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Aspidosperma flaviflorum (Apocynaceae), a New Species from Mato Grosso do Sul, Brazil, with Notes on Wood Anatomy

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***Abstract*—*Aspidosperma flaviflorum*,** is described as a new species from the submountain semideciduous forest in the municipality of Porto Murtinho in the state of Mato Grosso do Sul, Brazil. This new taxon is described and compared with the most morphologically similar species, *A. quirandy* and *A. tomentosum.* In its wood anatomy, *A. flaviflorum* is unique within the genus by the very scanty axial parenchyma and the lack of a line of axial parenchyma delimiting the growth rings.

***Keywords*—**Aspidospermateae, biodiversity, flora, apocynoids.

Aspidosperma Mart. comprises approximately 56 neotropical species of small to large trees. It ranges from Mexico and the West Indies to Argentina (absent in Chile). *Aspidosperma* belongs to the Rauvolfioids, which are composed of *Geissospermum* Allemão, *Haplophyton* A. DC., *Microplumeria* Baill., *Strempeliopsis* Benth., and *Vallesia* Ruiz & Pav. in tribe Aspidospermeae, although more phylogenetic studies are needed, since only the first two genera were included in the phylogeny by Simões et al. (2007). Brazil is the country where *Aspidosperma* is most diverse, represented by 42 species, of which 14 are found in the state of Mato Grosso do Sul (Machate et al. 2016), being present in all of the state's phytogeographic domains (Rapini et al. 2010).

Aspidosperma is ecologically an extremely important component in terms of species diversity, especially in Neotropical savannas and seasonally dry forests (Pennington et al. 2006). The species are also economically important for urban, landscaping, reforestation, construction, carpentry, cabinetmaking, health treatments, and in popular traditional medicine (Record and Hess 1943; Lorenzi 1998; Pereira et al. 2007). It can be recognized by its alternate or verticillate leaves, the presence of latex which varies from white, reddish, to colorless, petioles and axils lacking colleters, inflorescence consisting of a dichasium, pleiochasium, or pleiothyrsium, quincuncial calyx, salverform, slit, and contorted corolla, and one to two woody follicles with winged seeds.

In terms of wood anatomy, *Aspidosperma* has been extensively studied, given that it contains species of highly prized, heavy, resistant timbers in the Neotropics, known in the market as "quebrachos" in Spanish and "perobas" in Portuguese (Record and Hess 1943; Mainieri and Chimelo 1989; Miller and Detiénne 2001). Vessel grouping pattern, crystal location, and axial parenchyma type are among the most important features that help distinguish taxa within the family (Metcalfe and Chalk 1950, 1979; Lens et al. 2008, 2009). For this reason, in addition to describing the remarkable morphological features that distinguish this new species, a wood anatomical description is provided and the new species is compared with two putatively closely related species.

The flora of the state of Mato Grosso do Sul is still poorly known since it is one of the Brazilian states with the lowest number of botanical collections and taxonomists (Peixoto 2003; Alves et al. 2017), in particular the mountain regions of the municipality of Porto Murtinho, where the Chaco biome predominates. More studies are greatly needed to inventory the biodiversity of this area. Here we describe a new species to science, collected in the submountain semideciduous forest of the state of Mato Grosso do Sul.

Materials and Methods

***Sampling*—**In the process of reviewing *Aspidosperma* for the State of Mato Grosso do Sul, Brazil (Machate et al. 2016), 22 field expeditions were conducted. In addition, important collections from the following herbaria, CGMS, COR, CPAP, FACEN, FCQ, HSB, MBM, MO, NY, PY, RB, and UEC (acronyms according to Thiers 2019), were studied. Several regional floras to study morphologically related species were consulted (Ezcurra et al. 1992; Michel 1993; Jardim et al. 2003). Wood anatomical samples were either collected in the field or pulled from the SPFw wood collection at the University of São Paulo. When collected in the field, we chose a non-destructive sampling method, which consists of sawing a wedge from adult main trunks containing part of the sapwood, cambium, and bark. This method minimizes the impact on the trees, while collecting the most recent, mature wood from the main trunk. This method has only one drawback, that of not reaching the heartwood.

***Morphological Analysis*—**Leaf venation study was done by diaphanization. For the clearing, leaves were placed in 5% sodium hypochlorite. The solution was replaced every 12 hr and rinsed in running water for 90 (*A. flaviflorum*) to 120 d (*A. quirandy* and *A. tomentosum*) according to leaf texture, followed by staining with 1% safranin in 50% ethyl alcohol (Johansen 1940). Longer times coincide with thicker leaves. The arrangement of veins was classified according to Hickey (1979). The images were obtained on a photonic microscope (Motic-Moticam pro 252B), with system coupled to a video camera and computer equipped with image analyzer (digital Nikon Corporation Tokyo, Japan, eclipse Ci-s 50/60 Hz).

