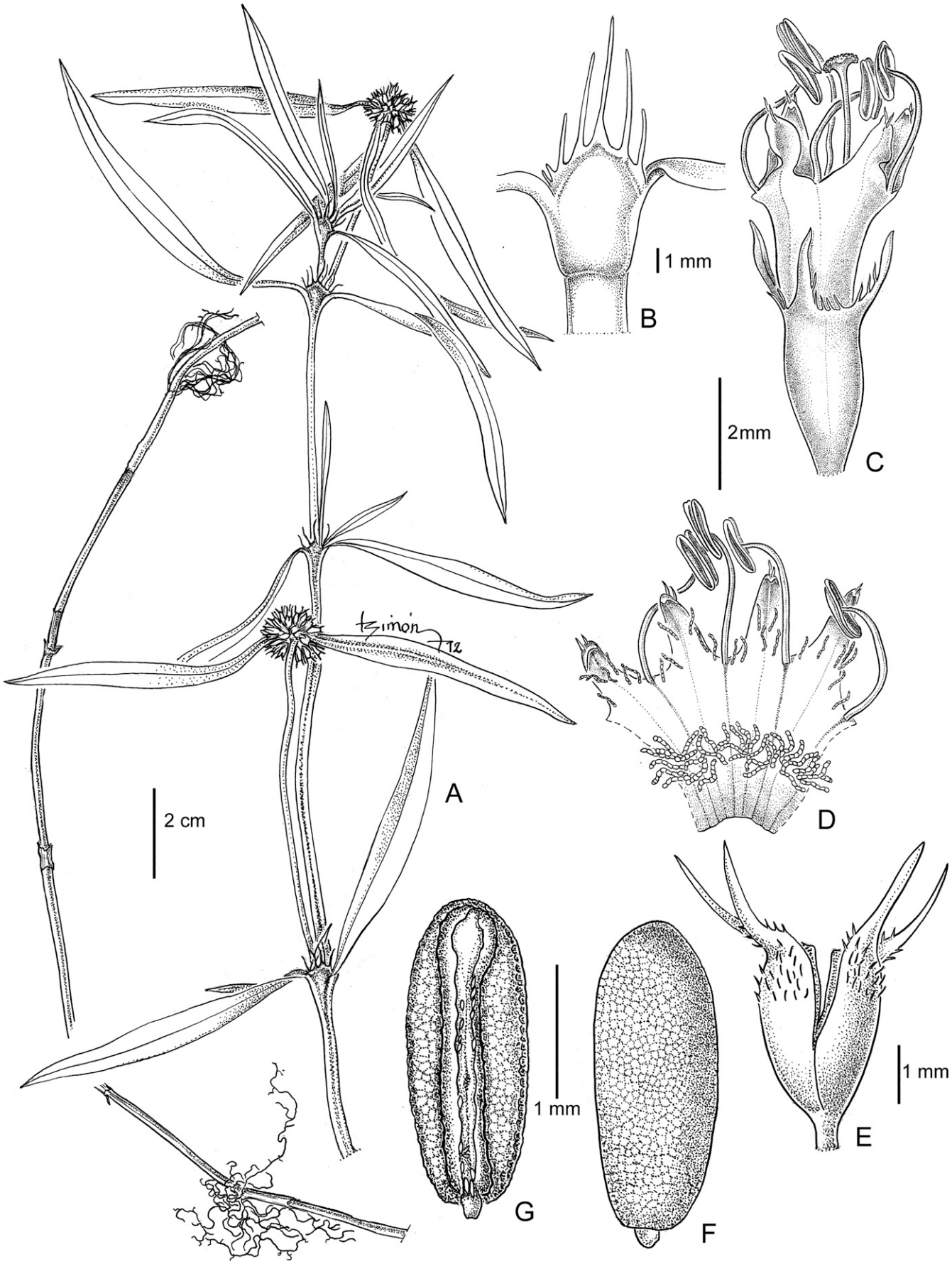

FIG. 5. *Borreria scabiosoides.* A. Habit. B. Stipular sheath. C. Flower. D. Inside of corolla. E. Fruit. F. Dorsal side of seed. G. Ventral side of seed. A. from *A. M. Carvalho et al. 3769* (CTES); B. from the epitype; C.–D. from *R. Seidel & M. Schulte 2295* (CTES); E.–G. from *D. Sucre 3710* (CTES).

