

GUIDE TO THE GENERA OF LIANAS AND CLIMBING PLANTS IN THE NEOTROPICS

SAPINDACEAE

By Pedro Acevedo-Rodríguez (17 Feb 2018)



Paullinia pinnata L. (photo: P. Acevedo)

circinate tendrils at the end of short axillary branches, or at the base of axillary inflorescences rachis.

A predominantly tropical family of trees, shrubs, lianas and vines, with few species extending to temperate zones. Lianas and vines in the Sapindaceae are restricted to the genera *Cardiospermum*, *Lophostigma*, *Paullinia*, *Serjania*, *Thinouia*, and *Urvillea*, all belonging to the predominantly Neotropical tribe Paullinieae. About 450 out of a total 800 species of Sapindaceae in the Neotropics are either lianas or vines which are ubiquitous in lowland moist forest, savannas, gallery forest, and in open disturbed biomes. Neotropical Sapindaceae is most diverse between 300 and 800 m of elevation, becoming less diverse between 1500 and 3000 m of elevation.

Diagnosics: In the absence of fertile material, climbing Sapindaceae are easily distinguished from vines in other families by the presence of compound, alternate leaves with stipules; a pair of

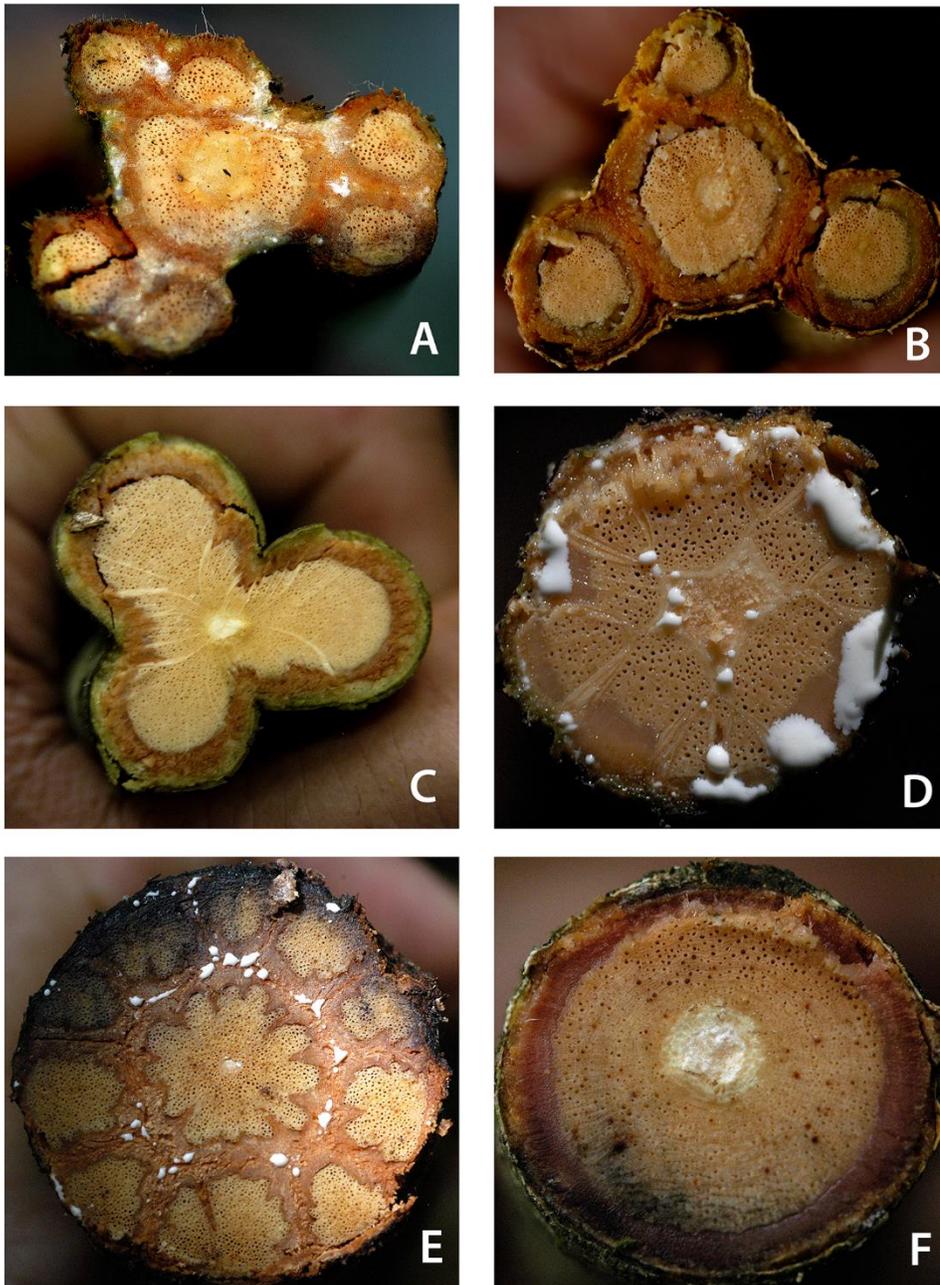


Figure 1. Cross sections of mature stems. **A.** *Serjania grandiceps* Radlk., compound stem (a central cylinder and six periferal cylinders). **B.** *Paullinia largifolia* Radlk., compound stem (a central cylinder and three periferal cylinders). **C.** *Paullinia clathrata* Radlk., simple, deeply triboled stem. **D.** *Serjania mexicana* (L.) Willd., simple stem with phloem wedges. **E.** *Serjania pyramidata* Radlk., compound stems (a central cylinder and 10 periferal cylinders). **F.** *Paullinia fibrigera* Radlk., simple, cylindric stem. Photos by P. Acevedo.

