# Histological Study of *Aristolochia triangularis*, *Casearia sylvestris*, and *Schinopsis balansae*

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**The content of this paper is concerned with the external and internal morphology of three little-known South American plant drugs: the dried stems of *Aristolochia triangularis* (*Aristolochiaceae*), the dried stem bark of *Casearia sylvestris* (*Flacourtiaceae*), and the dried leaves of *Schinopsis balansae* (*Anacardiaceae*). Stained and unstained sections were employed in this study, as were temporary and permanent mounts. The results of histological studies of powdered and macerated materials are also reported.**

THERE is little information in the literature concerning the histology of *Aristolochia triangularis* Chamisso, of *Casearia sylvestris* Swartz, and of *Schinopsis balansae* Engler. Parts of these plants are reportedly used in a ground drug mixture employed by some South American Indians as a remedy for arthritic conditions. This problem was undertaken in order to enter macroscopic and microscopic descriptions of these crude drugs into the literature. The crude drug materials used in this problem were authenticated by Professor Heber W. Youngken.

The histologies of the stems of *Aristolochia triangularis*, the bark of *Casearia sylvestris*, and the leaves of *Schinopsis balansae* have been worked out and are described in this paper.

## *ARISTOLOCHIA TRIANGULARIS* CHAMISSO

**Description of the Plant.**—*Aristolochia triangularis* Chamisso, family *Aristolochiaceae*, is a tropical woody vine indigenous to Brazil. Bailey (1) reports that it has been cultivated in California. There are about 300 species of *Aristolochia* found in the tropical and the temperate regions of the world. Most members of this genus are woody climbers that commonly possess irregular and grotesque flowers. These flowers often have an equally strange odor. According to Standley (2) the roots of a related species, *A. grandiflora* Swartz, have reportedly been used to poison human beings and animals in the West Indies and that they possess sudorific, abortive, and emmenagogue properties. He further reports that the roots of this and of several other species are used in preparing antidotes for snake bite.

The stems of *Aristolochia*, according to Schenke (3), are soft and tortuous because the ray parenchyma tissue is extensively developed. The soft phellem is thick and possesses numerous longitudinal fissures. Bailey (1) describes the plant as follows: the leaves are simple, deltoid, and glabrous, and have acute apices. They are pellucid-punctate and are palmately veined with three main veins. The lamina is averagely 4 inches long by 6 inches wide, and the petioles are prehensile. Each flower is borne singly and possesses a purple-spotted calyx. A corolla is absent. The fused sepals of the calyx form a bent tube with an oval, basal swelling. The termination of the tube is somewhat constricted, and at this point it widens out into a flat flare. The ovary of the flower is inferior with a lobed and fleshy style. The general floral shape is shown by the flowers of the common Dutchman's pipe, *A. macrophylla* Lam. The fruit is a 6-valued capsule.

**Crude Drug.**—The material used in this investigation was received as a bundle of dried stems, approximately 2 feet long by 8 inches in diameter. Pieces of stem varied in length from 1 foot to 4 feet and in diameter from 0.25 to 1 inch. The bundle had evidently been made from fresh material and was tied with a young stem. The ends of the stem segments were either cut diagonally or twisted off. The longer stems were bent double. The stem segments were very light in weight. The periderm is thick and very soft and possesses numerous deep longitudinal fissures. The bark is easily separated from the wood and is from tan to brown in color. The wood is light gray. There are occasional white patches of fungal growth on the periderm. The stems are rarely branched. The fracture is complete, brittle, and splintery. The severe drying that this material had been subjected to resulted in some breaking down of tissues and in considerable shrinkage.

**Stem Histology.**—In transverse section the arrangement of the vascular tissue is indicative of an abnormal woody dicotyledonous stem (Fig. 1). The periderm is layered and is fairly thick. Directly within the periderm lies a sclerenchymatous pericyclic zone made up of lignified cells arranged in an unbroken ring. The phloem consists of dome-shaped patches separated by large fan-shaped rays. The cambial zone is somewhat irregular, for it curves inward at the radii of the xylem rays. This results in a wavy general appearance. The xylem consists of wedge-shaped segments as well as broad rays, arranged in a ring. The xylem segments are usually seven in number and are penetrated by later-formed rays in the older stems. This vascular arrangement is known as an anomalous structure. The pith is small and irregular.

The phellem comprises the broadest area of the periderm. This region is layered with alternating light and dark colored layers. These layers are due

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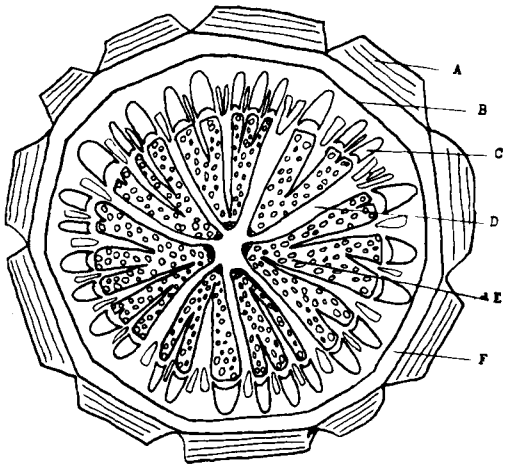


Fig. 1.—Transverse sectional diagram of *Aristolochia triangularis* stem. A, Phellem; B, pericycle; C, phloem; D, xylem ray; E, xylem "segment"; F, phelloderm.

to the variation in the radial dimensions of the cells. The light colored layers are composed of cells, each with a broad radial dimension. The more compact zone is composed of cells, each with a short radial dimension. These phellem layers are not uniform in width throughout. The phellem cells are laid down in radial rows and vary from large, nearly cubical cells to small cells that are nearly rectangular when viewed in transverse section. The cell walls are thin and often wavy. However, the outer walls of the cells are generally thicker than the radial and inner walls. The cells of the phellem contain a large amount of dark brown extractive matter.