Borreria linoides DC., Prodr. 4: 548. 1830. *Borreria tenella* var. *linoides* (DC.) K. Schum., in Mart., Fl. Bras. 6 (6): 55. 1888. *Borreria suaveolens* G. Mey. var. *linoides* (DC.) Standl., Publ. Field Mus. Nat. Hist., Bot. Ser. 11: 185. 1936.—TYPE: BRAZIL. S. l., 1828, *J. E. Pohl s. n.* (holotype: G-DC!; isotypes: BR!, M!).

Annual erect herb, 30–65 cm tall; stems quadrangular with ribs darker, sparsely branched, glabrous, internodes 2.2–7.5 cm long. Leaves opposite with axillary buds, sessile, leaf blades 21–45 × 1–2.5 mm, linear, glabrous, main nerve visible and secondary nerves obscure. Stipular sheath, glabrous, with 1–3 bristles; bristles 1.2–2.5 mm long, the central bristle with broad base, glabrous. Inflorescence terminal, sometimes axillary glomerules, 3.2–14.5 mm wide; involucral bracts 2, linear, two times longer than the glomerule. Flower sessile with translucent bracteoles; hypanthium 1.8–2 mm long, pilose on the upper part; calyx 4-lobed, lobes 1.3–1.5 mm long, narrowly triangular, glabrous, linear teeth 0.5–0.7 mm long between the lobes; corolla 3–3.5 mm long, infundibuliform, white, external surface glabrous with papillae on the apex of the lobes, internal surface with a ring of the moniliform hairs near the middle of the tube; stamens exserted, filaments 1.8–2 mm long, anthers 0.8–1 mm long, white; style 3.2–3.5 mm long, stigma 2-lobed; nectariferous disk bipartite. Capsule 3.5 mm long, sub-ellipsoid, pilose in the upper third. Seeds 1.6 mm long, linear ellipsoid, brown, ventral surface with a longitudinal groove covered by a strophiole, a white elaiosome covers the strophiole in the upper end and exceeds the apex like a cone; testa finely reticulate-foveate. Figure 6.

Phenology—This species is known from classical herbarium collections with no data about the month when the specimens were collected.

Distribution and Ecology—It is known for Goiás, Brazil (Fig. 3). The ecology is unknown.

Conservation status—The area of occupancy is estimated to be less than 10 km^2 (B2), and the species is only known from a single location (a) therefore it is critically endangered (CR, B2a) (IUCN 2001).

Remarks—This species was synonymized under *B. tenella* (Kunth) Cham. & Schltdl. and *B. suaveolens* G. Mey. by Schumann (1888) and Standley (1936), respectively. From the analysis of the type *J. E. Pohl s.n* (BR, G-DC, M) and the specimens *J. E. Pohl 1263* (W), we found that *B. linoides* has a stipular sheath with 1–3 bristles and seeds with a white apical elaiosome, all features that are absent in the two synonymized taxa to which *B. linoides* was related.

Representative Specimens Examined—BRAZIL. Brésil, s. l., 1828, *J. E. Pohl 1263, (787d)* (W). Goiás: in Province Goyaz prope capitalem, s. d., *W. J. Burchell 6895* (BR).

Borreria krapocarmeniana E. L. Cabral & L. M. Miguel, sp. nov.—TYPE: ARGENTINA. Misiones, Dpto. Capital, Ayo. Itaembé y ruta 12, 17 Jan 1966, *A. Krapovickas & C. L. Cristóbal 12091* (holotype: CTES!; isotypes: SI, UC).

Perennial, erect, sparsely branched subshrub, 35–50 cm long; stems quadrangular, fistulose, glabrous or with a few scattered hairs, internodes 10–95 mm long. Leaves opposite, pseudo-petiolate, leaf blades 40–120 × 5–8 mm, narrowly elliptic, glabrous, apex acuminate, base slightly narrowed, margins revolute, scaberulous, 4–5 pairs of secondary nerves conspicuous on the lower surface. Stipular sheath, subtriangular, glabrous to puberulous, with 5–7 bristles; bristles 3–5 mm long, glabrous. Inflorescence terminal and axillary glomerules, 15–20 mm wide; involucral bracts 2–4 (–6), narrowly elliptic, 3–4 times longer than the glomerule. Flower sessile; hypanthium 4–4.5 mm long, glabrous; calyx 4-lobed, lobes 2–2.5 mm long, narrowly triangular; corolla 5 mm long, infundibuliform, white, external surface glabrous with papillae on the apex of the lobes, internal surface with a ring of the moniliform hairs near the middle of the tube; stamens exserted, filaments 2.6–3 mm long, anthers 1.3–1.6 mm long, blue; style 5 mm long, stigma 2-lobed; nectariferous disk entire. Capsule 2.5–3.2 mm long, oblong, glabrous or with scattered hairs. Seeds 1.7–2.2 mm long, ellipsoid, brown, ventral surface with a longitudinal groove, the strophiole is covered by an elaiosome from the half to the upper third of the seed, without exceeding the apex; testa reticulate-foveate. Figures 4 C–E, 7.