For scanning electron microscopy (SEM), two leaf fragments were selected, each at one side of the main vein at the proximal region. Samples for

observing the abaxial and adaxial surfaces were mounted on an appropriate stub holder with double-sided adhesive tapes and given a fine coat of gold. A JEOL JSM-6380LV at 10 kV was used for the observations. For the SEM, no critical point drying was required for samples coming from silica collections or dry vouchers. Micromorphology and anatomical terminology followed Radford et al. (1974).

Anatomical Analysis—Wood descriptions followed the IAWA Committee (1989). Wood collected in the field or deposited in the University of São Paulo Wood Collection, Brazil (SPFw) were rehydrated by boiling in water and glycerin for several hours (Angyalossy et al. 2016). Since these woods are very hard, they were left for three days in 4% ethylenediamine within a hot chamber (Kukachka 1978; Carlquist 1982). They were subsequently sectioned with the aid of a sliding microtome using perfectly sharpened permanent steel knives (Barbosa et al. 2018). Sections were stained in iron mordanted safranin and mounted in a synthetic resin. Macerations were carried out using Jeffrey's method (Johansen 1940).

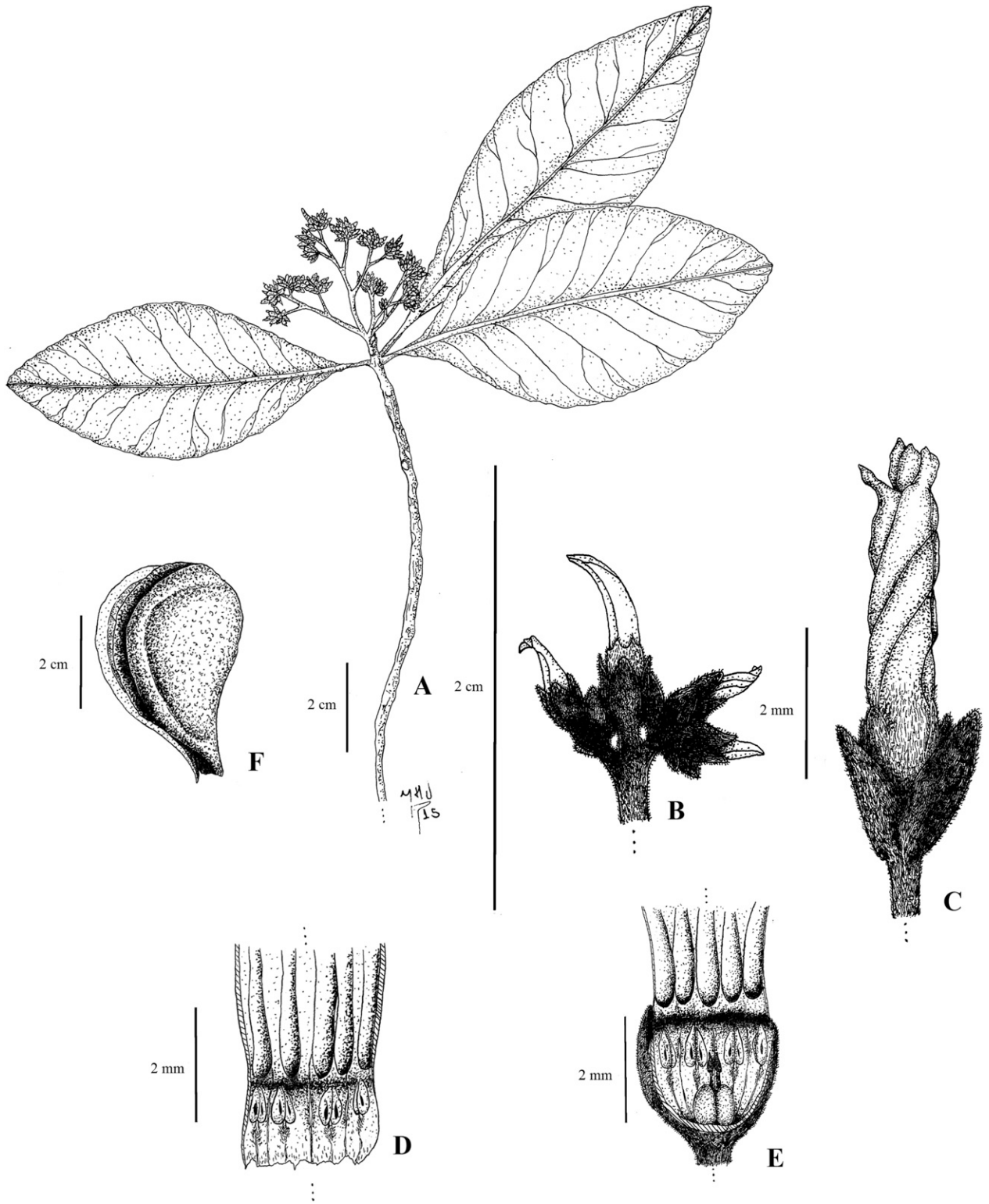

FIG. 1. *Aspidosperma flaviflorum*. A. Flowering branch. B. Dichasium inflorescence. C. Flower bud emphasizing corolla sinistrorse. D. Longitudinal section of flower showing slits among stamens. E. Longitudinal section of flower showing stamens, carpel, and slits. F. Fruit.