General Characters

1. **STEMS.** Stems are woody or less often herbaceous (e.g., some *Cardiospermum* and *Urvillea*). Woody, mature stems are usually 1 to 4 cm in diameter, although in species of *Paullinia*, *Serjania*, and *Thinouia* they may reach 15 cm or more in diameter, and up to 30 m in length. Stems are **cylindrical** (figs. 1e & f), **trigonous** (fig. 1a & b), **trilobed** (fig. 1c), or **pentagonal** (figs. 1d; 2b) in cross section, and usually deeply furrowed (figs. 1a & c; 2a). In general, climbing Sapindaceae (67% of the species) have simple stems (single vascular cylinder, fig. 1c & f). The remaining one third of the species have **compound stems** with a central, larger vascular cylinder surrounded by three to ten smaller vascular cylinders (fig. 1a, b, e & 2c), all of which show normal secondary growth. Compound stems are unique to the Sapindaceae being present in 58 % of *Serjania* and 12% of *Paullinia*. Few species of *Serjania* have a **divided xylem** where the xylem is produced in 5 radial sections, all of which have a central medulla (fig. 2d). In addition, several species of *Thinouia* and few species of *Paullinia* and *Serjania* present **neo-formed vascular cylinders** during later stages of secondary growth (fig. 2a, b & c). Stems with neo-formed vascular cylinders are superficially similar to compound stems but in the former the development of additional vascular cylinders occurs during primary growth, while in the latter occurs during late secondary growth. Most species with simple or compound stems produce **phloem wedges** (fig. 1d).
2. **EXUDATES.** For the most part exudates are odorless and colorless in all genera, with the exception of *Paullinia* and *Serjania* where several species are known to have milky white exudates (figs. 1a, d & e).
3. **TENDRILS.** All genera have circinate or less often spiral tendrils that are produced at the base of the floriferous part (rachis) of axillary inflorescences (fig 3a), or distally on short, axillary inflorescence-like branches whose floriferous part does not develop (fig 3b).
4. **STIPULES.** Within Sapindaceae, stipules are only present in the climbing genera of the Paullinieae tribe. These are usually minute or small (0.5-10 mm long), subulate, lanceolate or triangular and persistent. Less often, stipules are large (1.5-3 cm long), falcate, cordate, rounded or dissected (fig. 4 a-c), and usually deciduous. Minute and small stipules are found in all genera, while large stipules are restricted to *Paullinia*, *Serjania*, and a few species of *Urvillea*. Large stipules however, are more common in *Paullinia*, some of which have dissected margins or cordate bases.
5. **LEAVES.** Leaves are alternate, imparipinnate. These include **5-9-pinnate** (fig 5a, e), **partially bipinnate-tripinnate** (fig 5d), **trifoliolate** (fig. 5c), **biterminate** (fig. 5b), **triternate** or a combination of these. Palmate leaves and unifoliolate leaves are found in few species of

Paullinia (e.g., *Paullinia echinata* Huber; *Paullinia unifoliolata* Perdiz & Ferrucci). Petioles and rachis are nearly *cylindrical* (fig. 5a & c), slightly *flattened* adaxially (fig. 5b & d) or *winged* (fig. 5e).

6. INFLORESCENCES. Inflorescences are ascending or hanging, axillary, distal, or cauliflorous thyrses with flowers in lateral cincinni. Axillary inflorescences are solitary, *racemose* (fig. 6e), *spicate* (fig. 6f), or *umbelliform* (fig. 6b), and less often grouped in *fascicles* (fig. 6c). Distal inflorescences form a paniculate synflorescence at the end of branches and are common to all genera. Cauliflorous and fasciculate inflorescences are known only from *Paullinia* (fig. 6a), while umbelliform inflorescences are exclusive to species of *Thinouia* (fig. 6b), *Cardiospermum* and *Urvillea*. Axillary, solitary inflorescences are usually subtended by a pair of tendrils, but tendrils are mostly lacking in cauliflorous, fasciculate, and distal inflorescences.
7. PEDICELS. As in many other Sapindaceae, the climbing genera in the Paullinieae have flowers with articulate pedicels, i.e., have an abscission zone above the base.
8. FLOWERS. Flower symmetry is either zygomorphic (fig. 7) in *Cardiospermum*, *Lophostigma*, *Paullinia*, *Serjania*, and *Urvillea* or actinomorphic (fig. 8) in *Thinouia*, seemingly bisexual but functionally unisexual were plants are dichogamous, monoecious, or dioecious. Sepals distinct or two of them partly connate in zygomorphic flowers; petals distinct, usually white or cream; in zygomorphic flowers 4, with an adnate hood-shaped appendage with a fleshy crest (fig. 7c); in actinomorphic flowers, petals auriculate with bifurcate appendages (fig. 8d); nectary disc extrastaminal, unilateral, entire or lobed (fig. 7d) in zygomorphic flowers; annular in actinomorphic flowers; stamens 8; ovary superior and tricarpellate, with same number of locules as carpels, the style more or less elongated, the stigmas elongated (fig. 7d-e) or capitate; placentation axial, ovules 1 per locule.
9. FRUITS. Fruit type is the most important character in recognizing the genera of climbing Sapindaceae. These are either capsules or schizocarps. *Thinouia*, *Serjania*, and *Lophostigma* have schizocarps that split into 3 winged mericarps. Wings in *Thinouia* (fig. 9a) are in distal position while those of *Serjania* (fig. 9b) and *Lophostigma* (fig. 9c) are basal. *Paullinia*, *Cardiospermum*, and *Urvillea* have septicidal marginicidal capsules. Those of *Paullinia* (fig. 9f) are coriaceous to woody, while those of *Cardiospermum* (fig. 9e) and *Urvillea* (fig. 9d) are papery. Capsules in *Cardiospermum* have locules that are completely inflated while those of *Urvillea* flattened to various degrees.
10. SEEDS. Seeds in *Paullinia* are globose to sub-globose and partially to entirely covered with a fleshy tissue which is usually derived from the outer coat of the testa (fig. 10a, b & c). Those of *Cardiospermum* and *Urvillea* are globose or nearly so, lacking a fleshy tissue,

and usually have a with heart-shape arillode surrounding the hilum (fig. 10d). Seeds in *Serjania*, *lophostigma* and *Thinouia* are usually lenticular and lack any fleshy tissue.