Phenology—This species flowers and fruits from October to May.

Distribution and Ecology—This species is found in Argentina (NE Corrientes and Misiones), southern Brazil (Rio Grande do Sul and Santa Catarina) and eastern Paraguay (Fig. 3) in flooded fields, pastures, saturated soil, and river beds.

Conservation status—This species has an estimated area of occupancy of less than 2,000 km^2, and there is a continuing decline in area and quality of habitat due to human disturbance. Therefore, following the IUCN criteria (IUCN 2001), *B. krapocarmeniana* should be considered as Vulnerable: VU B2b(iii).

Remarks—The specimens of this species were identified as *B. scabiosoides*, because both species inhabit wet places and look superficially similar. However, the two taxa clearly differ in seed and pollen morphology (see Table 2 and Discussion).

Etymology—The epithet is in honor of two prominent Argentine botanists, Dr. Antonio Krapovickas and Dra. Carmen L. Cristóbal, who founded the Instituto de Botánica del Nordeste in Corrientes, where the present research was carried out, and who collected the specimen here selected as the holotype.

Representative Specimens Examined—ARGENTINA. Corrientes: Ituzaingó, 11 km N San Carlos, en campo, 11 Apr 1974, *A. Krapovickas et al. 24973* (CTES); Margen izquierda Ayo. Aguapey, 52 km SE de ruta nac. 12, desvío a Gdor. Virasoro, 29 Nov 1970, *A. Krapovickas et al. 16632* (BAB, CTES, LP, LL, P, WIS, ZT); Isla Apipé Grande, Puerto San Antonio, 9 Dec 1973, *A. Krapovickas et al. 23988* (CTES, SI); Río Aguapey y Ruta 38, 21 Mar 1981, *S. G. Tressens 1234* (CTES); idem, 29 Nov 1985, *C. L. Cristóbal et al. 2070* (CTES); Puerto Luján, Jan 1990, *S. Heinonen et al. 293* (CTES); Ruta 94 y Ayo. Chimiray, 28°05′57″ S, 55°42′45″ W, camino a Colonia Liebig, 22 Nov 2002, *A. Schinini 36258* (CTES); Ruta 14, 13 Dec 2011, *L. M. Miguel et al. 28* (CTES, FUEL, HUVA, JUA, MBM). Misiones: Candelaria, Santa Ana, Mar 1945, *J. E. Montes 1250* (CTES, LIL); idem, 15 Jan 1947, *E. Schwindt 56* (CTES, LIL); Loreto, 1 May 1945, *J. E. Montes 1349* (CTES, LIL); Candelaria, Pindapoy, 25 Nov 1945, *Bertoni 2440* (CTES, LIL); San Pedro, Monte Carlo, 11 Feb 1949, *E. Schwindt 1097* (CTES, LIL); San Pedro a Tohmas, 25 Apr 1950, *E. Schwindt 4072* (CTES, LIL); Guaraní, Ruta 14 km 304, prox. Ayo. Chafariz, 26 Feb 1950, *E. Schwindt 3195* (CTES, LIL); Iguazú, Delicia, 23 Oct 1949, *E. Schwindt 2884* (CTES, LIL); Posadas, 16 Mar 1930, *Rodriguez 196* (BAB).

BRAZIL. Rio Grande do Sul: Tramandaí, 6 Mar 1950, *B. Rambo 46157* (CTES, PACA); Osorio, 4 Jan 1950, *B. Rambo 45205* (CTES, PACA); Estaçao Guianuba, 17 Mar 1949, *B. Rambo 40561* (CTES, PACA); Campo Bonito, BR 101, km 6, 10 Feb 1983, *A. Krapovickas & C. L. Cristóbal 38516* (CTES, F, G, UC); Torres, Butiazal, 4 Feb 1984, *K. Hagelund 15056* (CTES, ICBN). Santa Catarina: Sombrio, 9 May 1945, *R. Ruiz c1058* (CTES).