Descriptions refer to sapwood instead of heartwood, since the collections were non-destructive and only removed a more external portion of the stems. The number of specimens analyzed are mentioned along with the anatomical descriptions.

Taxonomic Treatment

Aspidosperma flaviflorum Machate, sp. nov. TYPE: BRAZIL. Mato Grosso do Sul: Porto Murtinho, ao longo da Rodovia BR 267 para Porto Murtinho, 21°43′21,40″S, 57°37′03,40″W, 128 m, 16 Jul 2014. *D.J. Machate, M.R. Pace & J.R. Fabri 17* (holotype: CGMS!, isotypes: K!, MBM!, MO!, MY!, NY!, RB!).

Tree ca. 8 m tall; latex white; trunk suberous, fissured, rough bark, interrupted with crossed fissures, gray. **Branches** lenticellate, glabrous. **Leaves** alternate, smooth cuticle without ornamentation, glabrous, but abaxially puberulent along the margin; petiole 1–1.4 cm long; blade elliptical, 6.2–11.7 × 4–5.8 cm, base acute to cuneate, apex acute to obtuse, membranaceous; venation camptodromous; primary veins, type massive (> 4% leaf width); lateral veins 14–25, impressed, of acute angle (37–86°); tertiary veins of random reticulation, arrangement predominantly alternate; quaternary veins, thin, course orthogonal, areoles well developed; epicuticular wax smooth, cuticle ornamentation smooth, adaxially with discrete striations, abaxially striated-papillose. **Inflorescences** a dichasium, tomentose, terminal, 2.4–3.7 cm long; peduncle 0.3–1 cm long; pedicel 0.06–0.12 cm long. **Flowers** 0.6–1 cm long, tomentose abaxially; calyx lobes elliptic, 0.2–0.3 cm long, glabrous adaxially; corolla dark yellow, sinistrorse; tube 0.2–0.3 cm long, diam 0.07–0.12 cm, pubescent adaxially, slits in the lower third of the tube; lobe 0.3–0.4 × 0.1 cm, glabrous, lanceolate to oblong; anther 0.8–0.4 mm long; filament 0.3 mm long, emerges between the slits; ovary ovoid, 0.5 mm long, glabrous; style 0.6–0.7 mm long; stylar head 0.3–0.4 mm long, oblong, glabrous. **Follicles** woody, brown, obovoid, 3.9–4.2 cm long, lenticellate, glabrous, and middle back, costal ribs and a mucro absent; peduncle 2.2–2.6 cm long, glabrous. **Seeds** not observed. Figure 1.

***Additional Specimens Examined*—Brazil.** —MATO GROSSO DO SUL: Porto Murtinho, ao longo da BR 267 para Porto Murtinho, perto do Morro 21°43′23,80″S, 57°37′01,00″W, 128 m, 16 Feb 2016, *Machate et al. 150* (CGMS, COR, HUEFS, SPF, UEC).

***Etymology*—**The epithet "*flaviflorum*" refers to the strongly yellow corolla of this new species, which is much more pronounced than in other species of *Aspidosperma*.

Notes*—Aspidosperma flaviflorum* can be recognized by the following combination of characters: petioles 1–1.4 cm long, membranaceous leaves, glabrous leaf blades, camptodromous venation, and impressed secondary veins (Fig. 2A). Flowers tomentose externally, calyx lobes internally glabrous, anthers emerging between slits, ovary ovoid and glabrous, follicle depressed and ovoid, 3.9–4.2 cm long, glabrous, and back in the middle, lacking costal ribs and mucro.

Comments*—Aspidosperma flaviflorum* resembles *A. quirandy* and *A. tomentosum* based on the leaf and fruit similarity. However, *A. quirandy* has petioles sessile to < 1 cm long, leaf blades puberulent abaxially, calyx lobes tomentose adaxially, anthers emerging above slits, and follicles 4.4–7.48 cm long, tomentose, with costal ribs present. *Aspidosperma tomentosum* has sessile to sub-sessile leaves with petiole < 0.2 cm long, leaf blade tomentose adaxially, calyx lobes sericeous adaxially, anthers emerging above slits, follicles > 5 cm long, tomentose, and with costal ribs present. The morphological characters of *A. flaviflorum*, *A. quirandy*, and *A. tomentosum* are summarized in Table 1.