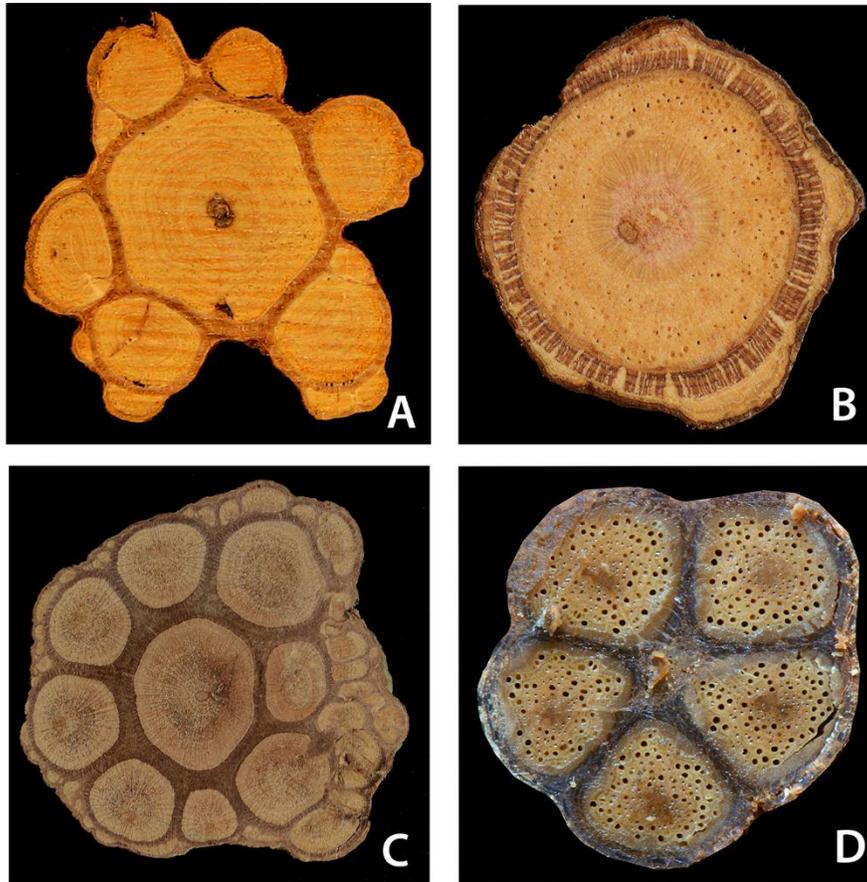


Figure 2. Cross sections of mature stems. **A.** *Thinouia myriantha* Tria. & Planch. late secondary growth with a central vascular cylinder neoformed cylinders of different sizes. **B.** *Thinouia mucronata* Radlk. early secondary growth with incipient neoformed cylinders. **C.** *Serjania caracasana* (Jacq.) Willd. late secondary growth of compound stem with neoformed cylinders. **D.** *Serjania paleata* Radlk. stem with divided xylem. Photos by P. Acevedo.



Figure 3. Paired tendrils distal on short, axillary branches. **A.** *Paullinia* sp. **B.** in *Serjania paucidentata* DC. Photos by P. Acevedo.



Figure 5. Stipules. **A.** Large, dissected in *Paullinia rugosa* Radlk. **B.** Large, falcate in *Paullinia bracteosa* Radlk. **C.** Large, lanceolate in *Paullinia* sp. Photos by P. Acevedo.