PARAGUAY. Guairá: Borja, 12 feb 1953, *J. E. Montes 16163* (CTES, G). Itapúa: Yacyretá Dam Island, San Miguel, 27°28′21″ S 56°45′34″ W, 24 Oct 1999, *E. Zardini & R. Gamarra 52040* (AS, CTES, MO); Cosme, Dans les prairies marécagenses, 2 Mar 1876, *B. Balansa 1775a* (CTES, P, SI). Canindeyú: In campis para Igatimi, 5 Nov 1898–1899, *E. Hassler 5506* (G); Jejui-mi-Arroyo Bandera, 17 Dec 1996, *G. Marín 482* (BM, CTES, PY); Río Corrientes, 19 Jun 1977, *A. Krapovickas & A. Schinini 32565* (CTES).

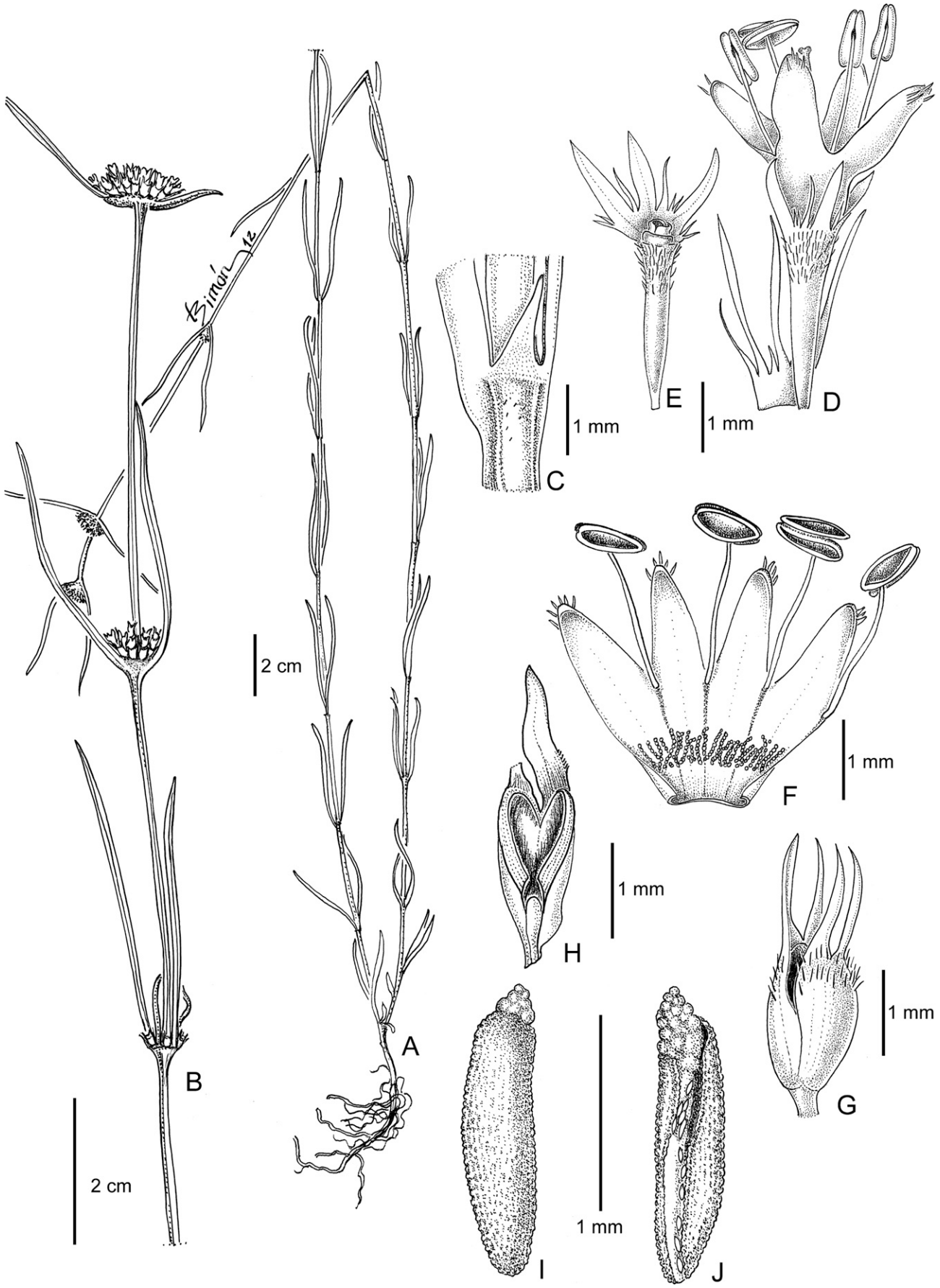

FIG. 6. *Borreria linoides.* A. Habit. B. Stem with terminal and axillar glomerules. C. Stipular sheath. D. Flower. E. Hypanthium, calyx and nectariferous disk. F. Inside of corolla. G. Fruit. H. Ventral side of fruit. I. Dorsal side of seed. J. Ventral side of seed. All from *J. E. Pohl 1263* (W).

