SARCANDRA IRVINGBAILEYI, A NEW SPECIES OF VESSELLESS DICOTYLEDON FROM SOUTH INDIA

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The re-establishment of the generic rank of *Sarcandra* Gardner (1846) of the Chloranthaceae as distinct from the genus *Chloranthus* Swartz (1787) of the same family has been proposed in a recent publication (Swamy and Bailey, 1950). In this contribution are also provided arguments that warrant such a taxonomic re-adjustment. In the course of assembling material for a detailed investigation of the comparative anatomy, morphology, and systematic relationships of the Chloranthaceae, which is in progress, herbarium specimens collected from South India and Ceylon were found to differ markedly from the two recognised species of the genus *Sarcandra*, *S. glabra* (Thunb.) Nakai, and *S. hainanensis* (P'ei) Swamy and Bailey.

There appears to be an opinion in some quarters that the vesselless dicotyledons are a small and insignificant group that lack evolutionary diversification. Although *Trochodendron*, *Tetracentron*, and *Amborella* are the only three genera that are represented by a single species in each genus, they exhibit among themselves a high degree of exomorphic diversification in regard to vegetative and reproductive structures. The nearly 88 species of the Winteraceae are spread in six genera and the smallest genera of the family (*Pseudowintera* and *Exospermum*) contain two species in each; three other genera, from six to 30 species; the genus *Drimys* includes 40 species and 12 varieties in two distinct taxonomic sections. Geographically, the vesselless dicotyledons at present have a wide distribution,—Australia, Malaysian Islands, Malay Peninsula, India, Central China, and Japan in the Old World, and South America in the New World. Furthermore, recent taxonomic studies, particularly on the flora of China, of Malasia, and other Pacific Islands have provided an excellent illustration of new and remarkably interesting plants coming to light with almost every botanical exploration in these areas. The recent discovery of two more genera of vesselless dicotyledons—*Amborella*, of the Amborellaceae (Bailey and Swamy, 1948) and *Sarcandra*, of the Chloranthaceae (Swamy and Bailey, 1950)—while exemplifying the realization of van Tieghem's (1900) prophecy, gives a sanguine hope of finding still newer and more diversified morphological types in future. Such considerations as these reflect that the vesselless dicotyledons cannot be dispensed away as an insignificant inconsequential group, but they are a flourishing, highly heterogeneous assemblage both in size and in geographic extent.

While annotating the herbarium specimens examined, I have used the following abbreviations: BM—British Museum (Natural History); G—Gray Herbarium; K—Kew Herbarium; MH—Madras Herbarium (Coimbatore); MICH—Michigan University Herbarium; NY—Herbarium of the New York Botanical Gardens; UC—Herbarium of the University of California (Berkeley).

Almost all specimens of this new species that are deposited in American and Indian herbaria have been sectioned and examined. The material for the accompanying illustrations has been selected from *Barber 6033* and *Erlanson 5489*.

Description.

Stem.—The oldest specimen of stem available for sectioning measures 0·5 cm. in diameter and shows a growth of two years (Fig. 13). The termination of the cambial activity towards the end of the first year is marked by a concentric zone of tracheids (two to four radial rows) that present a conspicuously narrow radial diameter (Figs. 8, 9).

Generally, the tracheids are arranged in relatively undisturbed radial series from the primary xylem outwards. When two radial rows of tracheary cells lie adjacent to one another in the region of the primary xylem, the mutually contacting radial walls appear to be placed at an oblique angle in relation to the tangential walls as seen in transections (Figs. 8, 9); however, with the diametrical increase of the secondary xylem, not only a more or less rectangular cross-sectional outline is attained by the tracheids, but also a uniform radial alignment.

The imperforate tracheary cells of the secondary xylem within the first year's growth zone are as long as two millimeters, and the ends overlap those of the vertically adjacent members over an extensive area. These features provide a remarkable similarity to the corresponding structures, not only of other species of *Sarcandra*, but also of other living vesselless dicotyledons,—*Trochodendron*, *Tetracentron*, *Amborella*, and the genera of the Winteraceae.