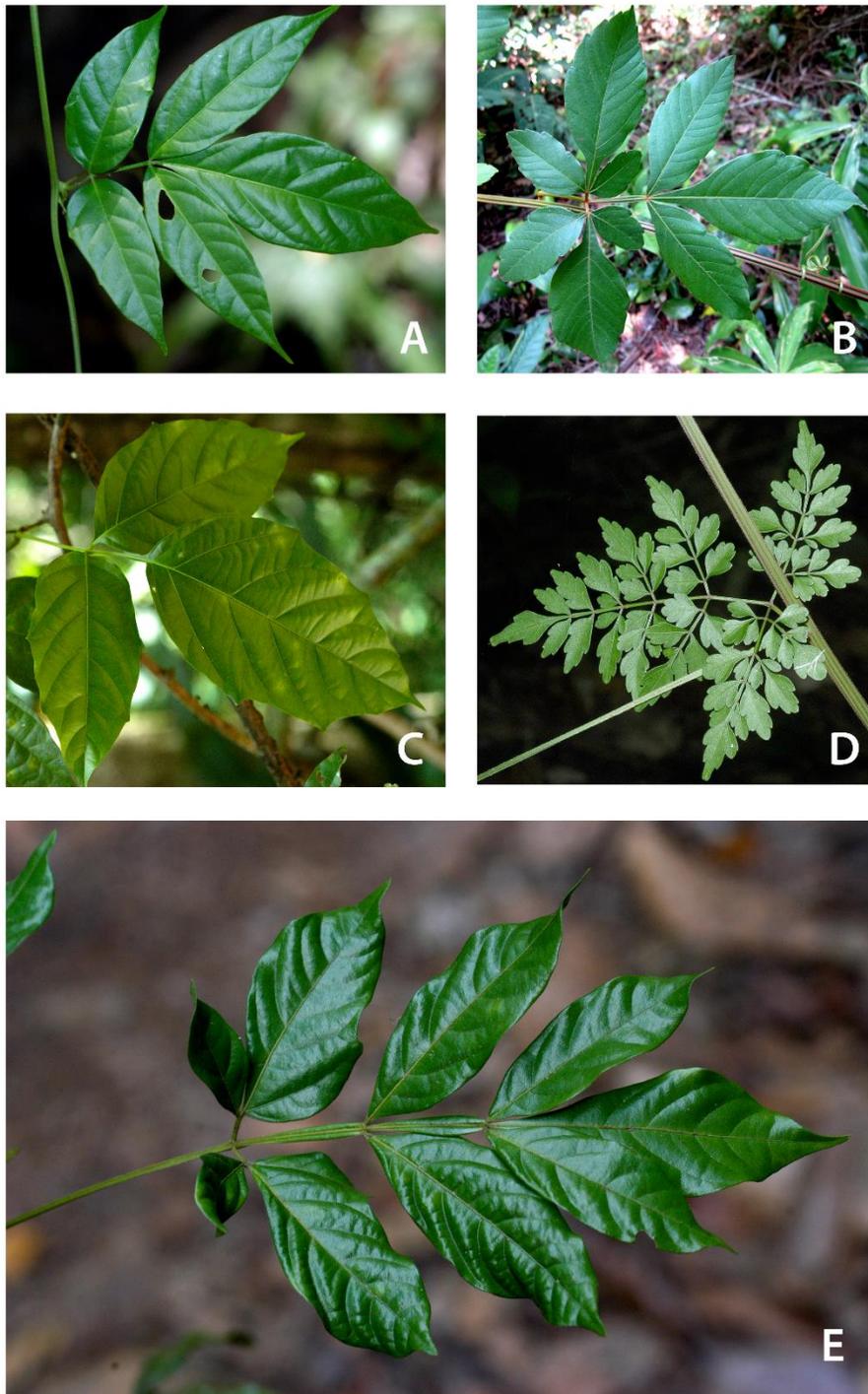


Figure 4. Leaves. **A.** 5-pinnately compound in *Paullinia* sp. **B.** Biternate in *Serjania cornigera* Turcz. **C.** Trifoliolate in *Paullinia turbacensis* Kunth. **D.** Partially bipinnate-tripinnate in *Serjania trachygona* Radlk. **E.** Partially bipinnate (7-pinnate, with compound basal pair of leaflets) *Paullinia* sp. Photos by P. Acevedo.