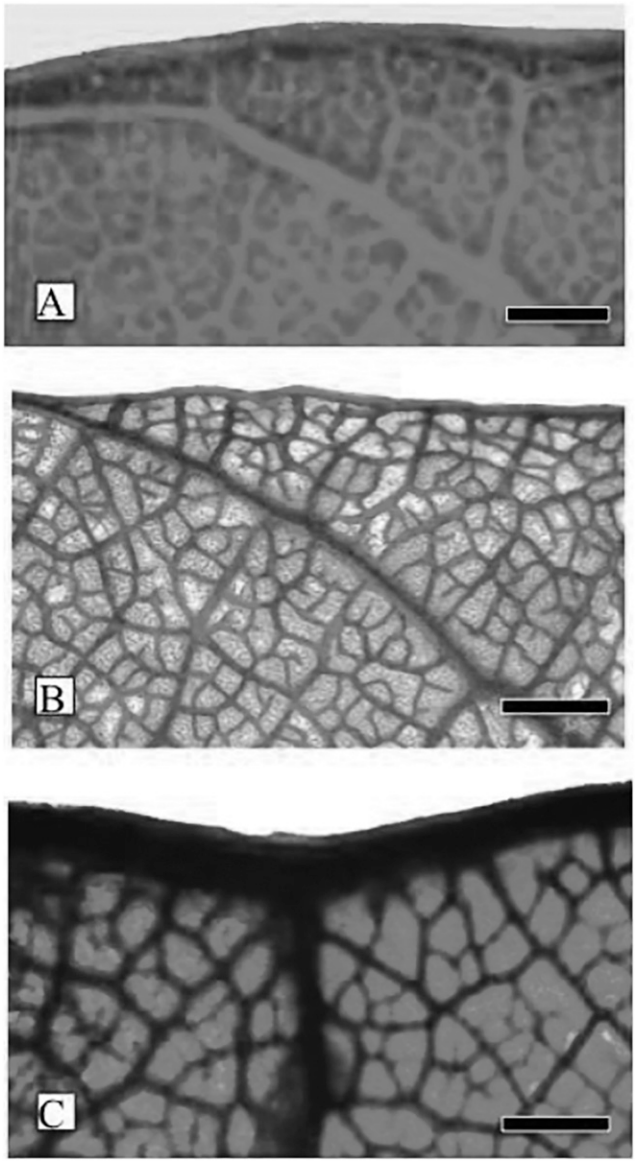

FIG. 2. Venation study of *Aspidosperma flaviflorum*, *A. quirandy*, and *A. tomentosum*. A. *Aspidosperma flaviflorum*. Relationship between the width of primary veins and leaf being massive (over 4%), and secondary veins weakly developed. B. *Aspidosperma quirandy*. Relationship between the width of primary veins and leaf being stout (2–4%), and secondary veins well developed. C. *Aspidosperma tomentosum*. Relationship between the width of primary veins and leaf being stout (2–4%), and secondary veins well developed. Scale bars: A–C = 500 μm.

***Informal Conservation Status*—**If a formal assessment were performed, *Aspidosperma flaviflorum* would probably be considered Data Deficient (DD), a category of the IUCN utilized when data are either insufficient (e.g. this species is only known from a single locality), when little information is known about the taxon (e.g. species have been recently described and their population and ecology are not known) (IUCN 2016). *Aspidosperma flaviflorum* is known only from the submountain semideciduous forest of the Chaco biome. In 22 field expeditions, this species was collected only in a single

Table 1. Morphological comparison of characters among the species of *Aspidosperma.*

Characters	*A. flaviflorum*	*A. quirandy*	*A. tomentosum*
Branch indument	Glabrous	Tomentose	Tomentose
Petiole (cm)	1–1.4	Sessile to < 1	Sessile to < 0.2
Leaf texture	Membranaceous	Chartaceous	Chartaceous
Leaf blade indument abaxially	Glabrous or puberulent along the margin	Pubescent	Glabrous
Leaf blade indument adaxially	Glabrous	Puberulent	Tomentose
Leaf venation	Craspedodromous	Semicraspedodromous	Craspedodromous
Relationship between the width of primary veins and leaf	Massive > 4%	Stout 2–4%	Stout 2–4%
Secondary veins	Impressed	Prominent	Prominent
Cuticle ornamentation	Discrete striations	Lenticular	Verrucose
Inflorescence type	Dichasia terminal	Pleiothyrse terminal	Pleiothyrse subterminal
Calyx internal indument	Glabrous	Tomentose	Sericeous
Corolla prefoliation type	Sinistrorse	Sinistrorse	Dextrorse
Filament insertion	Among slits	Above slits	Above slits
Fruit costal ribs	Absent	Present	Present
Length of fruit (cm)	3.9–4.2	4.4–7.5	5.1–8.2
Fruit indument	Glabrous	Tomentose	Tomentose

locality. Furthermore, we have not observed any populations of this species, probably because the area where the species was collected consists of private cattle grazing lands.