The tracheids of the first formed part of the primary xylem are relatively narrower in cross-sectional area and possess typical helical thickenings. Those of the metaxylem and of the subsequently formed earlier part of the secondary xylem exhibit larger lumina and predominantly uniseriate scalariform pitting on the radial facets. The successively formed tracheids gradually become narrower again and the intertracheary pits correspondingly assume circular outlines (Fig. 11). The early formed tracheids at the beginning of the second growth season possess approximately the same cross-sectional area as those formed later. However, the inter-tracheary pitting of the early formed tracheids (two to three rows) is scalariform in contrast to the circular bordered pitting of the later formed ones; the tracheids in between these two zones show a more or less transitional series. On the whole, the inter-tracheary pitting is largely confined to the radial walls.

The inter-xylary parenchyma is very scantily developed, a feature that appears to be a general tendency in the other species of *Sarcandra* also (Swamy and Bailey, 1950). Among the specimens of the present species, the one illustrated in this paper (Figs. 8, 9, from *Erlanson 5489*) shows an almost total absence of parenchyma; and *Gamble 18395*, a rather meagre development. In the latter specimen, it is diffusely distributed in the growth layer. As in other species of the genus, as also in *Trochodendron*, *Euptelea* and probably in other dicotyledons, the wood parenchyma cells are arranged in pairs, the total width of a pair being equal to the tangential diameter of the tracheids.

The ray system involves two distinct types of organization. Vertically extensive sheets of parenchymatous tissue of six to eight cells width radiate from the inter-fascicular parts of the eustele and constitute the primary multiseriate rays (Fig. 8). These rays consist wholly of vertically elongate cells as seen in a tangential section (Fig. 10). From the intra-fascicular regions single-celled rows of parenchymatous cells extend towards the periphery as seen in transections (Figs. 8, 9), and these constitute the uniseriate rays. The uniseriate rays are also considerably tall, and the component cells vertically elongate. Occasionally, the body of this kind of ray may be biseriate.

The structures .of the relatively thin bark are badly collapsed due to drying, and the only feature that could be observed is the groups of phloem fibres confronting the fascicular sectors of the secondary xylem (Fig. 8). The periderm takes its origin superficially.

Node.—The decussate phyllotaxy of the young leaves is carried over to the mature condition without alteration. The bases of the petioles of opposite leaves fuse to form a conspicuous vagina-shaped sheath. From the rim of the sheath emerge denticular processes of stipular nature. The petiole contains five vascular strands (Fig. 12), two of them larger and placed in an abaxial disposition; the other three strands are conspicuously smaller and are located alternatingly with the larger. The two larger strands are concerned in the major vascularization of the lamina and usually remain distinct for a greater distance in the costa. The small strand between the larger ones gradually becomes thinner, traverses as far as the middle distance of the costa, and finally either fuses with one of the larger strands, or disappears. The two adaxially situated smaller strands are also rather weakly developed and traverse along the margins to about half the length of the leaf.

At lower levels of the stem, the small, intervening median strand is seen to arise by the fusion of two minor branches of the larger strands. The latter in turn remain separate at still lower levels and ultimately fuse with independent parts of the eustele (Fig. 12). The four smaller adaxially situated strands of opposite leaves also originate independently from four separate systems of the eustele at lower levels of the stem, although the strands (later differentiating as laterals of a corresponding side) of opposite leaves may be fused for a short distance in the axis. Thus it is clear that no vascular strand of the leaf arises as a *dichotomy* of any one single strand of the eustele of the axis, but originates *independently from separate systems.* It should also be noted that of the five leaf strands, the three medians (two larger ones and the intervening smaller one) are related to a single 'gap' and that the two smaller adaxially situated strands to independent 'gaps', a feature sporadically seen with some variations in dicotyledons, e.g., Calycanthaceae, *Nyctanthes*, some genera of the Compositae, etc.