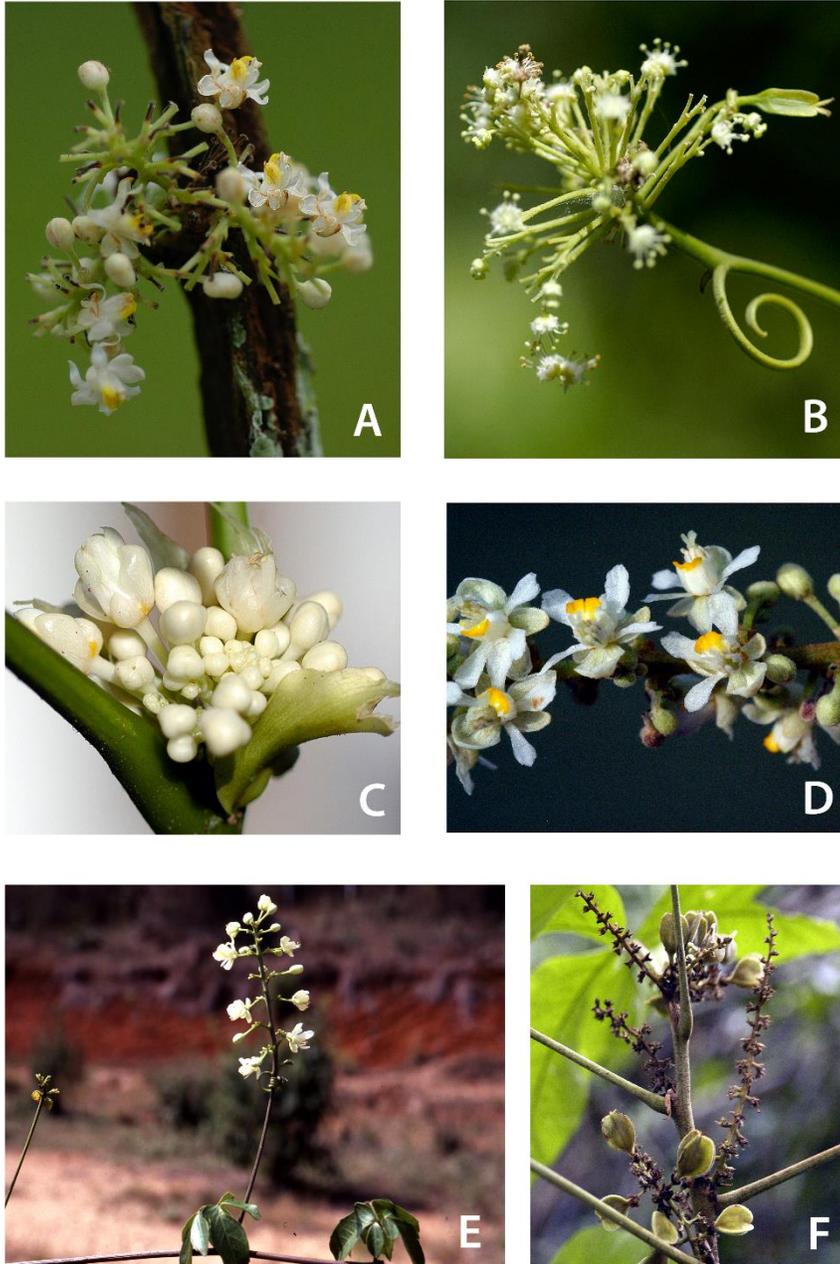


Figure 6. Inflorescences. **A.** Cauliflorous in *Paullinia largifolia* Radlk. **B.** Umbelliform in *Thinouia myriantha* Tria. & Planch. **C.** Fasciculate in *Paullinia* sp. **D.** Portion of inflorescence showing lateral cincinni in *Serjania mexicana* (L.) Willd. **E.** Axillary, racemose, ascending thyrses, with tendrils in *Serjania caracasana* (Jacq.) Willd. **F.** Axillary, racemose, ascending, tendril-less in *Paullinia dasystachya* Radlk. Photos by P. Acevedo.

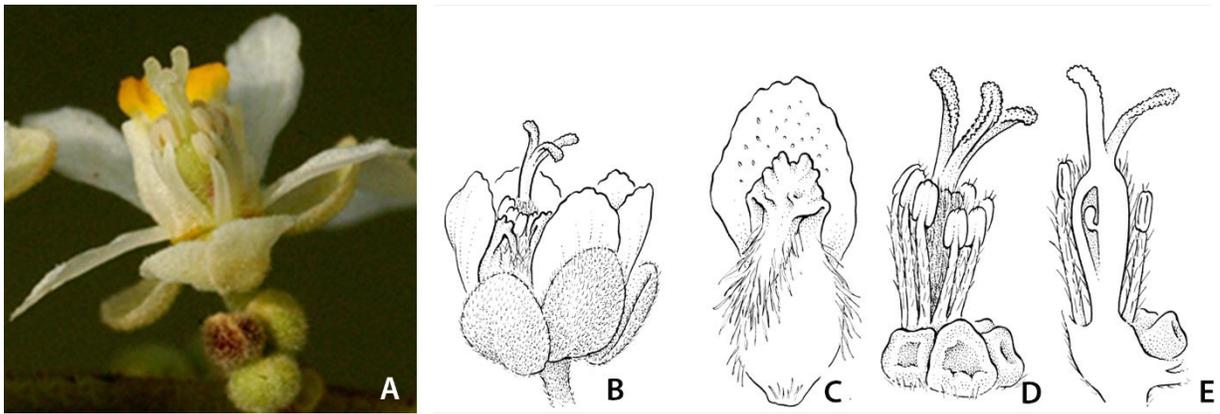


Figure 7. Zygomorphic flowers. **A.** *Serjania mexicana*. **B-E.** *Serjania lucida* Schum. Pistillate flower, petal (adaxial view), disc, staminodes and gynoecium, same long sect. Drawings by Bobbi Angell.

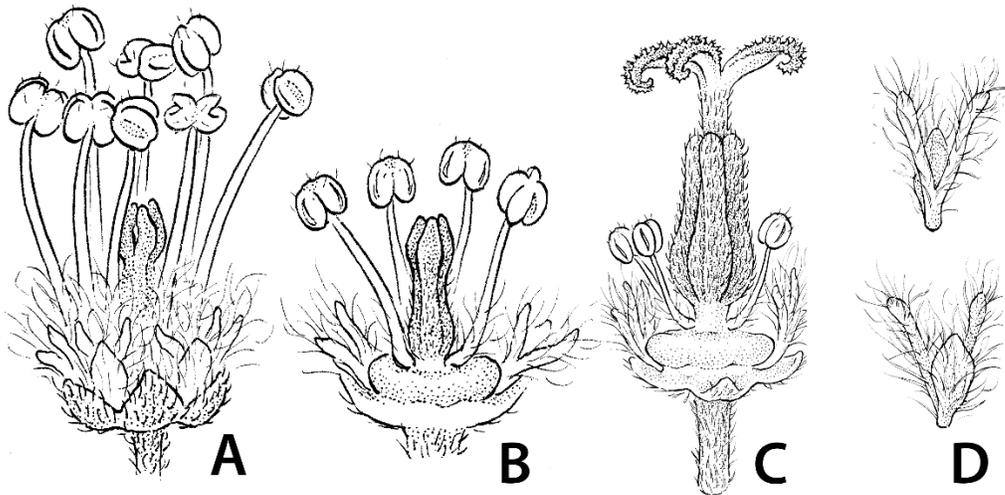


Figure 8. Actinomorphic flower in *Thinouia myriantha*. **A.** Staminate flower. **B.** Staminate flowers with part of perianth removed. **C.** Pistillate flower with part of the perianth removed. **D.** Petal, adaxial and abaxial views. Drawings by Bobbi Angell.