Morphological Leaf Description—Diaphanization results are summarized in Table 1 and illustrated in Fig. 2. In synthesis, *A. flaviflorum* has membranaceous leaves, abaxially glabrous or pubescent along the margins and adaxially glabrous, camptodromous venation, the relationship between the width of primary veins and leaf being massive (over 4%), and secondary veins weakly developed (Fig. 2A). *Aspidosperma quirandy* has chartaceous leaves, abaxially and adaxially pubescent, semicraspedodromous venation, the relationship between the width of primary veins and leaf being stout (2–4%), and secondary veins well developed (Fig. 2B). *Aspidosperma tomentosum* has chartaceous leaves, abaxially glabrous, adaxially tomentose, of craspedodromous venation, the relationship between the width of primary veins and leaf being stout (2–4%), and secondary veins well developed (Fig. 2C). In SEM, the adaxial side of the leaf is covered by an amorphous ornamented wax layer, different among the species (Fig. 3A, C, E). *Aspidosperma flaviflorum* cuticle ornamentation is smooth, with discrete striations (Fig. 3A), while in *A. quirandy* the cuticle ornamentation is smooth with ellipsoid ornamentation (Fig. 3C), and in *A. tomentosum* the cuticle ornamentation is verrucose (Fig. 3E). The abaxial surface shares a similarly conspicuous ornamented cuticle surface, which is striated-papillose (Fig. 3B, D, F).

Specimens Analyzed: *Aspidosperma flaviflorum*, *Machate et al. 17* (CGMS1074858), *Machate et al. 150* (CGMS1083413); *A. quirandy*, *Machate et al. 6* (CGMS1074900), *Machate and Graziela 77* (CGMS002168); *A. tomentosum*, *Machate and Júnio 41* (CGMS002220).

Wood Anatomy Description—*Aspidosperma flaviflorum* has distinct growth rings (Fig. 4A), delimited by fiber zones with fewer vessels and radially flattened fibers (Fig. 4A). Vessels present within these fiber zones are much narrower. Porosity is diffuse to semi-ring porous (Fig. 4A).

Vessels are mostly solitary (more than 90%: Fig. 4A), narrow, 28 ± 9 μm in diameter, abundant 246 ± 26 vessels/mm^2, with vessel elements 465 ± 49 μm in length. Perforation plates are simple. Intervessel pits are alternate, minute (3 μm), vestured. Vessel-ray pits with distinct borders, similar to intervessel pits. Fibers non-septate, thick walled, 749 ± 149 μm in length, pits distinctly bordered (Fig. 4G) and common in both radial and tangential walls. Axial parenchyma very scanty (Fig. 4A), diffuse, with 4–6 cells per parenchyma strand. Rays uniseriate to biseriate (Fig. 4B), shorter than 1 mm, homocellular with all cells procumbent (Fig. 4C), non-storied (Fig. 4B). Prismatic crystals present, located in the few axial parenchyma cells, distributed in chambers (Fig. 4G).

Specimen Analyzed: *Machate et al. 17* (CGMS).

Aspidosperma quirandy growth rings are distinct (Fig. 4D) and delimited by fiber zones with fewer vessels, radially narrow fibers, and a line of axial parenchyma present in some but not all growth rings (Fig. 4D). Vessels present within these fiber zones are narrower. Porosity is diffuse to semi-ring porous (Fig. 4D).

Vessels are mostly solitary (more than 90%: Fig. 4D), narrow, 39 ± 10 μm in diameter, abundant 134 ± 19 vessels/mm^2, vessel elements 616 ± 113 μm in length. Perforation plates are simple. Intervessel pits are alternate, minute (3 μm), vestured. Vessel-ray pits have distinct borders, similar to intervessel pits. Fibers are non-septate, thick walled, 936 ± 185 μm in length, with pits distinctly bordered and common in both radial and tangential walls. Axial parenchyma is diffuse (Fig. 4D) and in narrow marginal bands (Fig. 4D) with 4–7 cells per parenchyma strand. Rays uniseriate to biseriate (Fig. 4E), shorter than 1 mm, homocellular with all cells procumbent (Fig. 4F), nonstoried (Fig. 4E). Prismatic crystals present, located in chambered axial parenchyma cells.

Specimens analyzed: *Ceccantini 2709* (SPF and SPFw), *Machate et al.* 6 (CGMS).

Aspidosperma tomentosum growth rings are distinct, delimited by fiber zones with fewer vessels, radially flattened fibers, and a marginal band of axial parenchyma. Vessels present within these fiber zones are much narrower. Porosity is diffuse to semi-ring porous.

Vessels are mostly solitary, narrow (more than 90%), narrow 33 ± 7 μm in diameter, 22 ± 8 vessels/mm^2, vessel elements 350 ± 70 μm in length. Perforation plates are simple. Intervessel pits are alternate, minute (4 μm), vestured. Vessel-ray pits have distinct borders, similar to intervessel pits. Fibers are non-septate, thick walled, 845 ± 112 μm, with pits distinctly bordered and present only on the radial walls. Axial parenchyma is diffuse-in-aggregates and in marginal bands. Parenchyma with 6–8 cells per parenchyma strand. Rays