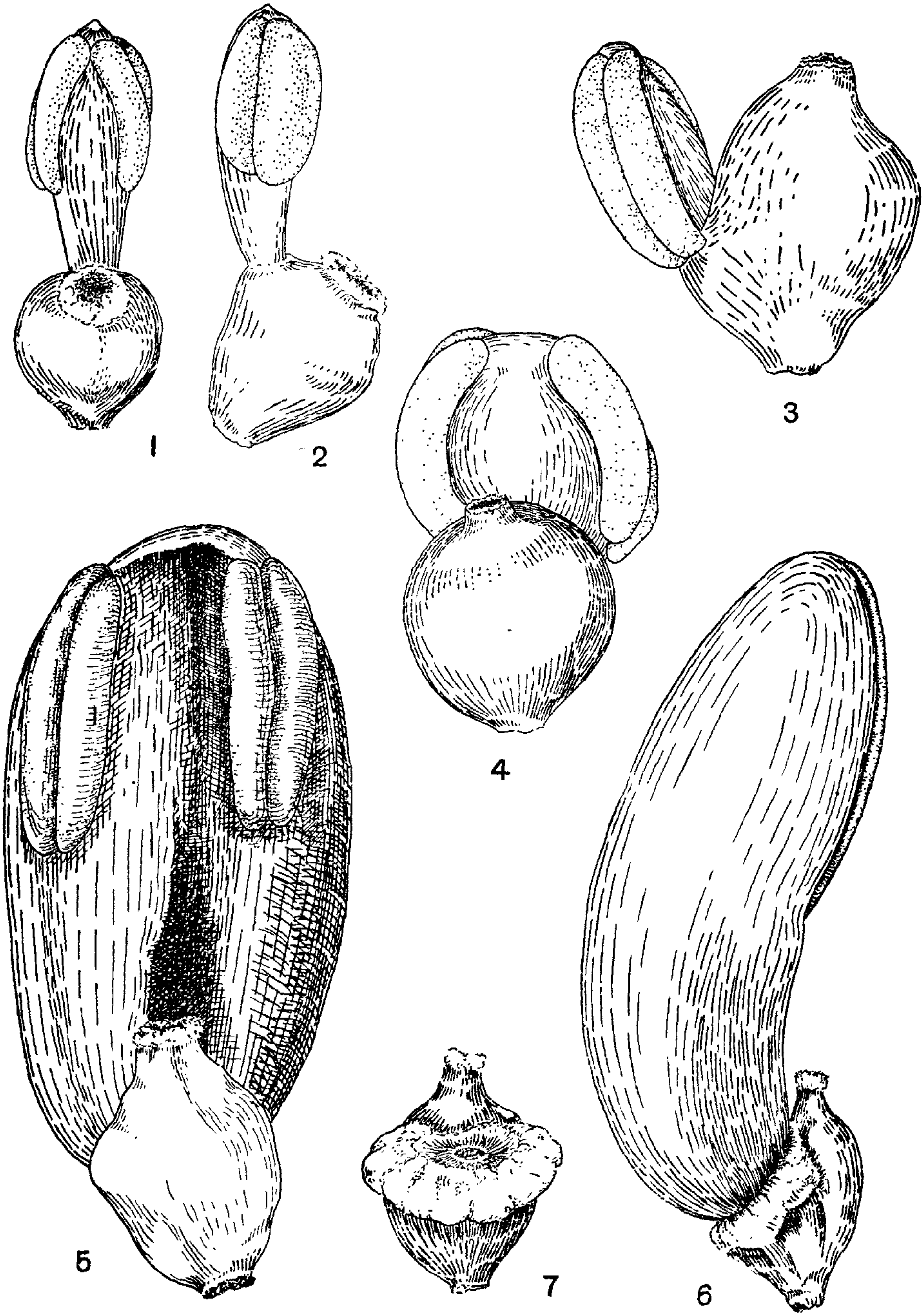
Reproductive structures.—The inflorescence is terminal and consists of three main branches, the median one again giving rise to three branchlets. About 10 flowers are borne on each branch. The flower is naked, sessile, hermophroditic, and is subtended by a somewhat carinate and persistent bract. The solitary urn-shaped carpel lodges a single orthotropous ovule hanging from the apex of the locule. The large fleshy stamen is attached at about the middle height on the abaxial side of the gynoecium (Fig. 6). At the junction of the stamen with the carpel, the latter shows a deformation in the form of a pronounced cushion (Figs. 6, 7). The stamen is oblong, abaxially concave, slightly sickle-shaped. The four thecae are disposed in pairs on the adaxial surface of the microsporophyll towards its distal end, and vertically extend towards the base to about half the distance (Fig. 5). The mature pollen grains are acolpate with a coarsely reticulated pattern of the exine.