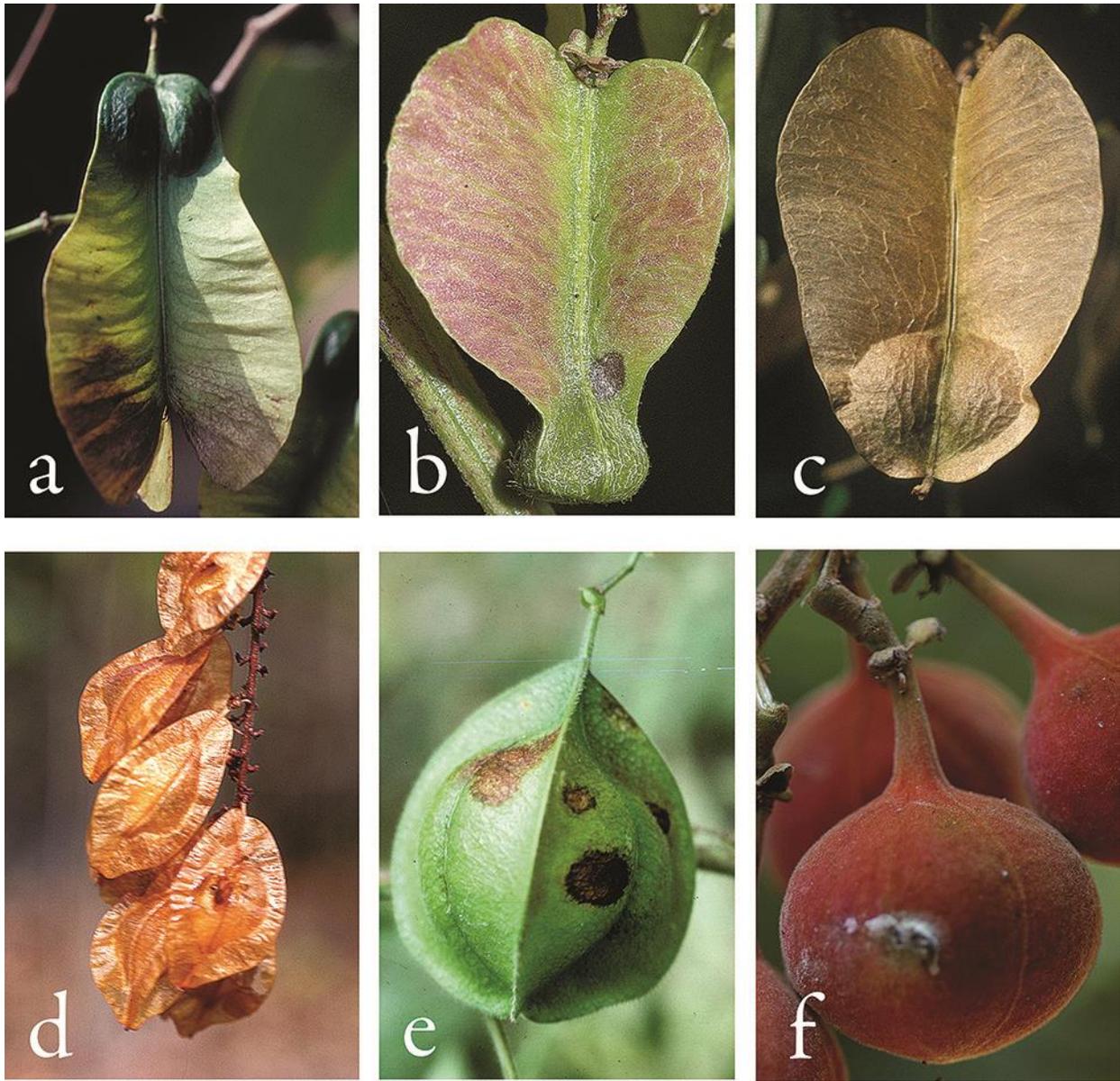


Figure 9. Fruit diversity in tribe Paullinieae. **A.** Schizocarps with distal wing in *Thinouia*. **B.** Schizocarps with proximal wing in *Serjania*. **C.** Schizocarps with proximal wing in *Lophostigma*. **D.** Papery, semi-inflated capsule with marginal wings in *Urvillea*. **E.** Papery, inflated capsule in *Cardiospermum*. **F.** Woody capsule in *Paullinia*. Photos by P. Acevedo.



Figure 10. Seeds in Paullinieae. **A.** *Paullinia* sp showing scar after removal of sarcotesta. **B.** *Paullinia* sp. seed completely covered by fleshy tissue (sarcotesta). **C.** *Paullinia* sp. seed almost completely covered by sarcotesta. **D.** *Cardiospermum corindum* L. heart-shaped arillode. Photos by P. Acevedo.

USES

In general most species of Sapindaceae including the climbers are used for fish poisoning in the Neotropics (Radlkofer 1886; Acevedo-Rodríguez 1990). Numerous species of *Paullinia* have been reported to be useful in the preparation of medicines, caffeine-rich beverages, binding and weaving material, and for fish, human and arrow poisoning (Beck 1990). The seeds of *Paullinia cupana* are the source of the important Brazilian crop guaraná, a source of caffeine and flavoring of soft drinks. Macerated stems of *Serjania yoco* Schultes are used in the preparation of a caffeine-rich drink. Three species of *Cardiospermum* are used as ornamental worldwide. Some species of *Serjania* (e.g., *S. lethalis* A. St.-Hil.) have been reported as toxic to grazing animals.

Key to the genera of climbing Sapindaceae

1. Flowers actinomorphic, with an annular extrastaminal disc; fruit a schizocarp; mericarps with a distal wing; leaves always trifoliolate *Thinouia* (Mexico to South America)
1. Flowers zygomorphic with a unilateral extrastaminal disc; fruit a capsule or if a schizocarp the mericarps with a basal or peripheral wing; leaves of many kinds2
2. Petals short, with a pair of minute, basal appendage, concealed by the sepals; stamen's filaments of equal length and as long as the anthers; nectary semi-annular, 4-lobed; pollen grains cylindrical-ellipsoid, 4-syncolporate; cross section of stem simple (Ecuador, Peru, Bolivia) *Lophostigma*
2. Petals much longer than the sepals, with a hood-shaped petaloid appendage almost as long as the petal; filaments of anterior stamens shorter than those of posterior ones; anthers much shorter than the filaments, appressed against petal's appendages; nectary reduced to 4 or 2 lobes; 2 pollen grains trigonous, triporate or tricolporate; cross section of stem simple or compound.....3
3. Fruit a schizocarp, mericarps with a basal or less often a peripheral wing; cross section of stem simple or compound; inflorescence never cauliflorous (southwestern North America to South America, West Indies) *Serjania*
3. Fruit a capsule; cross section of stem simple or compound; inflorescence sometimes cauliflorous in *Paullinia*4
4. Fruit wall papery; cross section of stem simple.....5
4. Fruit wall thick, coriaceous cross section of stem simple compound (Mexico to South America, West Indies) *Paullinia*
5. Fruit lobes inflated (North America to South America, West Indies) *Cardiospermum*
5. Fruits lobes more or less flattened lengthwise (Mexico to South America, Lesser Antilles) *Urvillea*