The phellogen zone is fairly distinct and is characterized by somewhat compressed rectangular thin-walled cells arranged in radial rows. It is a narrow zone of only a few cells in width.

The cells of the phelloderm are arranged in radial rows and are tangentially elongated. These cells are relatively thin walled. Stone cells are also abundant in this region. These cells are scattered, or are found singly, or in clusters of from two to five cells. These stone cells are tangentially elongated and are characterized by having thick, lignified secondary cell walls with simple pits and branching pit canals. Secretory cells are found scattered throughout the phelloderm. These cells are three to four times larger and less elongated and possess walls that are thin but more sharply defined than the other parenchyma cells of this tissue. The secretory cells contain usually one globular, yellow-orange body, presumed to be oleoresinous.

The inner border of the periderm lies adjacent to an unbroken band of sclerenchyma cells averaging between five and eight cells in breadth. This pericyclic band exhibits two types of cells. That is, it is made up of a band of small, nearly isodiametric, compactly arranged stone cells that is often interrupted by patches of thin-walled fibers. When viewed longitudinally, the pericyclic fibers are seen often to possess septations. The thin walls of the fibers take only a light lignin stain, and have small, oval to slit-like, simple pits. The fibers are long and narrow, and have blunt, tapering ends. One average-sized septate fiber was found to be 1140 $\mu$ long with an average width of 27 $\mu$. The stone cells of this region are small and possess thick, heavily lignified walls. Starch grains are rarely observed in the pericyclic sclerenchyma cells.

Stone cells are abundant in the phloem patches, but phloem fibers are absent. The stone cells are found in groups or are scattered. These stone cells possess heavily lignified thick walls. The stone cells in the phloem are fairly isodiametric with four to six sides and a somewhat rounded outline, except those adjacent to the cambial zone, where they are elongated. These are generally three to four times longer than they are wide, with their long axes in sections at right angles to the radius. These elongated stone cells are thinner walled than the scattered stone cells and they possess larger lumina. Furthermore, they are sharply rectangular in outline and are arranged in compact tangential rows, two to four cells in width. The cell walls exhibit numerous simple pits with unbranched pit canals.

Many secretory cells are present, scattered among the cells of the phloem. The secretory cells are large, thin walled, cubical cells with fairly regular outlines. They contain yellow-orange globular cell inclusions.

Phloem parenchyma cells and sieve elements are scattered, and they are indistinct in outline because of the extensive drying to which the material has been subjected. The large fan-shaped rays that separate the phloem patches contain numerous stone cells. These stone cells are thick walled and sharply rectangular in outline when examined in transverse section. The stone cells in the proximity of the cambial zone are more elongated and are arranged end to end in rows which follow the general contour of the phloem rays. The scattered stone cells of the phloem rays are usually situated with their long axes in a radial plane. The ray parenchyma cells contain starch grains more commonly than do the parenchyma cells of the phloem patches. Rarely, small druses are found in the phloem parenchyma.

The cambial zone dips inward between the xylem wedges, and this gives a scalloped appearance in transverse section to the wood region. The cambial zone is composed of a few rows of delicate compressed cells.

The fluted xylem, that is typical of *Aristolochia* and *Menispermum* and of some other vines, is due to abnormal secondary xylem formation. The xylem tissue of *A. triangularis* is divided into wedge-shaped segments, usually seven in number. These segments are often dichotomously divided by the formation of later formed rays. The number of later formed rays increases with the age of the stem. The xylem wedges of the young stems exhibit few of these later formed rays, whereas these rays become increasingly numerous in the older stems until the outer region of the xylem is composed of nearly equal, alternating areas of xylem wedges and rays. Growth rings are not evident.

Two general sizes of vessels are present. The more prominent size is up to 300 $\mu$ in diameter. The vessels are numerous and are distributed uniformly throughout the xylem segments. The wood is therefore ring-porous. The vessel members

(elements) here are as broad as or broader than they are high. Vessels with smaller diameters are more numerous. The members of these vessels are more elongated, being two to four times as high as they are wide. These members possess nearly transverse end walls that are characterized by large single pores. The side wall pitting is profuse. The pits are reduced and bordered, varying from large oval pits with distinct borders to small slit-like pits with indistinct borders. Tyloses are present in some vessels of the older regions of the xylem. Occasionally the lumina of some vessels are completely filled by the tyloses. The tyloses are commonly lignified and possess many simple pits that vary from small and slit-like to large and circular.