The exomorphic characters exhibited by the reproductive structures of the specimens under consideration indicate that these plants are significantly different from *S. glabra* (Thunb.) Nakai and *S. hainanensis* (P'ei) Swamy and Bailey. Therefore, the creation of a new species for the allocation of these plants is warranted. The name and the technical description of the new species may be given as follows:

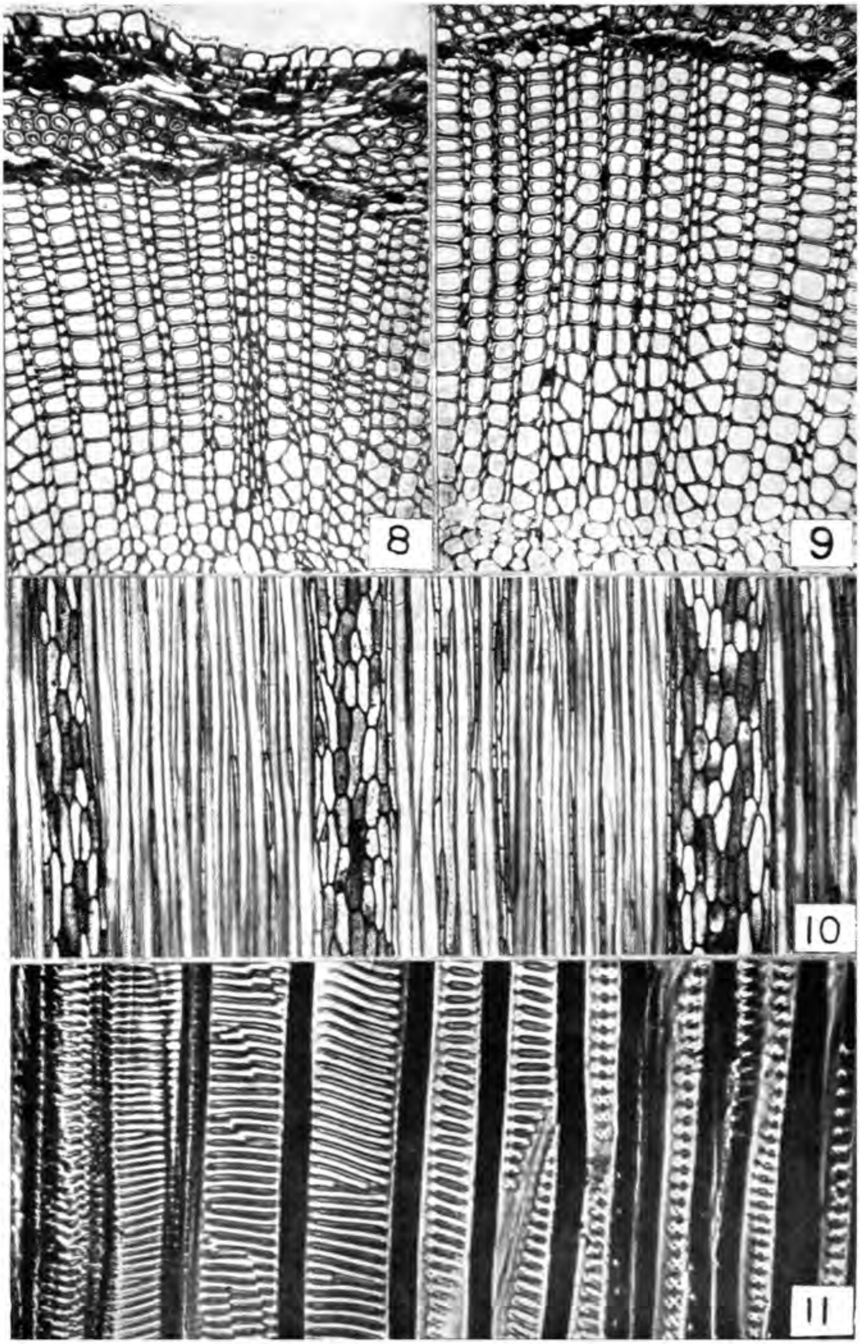
Sarcandra Irvingbaileyi sp. nov.

Sarcandra chloranthoides Wight, in Wight Ic. VI: t. 1946. *1853.* non *S. chloranthoides* Gard. Calcutta Jour. Nat. Hist. 6: 296. *1863* = *S. glabra* (Thunb.) Nakai, Fl. Sylv. Koreana 18: 17. t. 2. *1930.*

Frutex, 1-2 m. altus, glabratus; lignum primarium et secondarium homoxylum; folia opposita, breviter petiolata; petiolus 0·5—1·0 cm. longis, connatis ad basim atque vaginum efformantibus; lamina 6·0 cm.×3·0 cm., 11·5 cm.×4·5 cm. 20·0 cm.×8·0 cm. longa et lata, elliptico-ovata, apice mucronata; base cuneata, margine crasse glanduloso-serrato praedita; stipulae minutae, 1 mm. longae, lanceo-



FIGS. 1–7.