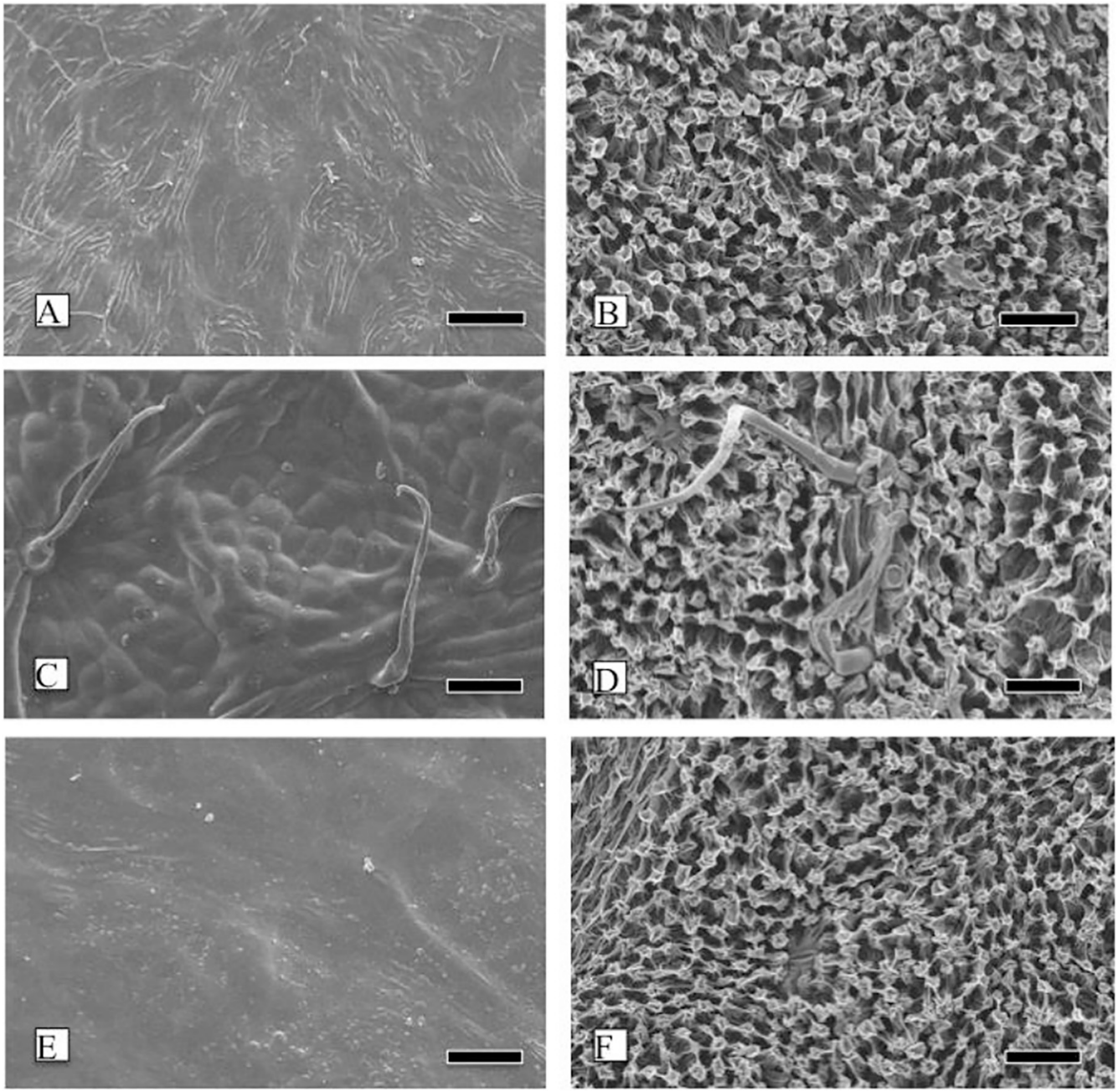

FIG. 3. Leaf blade cuticle under scanning electron microscopy. A–B. *Aspidosperma flaviflorum*. A. Adaxial surface with discrete striations. B. Abaxial surface with a striate- papillose ornamentation. C–D. *Aspidosperma quirandy*. C. Adaxial surface smooth with ellipsoid ornamentation. D. Abaxial surface with striate-papillose ornamention. E–F. *Aspidosperm tomentosum*. E. Adaxial surface verrucose. F. Abaxial surface striate-papillose.

uniseriate to biseriate, shorter than 1 mm, homocellular with all cells procumbent, nonstoried. Prismatic crystals common, located in chambered axial parenchyma cells.

Specimens analyzed: *Ceccantini 2496* (SPF and SPFw), *Ministério da Agricultura A.O*. 423 (SPFw).

The wood anatomical characters of the *Aspidosperma tomentosum* complex are summarized in Table 2.