Full-bordered pit-pairs between vessels as well as between vessels and fibers appear in face view as circles, each enclosing a cross. A longitudinal section showing a vessel wall junction reveals that the pits have small lenticular pit cavities and broad pit canals leading into the cell lumina. These are somewhat similar to the bordered pits of the conifers but they are much reduced.

In transverse view the numerous fibers appear angular in outline, while in longitudinal view they are usually long and tortuous, and they possess characteristically tapering ends. For the most part these fibers have walls that are approximately one-sixth as thick as the cell is broad. This was determined from examination of macerated material. These narrow fibers are, on the average, 1 mm. long. On their side walls they possess many slit-like pits with indistinct borders.

The presence of primary xylem is evidenced by the presence of vessels with annulo-spiral wall thickenings. The primary xylem elements are found on the inner extremities of the xylem wedges adjoining the pith area.

Sparsely scattered wood parenchyma cells occur both singly and in small clusters. These cells are relatively large. They are elongated up to eight or ten times their width. In macerated preparations they often show a distorted outline. The walls of these cells are thickened and lignified. Numerous round or oval simple pits occur in the walls. Even on the same wall these pits vary considerably in size. Small clusters as well as single, very small starch grains are commonly found within these cells.

According to Schenke (3) there are eight initial xylem rays extending from the cambium to the pith. In this investigation seven rays were found to be the more common number. The formation of younger rays divides the initial xylem segments as the stem increases in age. Many older stems show equal, alternating areas of ray and xylem wedge areas in the proximity of the cambial zone.

Ray parenchyma cells, secretory cells, and stone cells are present in the xylem rays. The parenchyma cells are thin walled and rectangular in longitudinal section. In transverse section they appear slightly elongated radially. Stone cells are usually found scattered through the deeper third of some of the rays near the pith. These stone cells are nearly isodiametric and most commonly occur singly, although occasional clusters of two or three are present.

The secretory cells found in the xylem rays are much larger than the ray parenchyma cells. They possess thin but clearly defined walls. Most of them contain a globular, yellow-orange body. These secretory cells are scattered and are not so numerous as the ray parenchyma cells, and they are generally larger but less elongated.

Starch grains are more abundant within the ray parenchyma cells than within any other cells of the xylem.

Crystals in the form of small druses and, rarely, prisms are often present as cell inclusions in the xylem ray cells. Druses of very fine crystals and irregular prisms are not commonly situated within the parenchyma cells bordering the fibers of the xylem. Commonly, only one crystal is present within a single cell, but near the pith region more are sometimes present.

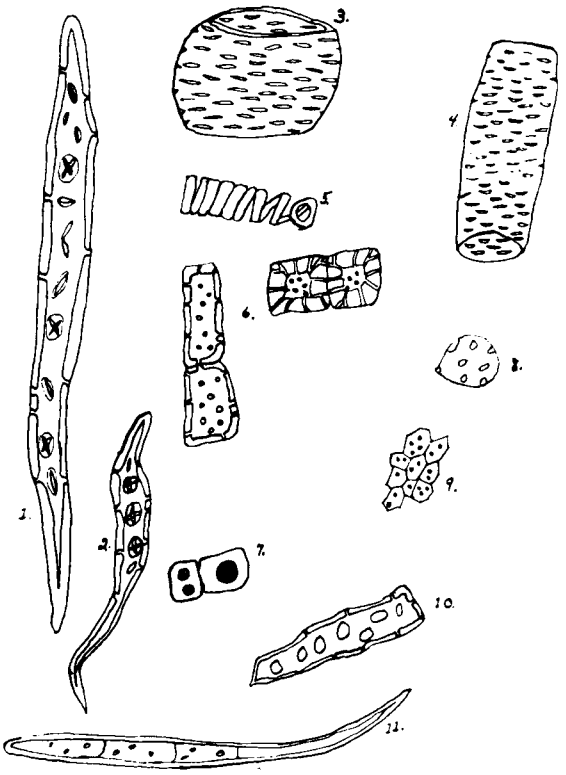


Fig. 2.—Elements of macerated and powdered *A. triangularis* stem. 1 and 2, Wood fibers; 3 and 4, vessel elements; 5, spiral element; 6, stone cells; 7 secretory cells; 8, tyloses; 9, periderm cells; 10, wood parenchyma; 11, septate pericyclic fiber.

The pith area is relatively small and it is irregular because the inner portions of the xylem wedges are not equidistant from the center of the stem. It is composed of typical thin-walled parenchyma cells with coarse simple pits. The cells are loosely arranged. Stone cells occur both singly and scattered in small clusters. They are fairly isodiametric, thick walled, and heavily lignified. Crystals occur more abundantly in the pith than in other tissues of the stem. These crystals are coarser than those of other tissues. They are prismatic or diamond-shaped, and are thin.

**Powdered and Macerated Material.**—Stem seg-

ments were broken and then ground in a drug mill. The resulting powder was screened through a 40-mesh screen. This resulted in a homogeneous brown powder with no odor.