FIGS. 8–11.

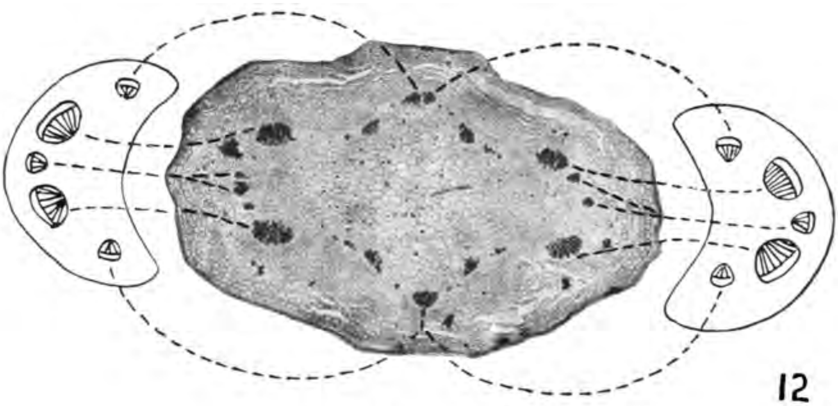


FIG. 12.

FIG. 13.

latae. Inflorescentia terminalis, panniculata, pedicellis primariis tribus, quorum inedius in tres interum dividiter; spicae singulae 2·0–2·5 cm. longae; bracteae singulae, 1·5–2·0 mm. longae, carinatae, persistentes ad rachedem horizontalis; flores hermaphroditi, sessiles; perianthium nullum; stamen 1, oblongum, in facie adaxiali concavum, in facie abaxiale convexum, amplum et carnosum, 4·5–5·0 mm. longum, 1·75–2·5 mm. latum, rachidi in facie abaxiale gynoecii insertum, parallelum et paene tangens; sporangia inparibus binis, 1·5–2·0 mm. longa, juxta staminis apicem; pollinis grana acolpata, cum extine crasse reticulato; pistillium solitarium, sessile, plus minusve ovoideum, pulvino prominenti abaxiali in staminis basi; stylus nullus; stigma subcapitatum; ovarii loculi singuli, ovula singula, orthotropa, ab apice loculi suspensa. Fructus non visus.

Specimens examined.

SOUTH INDIA: Madras Presidency, with no specific locality, *Wight 2509* (G).

Travancore State—Ponmudi, Merchiston Estate, edge of jungle, *Erlanson 5489* (MICH., NY.), March 3, 1934, alt. 933 m.

Tinnevelly District—Kalinayalpil, *Barber 3063* (K, MH), June 1, 1901; Kannikatti, *Barber 378* (K, MH), June 6, 1899; Naterikal to Sengalteri, no collector's name, Madras Herbarium No. 44265 (MH), September 24, 1916; Courtallum, ex. herb. *Bourne*, no number, August, 1899.

Madura District—Pulney Mountains, as illustrated in Wight. Ic. VI. t. 1946. 1853.

Coimbatore District—Anamalais, *Beddome 6079* (MH), alt. 666 m.; *Beddome 6710* (MH), alt. 1,000 m.; Udumanparai, *Barber 5856* (MH), May 11, 1903; Shola above Andiparai, *Barber 6033* (MH, TYPE), June 2, 1903; Ibex Hill Shola, Fischer, no number (K), May 24, 1913, alt 1,533 m.

Malabar District—Attapadi Hills, Adumudi Shola, *Fischer 2503* (K), January 28, 1911, alt. 1 000 m.; Wynad, *Beddome 6708* (BM).

Nilgiri District—? Concon Ghat, no specific locality, *Gamble 18395* (K), October, 1886, alt. 833 m.

CEYLON: With no specific locality, *Walker 207* (K); Gammaduva, in the jungle, *Alston 673* (UC), June 6, 1927.

Artificial key for the identification of the putative species of Sarcandra.

Although *Sarcandra Irvingbaileyi* is similar to *S. glabra* (Thunb.) Nakai and *S. hainanensis* (P'ei) Swamy and Bailey in several vegetative and anatomical characters, the three species can be readily identified by their floral structures as follows:

Stamen sessile, discoid, circular to broadly—elliptic in surface view, 2·0×2·0 mm., thecae latrorse, as long as the microsporophyll (Figs. 3, 4)—*S. hainanensis.*

Stamen stalked, somewhat cylindrical with slight dorsiventral flattening, thecae 1/3-2/3 the length of the microsporophyll, and always situated nearer to the apex.