Comments on the Wood Anatomy—*Aspidosperma flaviflorum* is similar in its wood anatomy to all previously described *Aspidosperma* by its growth rings delimited by a fiber zone with fewer vessels, mostly solitary vessels (a feature shared by the entire tribe Aspidospermae; Lens et al. 2008), minute alternate vestured pits, with thick walled, non-septate fibers, and low, nonstoried rays (Metcalfe and Chalk 1950; Mainieri and Chimelo 1989; Rebollar and Quintanar 2000; Miller and Detiénne 2001; León 2011; Moglia et al. 2012). Diffuse to diffuse-in-aggregates parenchyma is also ubiquitous, but a number of species also have paratracheal unilateral parenchyma or scanty vasicentric occurring in combination with the more common apotracheal parenchyma (Lens et al. 2008; León 2011). Paratracheal parenchyma is however absent in all species studied here. *Aspidosperma flaviflorum* shares with *A. quirandy* and *A. tomentosum* the presence of rays uniseriate to biseriate, exclusively homocellular, and prismatic crystals present in chambered axial parenchyma strands only. By this set of features, these species fit well with León (2011)

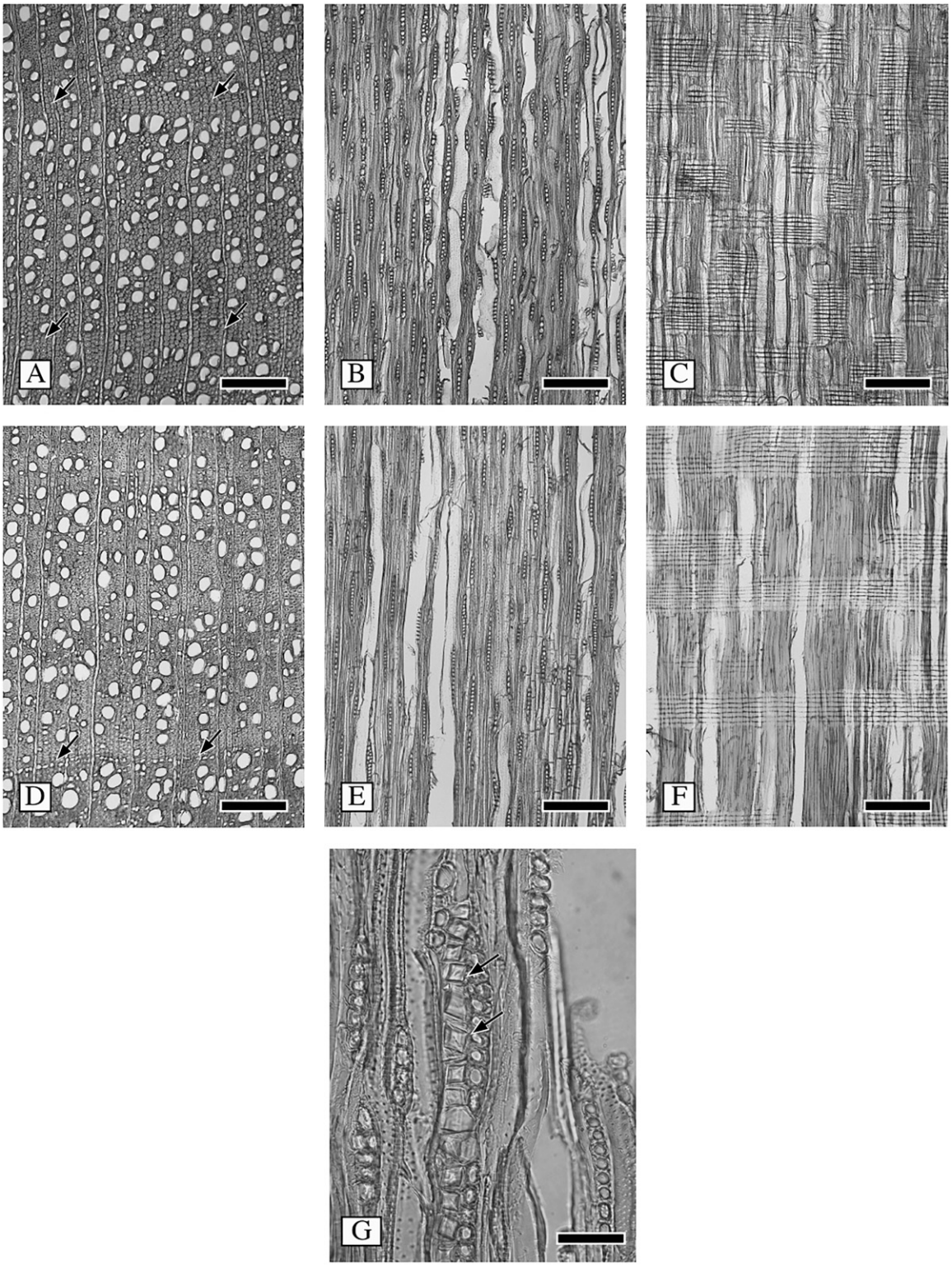

Fig. 4. Wood anatomy of *Aspidosperma flaviflorum* and related species. A–C, G. *Aspidosperma flaviflorum*. A. Transverse section (TS). Narrow, mainly solitary vessels, axial parenchyma practically absent, growth rings delimited by fiber zones with fewer vessels and radially flattened fibers (arrows). B. Longitudinal, tangential section (LT). Rays uni- to biseriate, nonstoried. Bordered pits evident in fibers. C. Longitudinal radial section (LR). Homocellular rays composed of procumbent cells only, simple perforation plates. D–F. *Aspidosperma quirandy*. D. TS. Narrow, mainly solitary vessels, axial parenchyma diffuse to diffuse-in-aggregates and marginal, growth rings delimited by fiber zones and marginal parenchyma (arrows). E. LT. Rays uni- to biseriate, nonstoried. Bordered pits evident in fibers. F. LR. Homocellular rays composed of procumbent cells. G. LT. Prismatic crystals present in chambered axial parenchyma cells. Scale bars: A–F = 200 μm, G = 40 μm.