Other portions of stem material were treated according to the Schulze maceration process. Stem segments were cut into thin longitudinal slices and were put into a beaker. A mixture of one part nitric acid and three parts water was added, and this was followed by a few crystals of potassium chlorate. The beaker was then warmed until bubbles and yellow fumes arose from the liquid. The reaction was allowed to continue until the pieces of wood became white. The material was then removed, washed with running water, and shaken with glass beads to dissociate the cellular elements. Microscopic examination of the powdered and macerated materials revealed the following (Fig. 2): in mounts of the powder, fragments of xylem are prominent. These are composed mostly of clusters of wood fibers and some small vessels. Fragments from the walls of the larger vessels are fairly numerous. Occasional tyloses lignified with numerous large simple pits are present. These have been separated from the walls of the older, large vessels. Fragments of periderm are easily detected because of the characteristic thin and wavy-walled cells of the phellem. Fragments of parenchyma tissue from the rays, pith, and phloem are present. Secretory cells are often present in the parenchymatous tissue fragments. There is usually only one yellow-orange body within any single secretory cell. Occasionally these cell inclusions are found separated from the secretory cells. Stone cells are either associated with parenchyma tissue or they are discrete. There are two general types of stone cells. One type is nearly isodiametric and thick-walled. The other type is elongated. A few small starch grains are present which vary from 3 to 5 $\mu$ in diameter. They are angular and possess a faint oval eccentric hilum. Occasional fragments as well as whole crystals are present as rectangular and diamond-shaped platelets and prisms.

Large barrel-shaped vessel elements are readily seen in macerated material. They show numerous bordered pits on their side walls. The pits vary from small slits to large ovals, within rounded borders. The end walls are nearly transverse, each with a single large pore. Many of these large vessels measure up to 300 $\mu$ in diameter and are sometimes broader than they are high. One vessel element was found to be 340 $\mu$ broad by 290 $\mu$ high. The smaller vessels are not nearly so broad, and they are commonly two to four times higher than they are broad. Xylem fibers are thick-walled and are, on the average, 750 $\mu$ long by 25 $\mu$ wide. They are commonly tortuous and possess numerous slit-like bordered pits. Less common are the thin-walled septate fibers of the pericycle. These average a little over 1000 $\mu$ in length by 25 to 30 $\mu$ in width. They have small, rounded, simple pits on their thick walls. Stone cells are numerous. An elongated stone cell of average size measures 100 by 36 $\mu$. The other type of stone cell is more nearly isodiametric, thicker-walled, and possesses branching pit canals. The lumen is much smaller in the latter type. Small segments of phellem tissue are present, as are some thin-walled parenchyma cells.

## *CASEARIA SYLVESTRIS* SWARTZ

**Description of the Plant.**—*Casearia sylvestris* Swartz, family *Flacourtiaceae*, occurs as a shrub or tree that ranges from 3 to 20 meters in height. It is indigenous to the West Indies and to Central and South America. The genera *Hydnocarpus* and *Taraktogenos*, some species of which yield chaulmoogra oil, are also members of this family.

According to Standley (4) the branches of this tree are slender and bear simple alternate leaves that are usually entire. The leaves are glabrous or nearly so with lanceolate to lanceolate-oblong outlines and acute apices. They are from 6 to 10 cm. in length by 2 to 3 cm. in width, and they are thin and densely pellucid-punctate.

Small greenish-white flowers of this plant are borne in umbels on pedicels which are 2 to 4 cm. The fruit is small and obovoid and is 3 to 4 cm. in length.

The pale yellow wood of the tree is hard, heavy, and compact. The tree is used as a source of lumber in Cuba.

Many common names have been given to this plant in the countries of its origin. Some of these are as follows: *comido de culebra*, Nicaragua; *cafeillo cimarron* and *laurel espada*, Puerto Rico; *sarne de perro*, Cuba and Puerto Rico; *rompe-hueso* and *sarnilla*, Cuba.

**Crude Drug.**—The part used is the stem bark which occurs as curved chips up to 6 inches long. Usually the pieces are not nearly so wide as they are long and they are, on the average, $^1/_4$ inch in thickness. The convex outer surface is brownish-tan with a scaly appearance caused by the sloughing off of small platelets of periderm. Small white areas of fungal growth and some adherent moss and lichens are sometimes evident. The fracture is complete, short, and sharp. The broken transverse surface shows narrow alternating tangential layers of light-brown sclerenchyma tissue and dark brown nonlignified tissue. The concave inner surface is grayish-tan. It is smooth except for slight longitudinal striations. Small white areas of fungal growth are rarely present on this surface. The odor is slightly musty.

**Histological Data.**—Beneath a thin layer of periderm are alternating strata of nonlignified and of lignified cells. There are numerous, but narrow, phloem rays present. Because of the nature of this material, its histology is essentially that of secondary phloem. The amount of periderm tissue present is usually slight (see Fig. 3).

The phellem is $^1/_8$ inch thick, on the average, and varies from 6 to 20 cells in thickness. The inner and radial walls of these cells are thickened and lignified. They are narrow, tangentially elongated cells with small lumina and are arranged in definite radial rows. The phellogen is indistinct and no phelloderm can be demonstrated. The later formed periderms arise in the outer regions of the secondary phloem, and this results in the sloughing off of the outer tissue in some areas.