- Microsporophyll small, 2·0×1·0—2·5×1·75 mm., club-shaped, thecae generally latrorse, less frequently introrse; orientation of the stamen nearly horizontal to the rachis; ovary without an abaxial cushion (Figs. 1, 2)—*S. glabra.*
- Microsporophyll large, 4·0×2·0–5·0×2·5 mm., very fleshy, oblong, adaxial surface concave, thecae always introrse, orientation of the stamen parallel to the rachis; ovary with a pronounced cushion on the abaxial side at the point of attachment of the stamen (Figs. 5–7)—*S. Irvingbaileyi.*

Summary.

An examination of vast collections of the genus *Sarcandra*, deposited in several herbaria of the United States of America, Great Britain, and India indicate that specimens coming from South India differ significantly in the exomorphic floral characters from other recognized species of the genus, *S. glabra* and *S. hainanensis*, and therefore warrant the establishment of a new species for the accommodation of these plants.

Attention is drawn to the vesselless nature of the xylem of these plants, and its structural characteristics are described. This important feature, together with data obtained from nodal anatomy and from comparative morphology fall within the range of variability exhibited by the genus *Sarcandra*. However, the specimens distinguish themselves significantly from other known species of the genus in the possession of an unusually large stamen and of a marked cushion-shaped deformation on the abaxial side of the carpel.

The name *Sarcandra Irvingbaileyi* sp. nov. is proposed for the reception of these plants and the diagnostic features of the species are described, together with annotations of herbarium specimens examined.

Acknowledgements.

I thank the authorities of the many Institutions mentioned under the list of specimens examined for having extended to me the privilege of examining their respective collections. I am grateful to the officers of the Madras Herbarium (Coimbatore) for their cordial co-operation that has rendered the completion of this contribution. With deep gratitude I record the encouragement given to me by the National Institute of Sciences of India through the award of a Research Fellowship which has enabled me to carry out this investigation. To the Madras University and to Prof. T. S. Sadasivan I am much obliged for making available to me all facilities to work in the University Botany Laboratory.

References.

Bailey, I. W., and Swamy, B. G. L. (1948). *Amborella trichopoda* Baill., a new morphological type of vesselless dicotyledon. *Jour. Arnold Arb.*, **29**, 245–254.

Gardner, G. (1846). Contributions towards a flora of Ceylon. *Calcutta Jour. Nat. Hist.*, **6**, 343–352.

Swamy, B. G. L., and Bailey, I. W. (1950). Sarcandra, a vesselless genus of the Chloranthaceae. *Jour. Arnold Arb.*, **31**, 117–129.

Swartz, O. (1787). Chloranthus, a new genus of plants. *Trans. Roy. Soc. London*, **78**, 359 (abridged in *Trans. Roy. Soc.*, **16**, 302-303, 1809).

Tieghem, P. van, (1900). Sur les dicotylédones du groupe des Homoxylées. *Jour. Bot.*, **14**, 259–297, 330–361.

Legend to figures.

Figs. 1–7.—Fig. 1. *Sarcandra glabra*, flower showing stamen and pistil, as seen from adaxial side. Fig. 2. Same, as seen from a side. Fig. 3. Flower of *Sarcandra hainanensis*, side view. Fig. 4. Same, adaxial view. Fig. 5. *Sarcandra Irvingbaileyi*, adaxial view of the flower. Fig. 6. Same, side view. Fig. 7. Same, from the adaxial side showing the pronounced cushion after removal of stamen. All figures are drawn to the same scale.

Figs. 8–11.—Fig. 8. *Sarcandra Irvingbaileyi*, transection of a sector of stem showing a multiseriate ray, phloem fibres confronting the fascicular parts of secondary xylem, etc., (× 84). Fig. 9. Same, a fascicular part showing predominantly uniseriate rays (× 84). Fig. 10. Tangi-longisection of early formed secondary xylem showing the multiseriate and uniseriate rays (× 50). Fig. 11. Inter-tracheary pitting of primary (left hand side) and of early formed part of secondary xylem (× 380).

Figs. 12, 13. *Sarcandra Irvingbaileyi*.—Fig. 12. Transection of young stem at the nodal level, indicating the relationship of leaf strands to the vascular bundles of the stem (× 62). Fig. 13. Transection of an older stem (× 18).

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