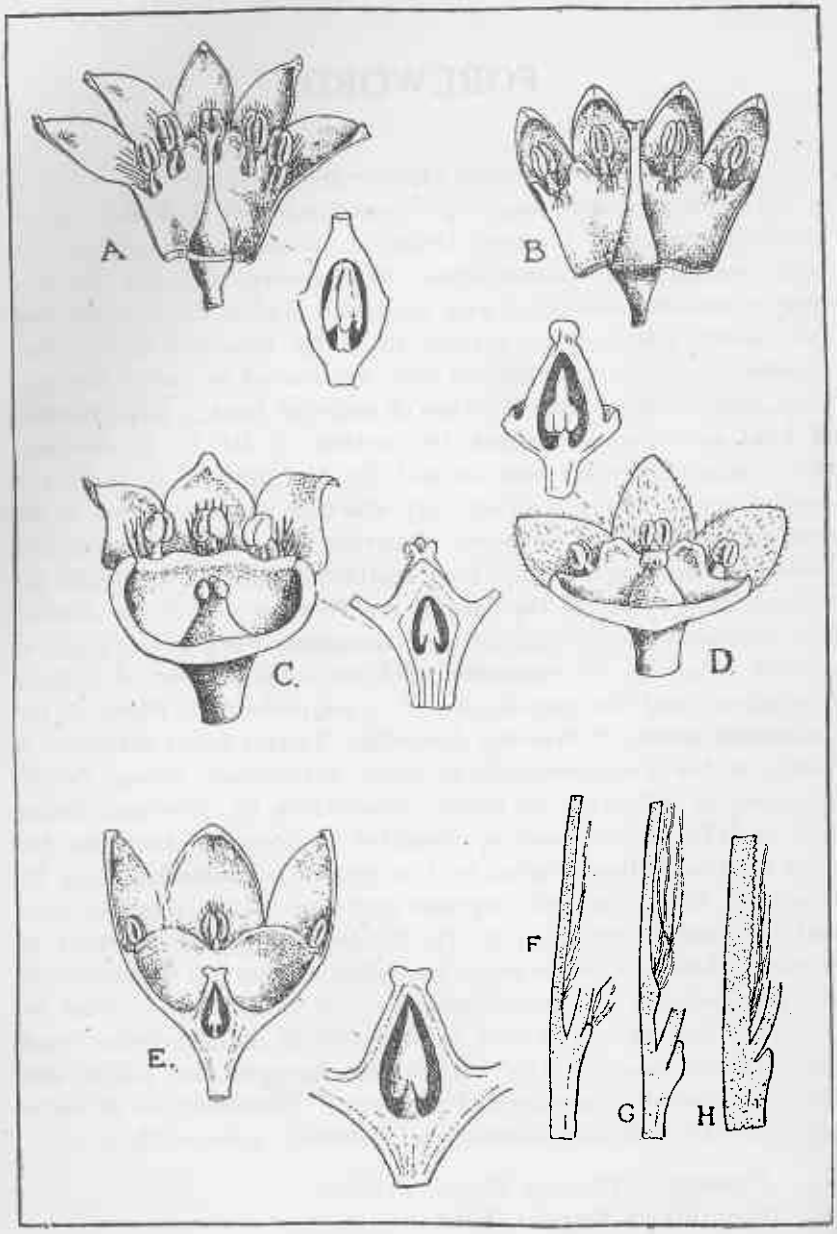
FOREWORD.

During the past ten years considerable attention has been paid to silvicultural and economic problems connected with the sandalwoods indigenous to Western Australia. Misunderstandings arising from confusion of nomenclature have drawn attention to taxonomic problems connected with the genus, and it was realised that the matter was one for careful study by botanists rather than Foresters. Recent contributions have not tended to clarify the position, and following the collection of material from a large number of local and overseas sources, the services of Mr. C. A. Gardner, Government Botanist, were secured for the purpose of making a careful review of the position. Mr. Gardner's contributions to the systematic botany of Western Australia are widely known, and arrangements have recently been completed which will enable his extensive knowledge of the flora of the Western side of the Australian Continent, and special gifts for taxonomic work to be turned to greater advantage in connection with the establishment of a State Herbarium, and the preparation of a comprehensive Flora of the indigenous plants of Western Australia. In this paper attention is drawn to the misunderstandings which have arisen among British botanists by adherence to faulty descriptions by Bentham dating back to 1873, and evidence is submitted in favour of following the basis of classification adopted by Continental botanists following De Candolle. Both data and diagrams prepared by Mr. Gardner show that the original inclusion by De Candolle of the sandalwoods of Southern Australia in the genus Santalum was correct on taxonomic grounds, and this is of considerable interest in view of the close relationship now known to exist in silvicultural characteristics, wood structure and essential oils particularly between the Indian and Western Australian members of the genus. Contributions of material from the following sources are gratefully acknowledged:—