IDENTIFICATION OF GENERA BASED ON VEGETATIVE CHARACTERS

The genera of climbing Sapindaceae are defined by the type of fruit they bear, and to certain degree by the symmetry of the flower; vegetatively the genera are very similar and difficult to tell apart. However, the following generalities can be useful in distinguishing the genera with certain degree of confidence.

1. *Biternate leaves* (fig. 4b). Biternate leaves are found in *Serjania*, *Paullinia*, *Cardiospermum* and *Urvillea* with a total of 169 species showing this leaf type. There is a higher probability for an individual having this type of leaf to be a *Serjania* since nearly 60% of its species (145 species) are known to have biternate leaves. In contrast, 15 species of *Paullinia*, 7 species of *Cardiospermum*, and 1 species of *Urvillea* are known to have biternate leaves.
2. *Multijugate leaves* (fig. 4e). The occurrence of this character is more prevalent in *Paullinia* with 33 species presenting this character. In contrast, only 8 species of *Serjania* have multijugate leaves.
3. *Compound stems with a central vascular cylinder surrounded by (6)8-10 smaller peripheral vascular cylinders* (fig. 1e, 2c) is a feature only present in 30 species of *Serjania*. The widely distributed *Serjania caracasana* is an example of a species bearing this character.
4. *Co-occurrence of biternate leaves and compound stems*. This combination of characters is unique to *Serjania*, and is present in about 56 % of its species. Conversely, all species of *Paullinia*, *Cardiospermum* and *Urvillea* with biternate leaves have simple stems.
5. *White or milky exudate*. A character restricted to *Paullinia* and *Serjania*, but only found in a few species (fig. 1a, d, e).
6. *Prickly stems*. A character found only in 4 species of *Serjania*. (e.g. *S. mexicana*)
7. *Cauliflorous inflorescences*. A character found only in about 20 species of *Paullinia* (fig. 6a). The widely distributed *Paullinia alata* (Ruiz & Pav.) D. Don is an example of a species that has this character.

GENERIC DESCRIPTIONS

CARDIOSPERMUM L., Sp. Pl. 366. 1753.



C. corindum L. (photo: P. Acevedo)

Herbaceous tendrilled vines, or less often erect subshrubs, with woody base, with watery sap; stems furrowed, cylindrical or slightly angled; cross section with a single vascular cylinder. Leaves ternately or biternately compound, membranous or chartaceous; leaflets deeply serrate or lobed; petioles and rachis unwinged; stipules minute, early deciduous. Flowers zygomorphic, functionally staminate or pistillate, produced in axillary thyrses; thyrses bearing a pair of tendrils at base of rachis; calyx of 4 or 5 unequal sepals;

petals 4, distinct, white, with a hood-shaped appendage; nectary unilateral reduced to 4 lobes or 2 corniform projections; stamens 8, the filaments unequal, connate at base, the anthers dorsifixed, sometimes with an apical connective; ovary 3-carpellate, each locule with a single ovule, the style slender, the stigmas 3, recurved. Fruit an inflated, membranous, capsule, with a persistent septa. Seeds spherical, black, with a small, white, cordate arillode, persistent on septa after fruit dehiscence.

Distinctive features: Fruit inflated, membranous; seeds with a white, heart-shaped arillode; leaves trifoliolate or biternate.

Distribution: A tropical genus with about 15 species, native to the Neotropics, but a few species with pantropical distribution. Also cultivated as an ornamental in North America and Europe, some species becoming weedy.

LOPHOSTIGMA Radlk. in Engl. & Prantl, Nat. Pflanzenfam. Nachtr. 1: 228. 1897.



L. plumosum (photo: P. Acevedo)

Woody vines. Cross section of stem with a single vascular cylinder. Leaves alternate, trifoliolate; stipules minute. Inflorescences axillary thyrses with a pair of tendrils at base of rachis. Flowers zygomorphic, functionally unisexual; sepals 5, unequal, imbricate; petals 4, much shorter than the sepals, with 2 basally adnate digitate appendages; disk unilateral, 4-lobed; stamens 8, with short filaments; pollen cylindrical-ellipsoid, 4-aperturate; ovary 3-carpellate, with a single ovule per carpel; style with 3 stigmatic branches. Fruit a schizocarp splitting into 3 mericarps with an elongated proximal wing. Seeds lenticular, exarillate.

Distinctive features: Petals much shorter than the sepals; pollen cylindrical-ellipsoid, 4-aperturate; mericarps with a proximal wing similar to *Serjania*.

Distribution: Two species, one from Ecuador and Peru, the other from Bolivia.

PAULLINIA Linnaeus. Sp. Pl. 365. 1753.