The lignified layers of the phloem are made up predominately of stone cells that are elongated vertically. These cells are one and one-half times as high as broad. Tangential bands of stone cells course through the phloem in a regular manner with only occasional dividing or joining. Because the

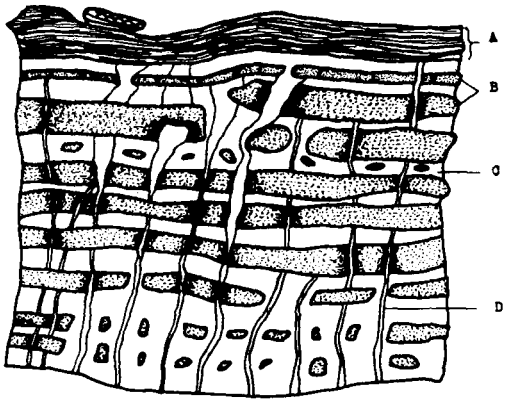


Fig. 3.—Transverse sectional diagram of *Casearia sylvestris* bark. A, Periderm; B, stone cell strata; C, parenchymatous stratum; D, phloem ray.

cells of these areas are very similar in size and shape, they form a regular pattern of rows both tangentially and radially. This pattern is referred to as a "storied arrangement." In transverse section the stone cells of these bands possess fairly regular outlines and have thickened, heavily lignified walls. The walls are densely pitted with simple pits and have unbranched pit canals. The majority of these stone cells contain a single large crystal that often completely fills the cell lumen. The strata of stone cells vary from 2 to 25 cells in radial dimension. The strata are continuous in the inner region of the phloem, but they become increasingly discontinuous in the regions nearer the periderm. These discontinuous strata of lignified cells are interrupted by phloem ray cells and by other cells of the nonlignified strata. Included in the lignified strata are also definite aggregations of nearly isodiametric stone cells. These stone cells are thicker-walled than the other stone cells of the strata and they possess branching pit canals but they rarely contain crystals. Similar stone cells are occasionally found singly or in small clusters among the cells of the nonlignified strata. These cells are infrequently found in the lignified strata. These cells are five to eight times longer than wide, with walls about $^1/_6$ as thick as the cell is wide. Each possesses a broad lumen. One end wall is often oblique, and the other end wall is at a right angle to the longitudinal walls. All the walls of these cells possess numerous simple pits with branched pit canals.

The outermost stratum of lignified cells is made up of thinner-walled stone cells with larger lumina and fewer crystals than the stone cells of the inner strata.

The strata of nonlignified cells are composed of phloem parenchyma, sieve elements, ray parenchyma, and sparsely scattered stone cells. The sieve tube elements are thin-walled and possess oblique end walls. Their sieve plates are compound as seen in a radial longitudinal view. The phloem parenchyma cells are numerous. In longitudinal section these cells are seen to be from two to three times as high as they are broad. In transverse view these cells appear nearly square in outline.

The phloem rays are very numerous and their regular arrangement is often interfered with by the stone cell strata. Rays vary from two to five cells in width at an expanded middle portion, and they commonly possess a many-celled elongation on the top and on the bottom that is evident in tangential sections. These elongations of the rays are one cell in width. The ray cells vary in size, and each exhibits a rounded outline in a tangential view.

Starch grains occur in small clusters within some of the phloem parenchyma cells and rarely within the ray parenchyma cells. They are two- to four-compound.

**Powdered and Macerated Material.**—The chips of bark were ground in a drug mill and the powder was then put through a number 40-mesh sieve. The resulting powder was homogeneous and light tan in color, with no noticeable odor. Material prepared by the Schulze maceration process was also examined. The following elements were observed during a microscopic examination (see Fig. 4).

The most prevalent element present is the crystals. These crystals are greatly varied in shape and give a play of colors with polarized light. Some of the crystals still remain within the stone cells. Stone cells are very numerous. These occur singly and in clusters. The clusters are most commonly composed of one or more rows of cells. Solitary crystals are usually present in the lumina of the stone cells in these rows. Two types of stone cells are present. Thick-walled nearly isodiametric stone cells are present. They possess branching pit canals and

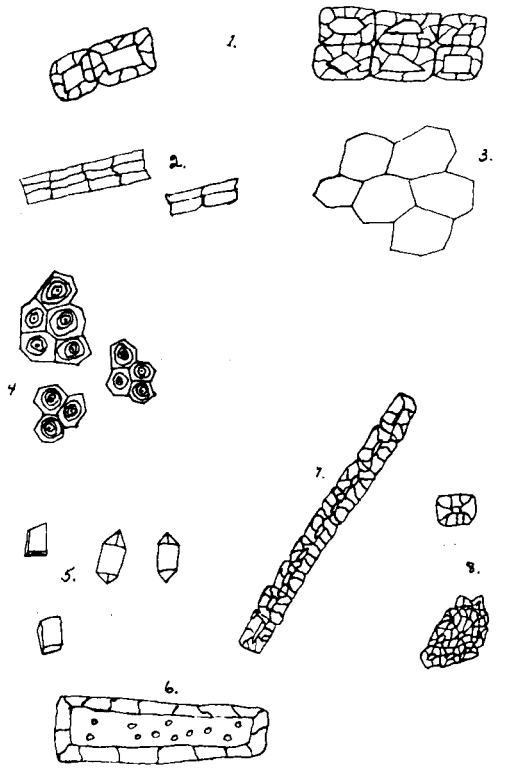


Fig. 4.—Elements of macerated and powdered *C. sylvestris* bark. 1, Crystal-bearing stone cells; 2 and 3, periderm fragments; 4, starch; 5, crystals; 6, elongated stone cells; 7, row of stone cells (crystals lacking); 8, stone cell cluster.