Provisional Forestry Board, Brisbane.
Government Botanist, Brisbane.
Technological Museum, Sydney.
Forest Research Institute, Dehra Dun, India.
Inspector General of Forests, Canberra.
Acting Official Secretary of the Papuan Government.
Government Resident, Darwin, Northern Territory.

S. L. KESSELL,
Conservator of Forests.



A.—*Santalum Yasi*, Seem.
B.—*Santalum lanceolatum*, R. Br.
C.—*Santalum salicifolium* (A. Cunn.). Gardner.
D.—*Santalum fernandezianum*, E. Phil.
E.—*Santalum spicatum* (R. Br.) D.C.
F.—Showing attachment of filaments in *S. lanceolatum*.
G.—Showing attachment of filaments in *S. album*.
H.—Showing attachment of filaments in *S. spicatum*.

A TAXONOMIC STUDY OF THE GENUS SANTALUM.

With Special Reference to the Sandalwoods of Australia.

(By C. A. GARDNER, Government Botanist.)

The taxonomy of an Australian species which supplies a large proportion of the Sandalwood consumed in the markets of the Far East has received remarkably little attention for a species of such considerable economic importance, and the most recently published article upon the subject, "*Santalum, Eucarya and Mida,*" by T. A. Sprague and V. S. Summerhayes (Kew Bulletin of Miscellaneous Information. 1927, pages 193-198) has thrown no new light upon the subject.

The species in question has been variously known as *Fusanus spicatus* (R.Br.); *Santalum spicatum* (R.Br.), A.D.C.; and *Eucarya spicata* (R.Br.), Sprague and Summerhayes. The doubts expressed by botanists have all been concerned with the generic status of the species; while some have recognised *Fusanus* as a genus, others have agreed that *Fusanus* has no generic standing, and have merged it into *Santalum*.

The Australian plant was first described by Robert Brown (*Prodromus Florae Novae Hollandiae*) in 1810, under the name *Fusanus*, this name having been applied to a genus of African plants by Murray. Brown did not make a new genus, and the effect of his nomenclature is to place the Australian plant in *Osyris*, for *Osyris* is acknowledged to include *Colpoon*, and, incidentally, *Colpoon* is the earlier name for *Fusanus*. Brown therefore places two Australian species in what we now recognise as *Osyris*, distinguishing them from *Santalum* by reason of the shorter perianth-tube, and the shorter lobes of the epigynous disc.

A. De Candolle gives us the first adequate description of our plant in his "*Prodromus Systematis Regni Vegetabilis,*" XIV. (1857). It is here included under *Santalum*, which he divides into two sections:—*Eusantalum* (leaves opposite, flowers in cymes) and *Mida* (leaves alternate, flowers in racemes with alternate pedicels). *Eusantalum* he divides into two series; the long-styled species (*Santalum* of Bentham) and the short-styled (*Fusanus* of R.Br. and

Benth). De Candolle separates his *Santalum* from its closest affinities by the placentation of the ovules. In *Santalum* they are adnate to the placenta and borne near its base, whereas, in related genera, the ovules are almost apically attached. De Candolle also observes the true position of the ovary in *Santalum* (including Brown's *Fusanus*).

Bentham, in the "*Flora Australiensis*" (VI. 1873) separates *Fusanus* as generically distinct from *Santalum*. Later with J. D. Hooker in the "*Genera Plantarum*," he reiterates this view, but it is noteworthy that the distinctions given in the latter work are not identical with those of the "*Flora Australiensis.*" In the "*Flora Australiensis*" Bentham stresses the point of a free continuous disc within the stamens. This point is omitted from the "*Genera Plantarum.*" It is a point which will be considered later.