Aspidosperma group II, except that he describes the species within this group as having prismatic crystals also in the rays, a feature not recorded here and another shared affinity among these species. Crystal location has been shown to be informative also to identify tribes Wrightieae, Malouetieae, and Nerieae of the Apocynaceae (Lens et al. 2009). *Aspidosperma flaviflorum* is yet unique for the very scanty axial parenchyma, lacking also the marginal parenchyma present

Table 2. Comparison of wood anatomical characters among the species of *Aspidosperma*.

Characters		*A. flaviflorum*	*A. quirandy*	*A. tomentosum*
Vessel	Porosity	Diffuse to semi-ring porous	Diffuse to semi-ring porous	Diffuse to semi-ring porous
	Diameter	28 ± 9 μm	39 ± 10 μm	33 ± 7 μm
	Abundance	246 ± 26 vessels/mm^2	134 ± 19 vessels/mm^2	110 ± 30 vessels/mm^2
Parenchyma	Length	465 ± 49 μm	616 ± 113 μm	350 ± 70 μm
	Arrangement	Indistinct	Diffuse	Diffuse in aggregates
	Number of cells	4–6	4–7	4–8
Fibers	Length	749 ± 149 μm	936 ± 185 μm	845 ± 112 μm

in the other presumably closely related species studied here, and also other known species of *Aspidosperma*. Further studies using molecular data would help clarify the relationship among these morphologically similar species. This feature sets this species aside from all others in terms of wood anatomy.

Key to the Species of the *Aspidosperma* in Mato Grosso Do Sul State

1. Whorled leaves; leaf apex with spine; colorless latex . . . 2
   2. Secondary vein pairs ≥ 15; follicles without mucro; 23–26 seeds in fruit . . . *A. quebracho-blanco*
   2. Secondary vein pairs ≤ 12; follicles with mucro; 6–12 seeds in fruit . . . *A. triternatum*
1. Alternate leaves; leaf apex without spine; red or white latex . . . 3
   3. Red latex; ellipsoid follicles . . . *A. nobile*
   3. White latex; oblong, flattened, rounded, widely obovate, depressed obovate or depressed ovate follicles . . . 4
      4. Oblong, flattened or rounded follicles . . . 5
         5. Flattened follicles . . . *A. cuspa*
         5. Rounded follicles . . . 6
            6. Petiole < 1.2 cm long; follicles with mucro; 2–4 seeds per fruit . . . *A. polyneuron*
            6. Petiole ≥ 1.3 cm long; follicles without mucro; 10–16 seeds per fruit . . . *A. cilindrocarpon*
      4. Widely obovate, depressed obovate or depressed ovate follicles . . . 7
         7. Widely obovate follicles . . . 8
            8. Lenticellate rhytidome; petiole glabrous; follicles without middle back and costal ribs . . . *A. australe*
            8. Rhytidome not lenticellate; petiole puberulent to glabrescent; follicles with middle back and costal rib . . . *A. parvifolium*
         7. Depressed obovate or depressed ovate follicles . . . 9
            9. Depressed obovate follicles . . . *A. pyrifolium*
            9. Depressed ovate follicles . . . 10
               10. Follicles without lenticels . . . 11
                  11. Leaf blades ≤ 18 cm long; 11–17 seeds per fruit . . . *A. macrocarpon*
                  11. Leaf blades ≥ 19 cm long; 20–22 seeds per fruit . . . *A. verbascifolium*
               10. Follicles with lenticels . . . 12
                  12. Petiole ≥ 2 cm long; leaves brochidodromous; follicles with mucro . . . *A. subincanum*
                  12. Petiole ≤ 1.5 cm long; leaves craspedodromous or semicraspedodromous; follicles without mucro . . . 13
                     13. Leaves semicraspedodromous . . . *A. quirandy*
                     13. Leaves craspedodromous . . . 14
                        14. Leaf blades tomentose; follicles tomentose, ≥ 5.1 cm long . . . *A. tomentosum*
                        14. Leaf blades glabrous; follicles glabrous, ≤ 4.2 cm long . . . *A. flaviflorum*

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Author Contributions

DJM and MAF designed the project. DJM and MRP made field collections. JFCQ and MAF performed leaf diaphanization and description. DJM and FMA realized leaf morphological by scanning electron microscopy. DJM, MAF, and FMA wrote the morphological description. MRP conducted wood anatomy procedures and description. All authors contributed towards writing, editing, and reviewing the manuscript.

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