small lumina. These are, on the average, 30 μ in diameter. The thinner-walled stone cells are elongated. They average from 50 to 60 μ in length by 25 to 30 μ in width. These cells have unbranched pit canals and many simple pits. Their lumina are often angular because of the crystals that completely fill them. Clusters of phloem parenchyma cells and sieve elements are also found. Fragments of phellem are composed of narrow, tangentially elongated cells of about 10 by 30 μ. Phellem fragments in surface view appear as clusters of three- to six-sided cells. In macerated preparations they appear rounded, with clear, refractive cell walls and nonrefractive lumina. Small angular starch grains are present in small numbers. They occur commonly as three- to many-compound grains. The individual grains are, on the average, 3 to 4 μ in diameter. They possess tiny, faint, central hila and concentric lamellae.

## *SCHINOPSIS BALANSAE* ENGLER

**Description of the Plant.**—*Schinopsis balansae* Engler is an anacardiaceous tree attaining a height of from 10 to 20 meters, indigenous, according to Cabrera (5), to the hot, dry forests of the southern Matto Grosso in Paraguay and northeastern Argentina.

Engler described the plant in 1885 (6). The bark of the trunk is ash gray in color and the wood is dark red and very hard. The young branches are light gray and sometimes possess sharp spines that are stout and straight, and from 1 to 2 cm. long. Simple leaves are borne alternately, and the twigs have short internodes. Each leaf possesses a semicylindrical petiole varying from 4 to 10 cm. in length. They are coriaceous, glabrous, and oblong to oblong-lanceolate. Their apices are very short and mucronate. The margins are entire and somewhat undulate, and the obtuse bases are rounded. The midrib is reddish, thick, and hard. There are numerous thin, but prominent, lateral veins. The leaf is from 4 to 8 cm. long by 1.5 to 2 cm. wide. The flowers are borne in terminal, pyramidal panicles having a length of 6 to 7 cm. Bractioles of the panicles are concave and ciliate, and about 1 mm. long. The pedicels are slightly pubescent. The fruit is a lustrous and woody single samara. It is knife-shaped and possesses an ovoid "seed body."

Leaves of this plant contain a considerable amount of a catechol-type tannin that is water soluble and that gives a dark green color with ferric chloride solution.

According to Youngken (7), the dried heartwood of *Schinopsis balansae* Engler and *S. lorentzii* (Grisebach) Engler are the sources of *Quebracho Colorado* which has been valued for its high tannin content. The name *Quebracho* means "axe-breaker." Therefore, the name *Quebracho Colorado* means "red axe-breaker wood." *Quebracho Colorado* is not related to *Quebracho blanco* which refers to the bark of *Aspidosperma quebracho-blanco* Schlectendal, family *Apocynaceae*. Preparations of the last named bark were once used as respiratory stimulants.

Cabrera (5) reports that the natural range of *S. lorentzii* borders on the north of that of *S. balansae*. The simple leaves of *S. balansae* enable one to distinguish this species easily from *S. lorentzii*, which possesses imparipinnate leaves, each with 7 to 15 leaflets.

**Histological Data.**—As seen in transverse section, the arrangement of tissues of the lamina is indicative of a bifacial leaf. The midrib area is somewhat semicircular in this view, the dorsal side of the midrib being more prominent than the ventral side (see Fig. 5).

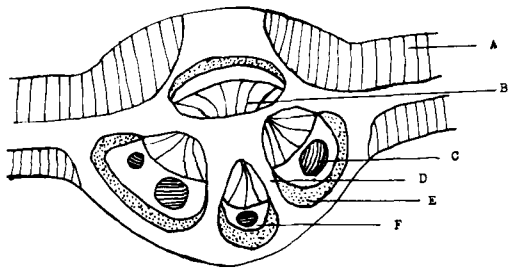


Fig. 5.—Transverse sectional diagram through the midrib of *Schinopsis balansae* leaf. A, Palisade zone; B, xylem; C, secretory canal; D, parenchyma; E, sclerenchyma fibers; F, phloem.

The upper epidermis of this leaf consists of a single layer of cells which are rectangular in outline. Their outer walls and the outer third of their radial walls are considerably thickened. In many instances these epidermal cells have lignified walls. There is a very well developed cuticle present. Stomates are present in about the same number as in the lower epidermis. The neighboring cells in this view appear somewhat L-shaped, with the base of the L forming a flange upon which the guard cells are situated.

Palisade cells are oriented with their long axes perpendicular to the epidermis. The palisade cell regions are each composed of from two to three layers. The palisade zones constitute three-fourths of the mesophyll of the lamina. The palisade regions are separated by a narrow region of fairly compact spongy mesophyll cells.