Lianas, vines or less often understory shrubs; cross section with a single or multiple vascular cylinders, often producing milky sap. Stipules minute to foliaceous, persistent or deciduous. Leaves alternate, trifoliolate, 5-pinnately foliolate, biternate, triternate, or partially bipinnate. Thyrses solitary or fascicled, axillary, terminal, or cauliflorous, racemiform, spicate, or paniculate, with flowers in lateral cincinni or drepania. Flowers zygomorphic; calyx 4-5-merous, the sepals distinct, or the two anterior ones connate to different degrees into a larger sepal; petals 4, distinct, clawed, bearing a hood-shaped appendage, these with a fleshy, yellowish apex, smaller in anterior



Figure 11. Fruits in *Paullinia*. **A.** *Paullinia hystrix* Radlk. **B.** *Paullinia obovata* (Ruiz & Pav.) Pers. **C.** *Paullinia verrucosa* Radlk. **D.** *Paullinia caloptera* Radlk. Photos by P. Acevedo.

petals; disc unilateral, 2- or 4-lobed; stamens 8, the filaments of unequal length, usually pubescent; ovary 3-carpellate, the carpels with a single ovule. Fruit a septifragal (marginicidal) capsule, rugose, or echinate, membranous, crustose, leathery or woody (fig. 11). Seeds usually globose, with a sarcotesta at base, but sometimes covering almost the whole seed. A few species of *Paullinia* are known to be shrubby in early stages but can grow into lianas as they mature.

Distinctive features: Seed mostly sarcotestal; some species with cauliflorous inflorescences; pollen grains triporate.

Distribution: A Neotropical genus with ca. 200 species distributed from Mexico to northern Argentina, including the West Indies, with its center of distribution in western Amazonia. One species (*P. pinnata*) apparently occurring naturally in tropical Africa and Madagascar.

SERJANIA Miller. Gard. Dict. Abr. Ed. 4. 1754.

Houssayanthus Huntziker, Kurtziana 11: 17. 1978.

Balsas J. Jiménez Ram & K. Vega, Novon 21: 197. 2011.



S. rhombea Radlk. (photo: P. Acevedo)

Lianas or vines of forest canopy, open disturbed areas, or savanna vegetations. Cross section of stems with a single or multiple vascular cylinders, often producing milky sap. Stipules minute to small, early deciduous or persistent. Leaves alternate, trifoliolate, 5-pinnately foliolate, biternate, or triternate, or seldom bipinnate. Thyrses axillary or terminal, racemose or paniculate,

with flowers on lateral cincinni. Flowers zygomorphic; sepals 4 or 5, distinct, or two of them connate; petals 4, distinct with a hood-shaped appendage; disc unilateral, 2-to 4-lobed; stamens 8,

the filaments of unequal length, the anthers dorsifixed; ovary 3-locular, the locules with a single ovule. Fruit a schizocarp splitting into three samaroid mericarps, with a proximal wing, or less often, the wing marginal or exceptionally fruits late dehiscent. Seeds lenticular to globose, not arillate.

Distinctive features: Co-occurrence of biternate leaves and stems with multiple vascular cylinders; stems (cross section) with a central vascular cylinder surrounded by 8 to 10 smaller vascular cylinders.

Distribution: A Neotropical genus with about 300 species mostly distributed below 1500 m in savannas, dry forest, or open, disturbed habitats from Mexico to northern Argentina, including the West Indies, with a main center of distribution in the Brazilian plateau and the Mexican savannas.

THINOUIA Triana & Planch., Ann. Sci. Nat. Bot. Ser. 4, 18: 368. 1862.



T. scandens Tria. & Planch. (photo: P. Acevedo)

Lianas of forest canopy or disturbed areas. Stems terete or trilobed, lenticellate, becoming warty with age; cross section with a single vascular cylinder; older stems with many cortical vascular cylinders. Stipules minute, early deciduous. Leaves alternate, trifoliolate or less often biternate; petioles and petiolules unwinged; leaflets coriaceous. Inflorescences axillary, umbel-like or racemiform thyrses, with lateral cincinni, seldom bearing tendrils. Flowers actinomorphic; calyx cup-shaped with 5 distinct sepals; petals 5, distinct, spatulate, auriculate or with a petaloid appendage; disc annular; stamens 6-8, the filaments of equal length, free; ovary 3-locular, each locule with a single ovule. Fruit a schizocarp, splitting into 3, samaroid mericarps with a distal wing. Seeds subglobose, not arillate.

Distinctive features: Actinomorphic flowers; mature stems with cortical vascular cylinders of different diameters.

Distribution: About 12 species from Central America and South America, with its center of distribution in southern tropical South America.

URVILLEA Kunth in F.W.H.A. von Humboldt, A.J.A. Bonpland & C.S. Kunth, Nov. Gen. Sp. (quarto ed.) 5: 105. 1821.



U. triphylla Radlk. (photo: P. Acevedo)

Herbaceous to woody vines. Stems terete and lenticellate, becoming 3-lobed with age, producing milky sap; cross section with a single vascular cylinder. Stipules minute, deciduous or persistent. Leaves trifoliolate or less often biternate; petioles or rachis unwinged. Inflorescence a thyrse with closely spaced cincinni. Flowers zygomorphic, bisexual. Calyx of 5 unequal sepals; petals 4, distinct, usually < 4 mm long, spatulate, with an adnate, hood-shaped appendage on adaxial surface; disk unilateral, 4-lobed, receptacle enlarged into a short androgynophore. Stamens 8; filaments unequal; anthers usually with an apical connective. Ovary of 3 uniovular carpels; style terminal with 3 stigmatic branches. Fruits thin, papery, semi-inflated capsules, with narrow marginal wing. Seeds subglobose,

black, with a heart-shaped or reniform white arillode around the hilum; embryo with the abaxial cotyledon bent over the biplicate adaxial cotyledon.

Distinctive features: Capsules thin, papery, carpels with a narrow marginal wing; seeds subglobose, black, with a heart-shaped or reniform white hilum.

Distribution. About 15 species from Central America, South America (except Chile), and some of the Lesser Antilles, with its center of distribution in the Brazilian plateau.

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