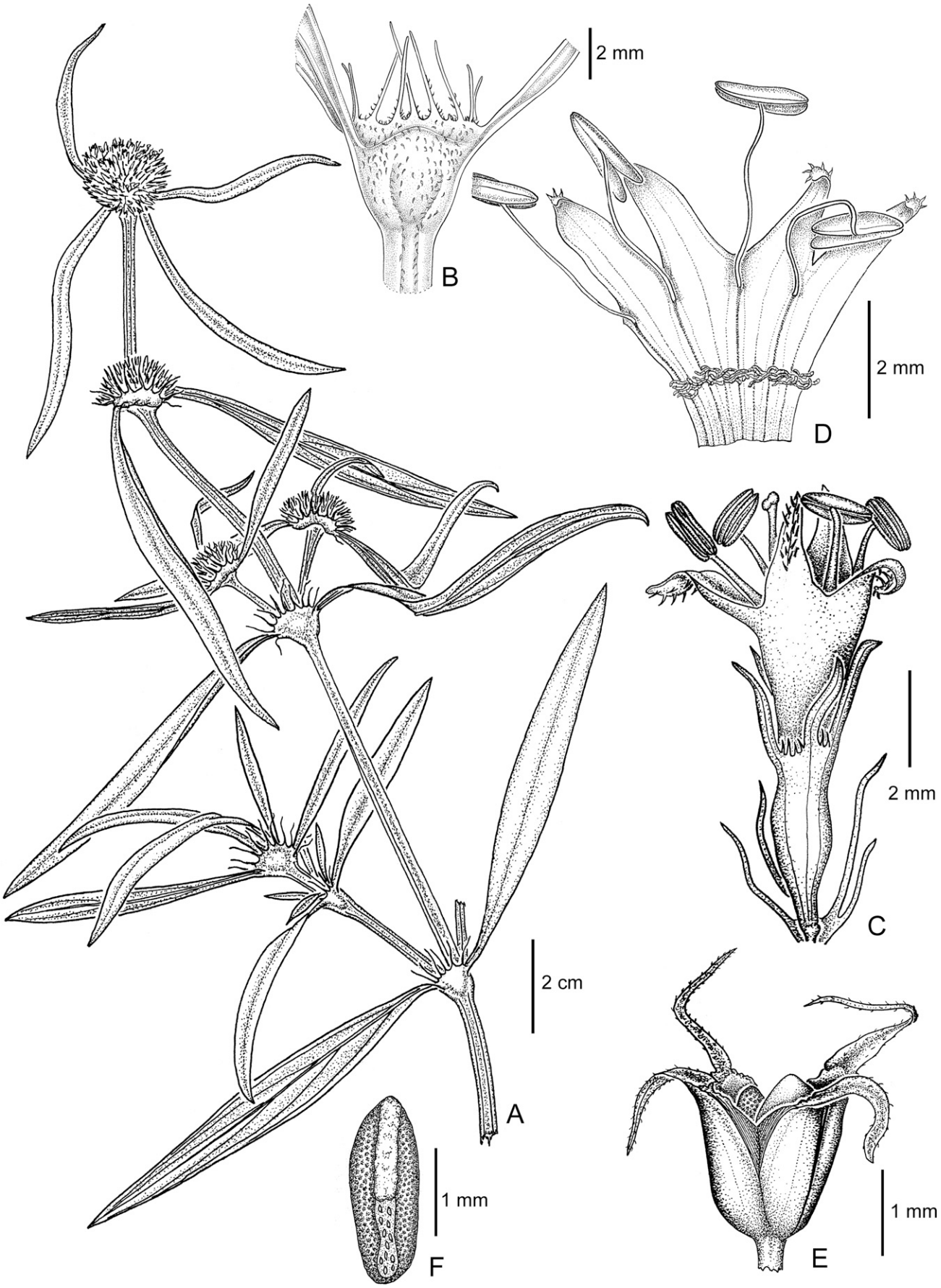

FIG. 7. *Borreria krapocarmeniana*. A. Stem with terminal and axillar glomerules. B. Stipular sheath. C. Flower. D. Inside of corolla. E. Fruit. F. Ventral side of seed. A., C., E. and F. from *A. Krapovickas et al. 16632* (CTES), B. and D. from *J. E. Montes 16163* (CTES).

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