The lateral veins possess well developed bundle sheaths. The sheaths of the small veins are parenchymatous. Those of the larger veins are sclerenchymatous and they extend to both epidermises. A small group of fibers whose walls are thick and slightly lignified is usually associated with the phloem of the bundle. A single secretory canal is commonly present within the phloem of these large veins. Prismatic or diamond shaped solitary crystals are found in many of the cells of the bundle sheath. Characteristically large, coarse druses are sometimes present within the bundle sheath cells of the small veins.

The cells of the lower epidermis are very similar to those of the upper epidermis.

The epidermal cells of the midrib are about one-third the size of those on the rest of the leaf blade, but they are of similar shape. The palisade region within the upper epidermis extends into the midrib from each side to a distance of about one-third of the width of the midrib region. Beneath the upper epidermis of the midrib and between the palisade cell regions is an area of well developed collenchyma tissue. The most striking characteristic of the histology of this leaf is the arrangement of the

vascular tissue in the midrib. It is arranged in a broken semicircle of five vascular strands. Two inverted strands with the phloem regions toward the upper epidermis are situated ventrally, the other three strands are oriented with their phloem regions toward the lower epidermis. These strands form an arc under the upper strands. The secondary development of the xylem is fairly extensive, whereas the phloem region is not as well developed. The cambium of the bundles is indistinct.

Secretory canals are present within the phloem regions of the three lower vascular strands of the midrib and rarely within those of the upper vascular strands. From two to three canals occur within the two lateral strands, and one canal is found in the lowest strand. The content of these canals is presumed to be oleoresinous (see Fig. 5).

Transverse sections through the midrib at the base of the lamina show five vascular strands. Similar sections cut close to the apex show but one strand.

The center of the midrib is composed of parenchyma cells with thickened lignified walls that are marked by round simple pits. Narrow zones of parenchyma cells radiate out between the vascular strands and encircle the stele. Between this parenchymatous region and the lower epidermis is an extensive area of collenchyma. Many of these cells contain solitary crystals that vary from diamond-shaped to prismatic.

A region of thick-walled fibers is associated with the phloem region of each vascular strand. Commonly only the outer walls of these cells are lignified.

In surface sections of the lamina the epidermal cells present a fairly regular outline although the cell walls are irregularly thickened. Patches or small areas exhibit epidermal cells with lignified walls. These areas have no definite pattern. The lignified walls of these cells possess simple pits. Stomates occur about equally in each of the two epidermises. The guard cells of the stomates are surrounded by narrow neighboring cells. The number of neighboring cells is seven, on the average, but varies from a minimum of five to a maximum of nine. There are usually two neighboring cells along each side of the paired guard cells, two neighboring cells at one end of the pair, and only one at the other end. Rows of crystal-bearing cells accompany most of the veins. Such rows are parallel to the veins with which they are associated. The crystals are commonly diamond shaped or prismatic. Occasional one-celled, appressed, nonglandular hairs are associated with the epidermal cells of the midrib and of the larger lateral veins. These hairs are thick-walled and possess narrow lumina that extend about one-half the length of the hairs. The bases are only slightly enlarged. The hairs vary from about 35 to 90 $\mu$ in length. The average length of these hairs is approximately 60 $\mu$ and their bases are about 13 $\mu$ wide.

In transverse sections of the petiole one can see five leaf traces entering the base of the petiole. These traces are arranged in the semicircular pattern (see Fig. 6). There are three traces in an arc and their phloem regions face the lower epidermis. There are two small ventral traces across the top of the arc, and they are inverted so that their phloem regions face the upper epidermis. The xylem regions of the traces are separated by regions of

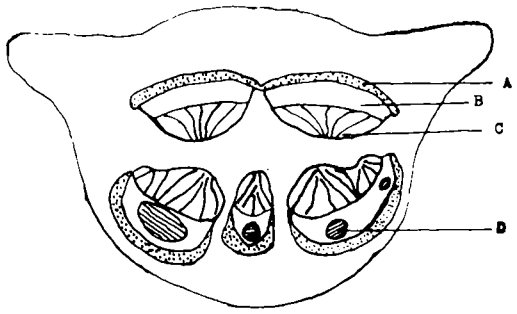


Fig. 6.—Transverse sectional diagram of *S. balansae* petiole. A, Sclerenchyma fibers; B, phloem; C, xylem; D, secretory canal.

parenchyma cells. The central portion of the midrib is composed of parenchyma cells whose walls are thickened and lignified. These cells are relatively large and have conspicuous intercellular spaces. In the phloem region of each of the three dorsal traces one or more secretory canals are situated. Each of the five traces possesses a definite sclerenchymatous cap of thick-walled fibers. The walls of these fibers seldom are lignified. Collenchyma is extensively developed between the vascular tissue and the epidermises. Many of these collenchyma cells contain crystals of the types found in the midrib. Crystals are sometimes found also within

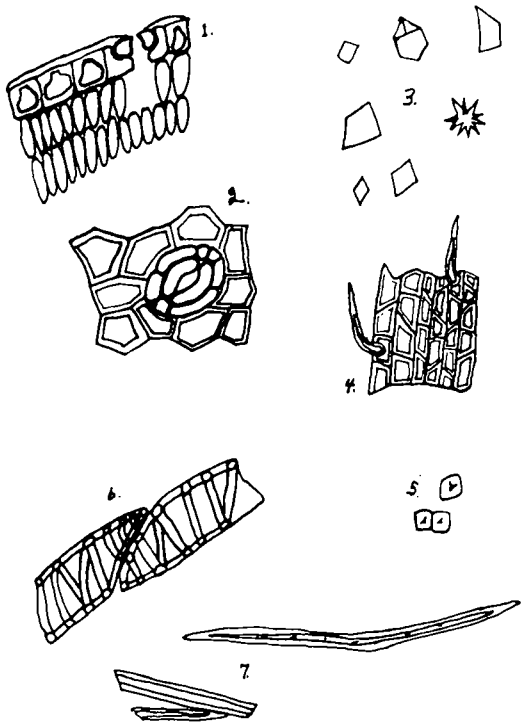


Fig. 7.—Elements of macerated and powdered *S. balansae* leaf. 1, Epidermal fragment with stomate and attached palisade cells; 2, epidermal fragment in surface view; 3, crystals; 4, hairs on epidermal fragment of petiole or midrib; 5, starch grains; 6, xylem elements; 7, sclerenchyma fibers.

the cells of the phloem regions and within the parenchyma cells in the center of the midrib.

Some slightly developed periderm can be found to have replaced the epidermis in scattered areas on the dorsal surface of the petiole base. It is formed from the subepidermal layer. Nonglandular hairs of the type found on the midrib are occasionally present on the dorsal surface of the petiole. The petiole has a normal clasping base. A short distance from the base the petiole becomes semicylindrical with the ventral side flattened. Its firmness is due to the extensive development of collenchyma tissue.

**Powdered Material.**—A sample of dried leaves was crumbled and then was screened through a 40-mesh sieve. The resulting powder was greenish and possessed a very slight musty odor. The following elements were observed in microscopic examination (Fig. 7): fragments of epidermis from the lamina are prevalent. The epidermal cells are polygonal and possess thick walls when seen in surface view. Occasionally some of the walls of the epidermal cells are lignified. Stomates are prominent in these epidermal fragments. The guard cells are long and elliptical. The number of neighboring cells varies from five to nine but is, on the average, seven. There are usually two neighboring cells along each side of the paired guard cells, two neighboring cells at one end of the pair, and only one at the other end. Fragments of mesophyll tissue are commonly associated with epidermal tissue.

Fragments of epidermis from the midrib and the petiole are composed of cells that are smaller than those found on the lamina, and these are arranged in rows with their end walls sometimes oblique when seen in a surface view. These epidermal cells have thick, but nonlignified, walls. No stomates are present in this tissue. One-celled, appressed, nonglandular hairs are often present on these fragments of epidermal tissue.

Broken clusters of thick-walled fibers with sparse, small, simple pits are present. Sometimes crystal-bearing cells accompany these fibers.

Fragments of xylem elements show spiral wall thickenings or scalariform pitting.

Occasional tissue fragments contain portions of the secretory canals with an amorphous red-brown content. Fragments of collenchyma tissue made up of cells with characteristic unevenly thickened walls are present. These cells are elongated. Crystals are a prominent element. They occur as fragments and as entire prisms, rarely as druses. The prisms are on the average 15 $\mu$ long. Starch grains are not common, but some do occur as simple or two-compound grains with diameters of from 4 to 5 $\mu$.

## SUMMARY

This paper contains reports on the histologies of the stem of *Aristolochia triangularis* Chamisso, the bark of *Casearia sylvestris* Swartz, and the leaf of *Schinopsis balansae* Engler. The following characteristics are noteworthy.

1. *Aristolochia triangularis* stem. This stem exhibits an anomalous vascular structure. The wood is diffuse porous. Wood parenchyma is sparse and diffuse. Thick-walled wood fibers are abundant. Stone cells occur scattered in the broad xylem rays. Some of the vessels contain tyloses. Some of the ray and pith cells contain prismatic and thin diamond-shaped crystals. The fan-shaped phloem rays consist, in part, of stone cells. The pericycle consists of stone cells and fibers. The extensively developed phellem is deeply fissured.

2. *Casearia sylvestris* bark. This bark consists mainly of secondary phloem, only a small amount of periderm being present. In the phloem numerous tangential bands of stone cells alternate with bands of nonlignified cells. Most of the stone cells contain crystals. The crystals are prismatic, nearly rectangular, or diamond-shaped. Sieve tube elements possess compound sieve plates on their radial walls. The small starch grains are usually two- to many-compound. Two types of stone cells are present. No fibers are present.

3. *Schinopsis balansae* leaf. This leaf possesses a well developed cuticle and the stomates are rather evenly distributed in the two epidermises. Stomates most commonly have seven neighboring cells. In scattered areas of the epidermis the cell walls are lignified. The lamina exhibits a bifacial structure. The midrib exhibits five vascular strands arranged in a semicircle. The two upper strands are inverted. The phloem areas of many vascular strands possess secretory canals. Fibers that accompany vascular strands are often nonlignified. Coarse druses and prismatic crystals are often associated with the vascular strands. Appressed nonglandular hairs are sometimes present on the dorsal surface of the petiole.

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