Hieronymus, in Engler & Prantl's "*Pflanzenfamilien*" III. (1889), accepts Bentham's arrangement. This acceptation does not imply that he has studied the question; in fact, there is every reason to believe that his system for the family, which is the same as Bentham & Hooker's (in a slightly different sequence with one or two minor alterations) is based upon published work and not upon actual specimens.

The Santalaceae have not been the subject of a separate monograph. Until this is undertaken, the opinions which have been built up on incomplete observations are almost certain to continue, and give rise to still further misconstructions. An example of this is the work of Sprague and Summerhayes quoted above. They have accepted as a fact from Bentham that his "*Fusanus*" has an inferior ovary, and have thus recognised a new genus in *Mida*, which can have no generic status. The writer, in addition, considers the system proposed by Bentham and Hooker to be artificial. It is perhaps a convenient method of classification to divide a section of the tribe *Osyrideae* on account of the degree of disc division, but the character is obviously artificial when, in another section of the same tribe, it is of no more than specific importance. Hence, in Australia, we have had the vexed *Santalum-Fusanus* question, just as there are differences of opinion regarding the African *Colpoon* and *Osyris*, and it is only by a critical investigation of the whole family, made from good material, that the true position of these genera can be established.

In 1927, the writer, in a note submitted to the Royal Gardens, Kew, pointed out that the name *Fusanus* was invalid under the International Rules, and the subject was thereupon taken up by

Sprague and Summerhayes in the publication quoted above. Apart from supporting Bentham's decision, the authors of the paper agreed to give generic rank to two species, under the name of *Mida*, and proposed *Eucarya* as a generic name in place of *Fusanus*. The Australian material examined must have been very poor, and this is borne out by the fact that they found it necessary to refer to a plate of Miss Flockton's in Maiden's "*Forest Flora of New South Wales*" to help out their generic diagnosis of *Eucarya*. Following Bentham they have assumed that an inferior ovary is a generic characteristic for their "*Eucarya*" (*Fusanus*), and they thus have no difficulty in separating *Mida* as a genus. When, however, it is considered that *Eucarya* has not an inferior ovary at anthesis, it becomes quite impossible to accept the proposals of Sprague and Summerhayes.

Bentham, in the "*Flora Australiensis*," contrasts *Santalum* and *Fusanus* as follows:—

> *Santalum*, Linn. "Perianth-tube . . . . lined with the disc, which is entirely adnate but produced between each two stamens into a spathulate or ovate-triangular scale . . . . Ovary semi-inferior."
>
> *Fusanus*, Linn. "Perianth-tube . . . . lined by the sinuately 4-lobed disc, the margin of which is continuously free inside the stamens . . . . Filaments short, inflected over the notches of the disc . . . . Ovary inferior."

Later, in the "*Genera Plantarum*," any reference to the free disc-margin is omitted.

For the purpose of confirming these observations or otherwise, an examination was made by the writer of *Santalum album* from Dehra Dun, India; *S. lanceolatum* from various parts of Australia; and *Fusanus spicatus* and *F. acuminatus* from Western Australia. More attention was paid to *F. spicatus* than to *F. acuminatus*. The results of this examination are as follow:—

(a) The perianth-tube of *Fusanus spicatus* differs from the *Santalum* spp. mentioned in never being campanulate. It is usually cupular or saucer-shaped. *Santalum lanceolatum*, however, does vary in the comparative length of the perianth-tube, and the same applies to *S. album*.

(b) The ovary in *S. album* and *S. lanceolatum* is not superior. At anthesis it is half-superior or two-thirds superior, later it is fully half-inferior and ultimately inferior. In *Fusanus spicatus* the ovary at anthesis is half-superior. In *F. acuminatus* it is often two-thirds inferior at anthesis. Ultimately in both it is totally inferior.

(c) The discs of *Santalum album* and *S. lanceolatum* have lobes which vary in shape and size, especially *S. lanceolatum*. They are, however, always longer than wide, a feature I have not observed in *Fusanus*, in which the disc lobe approaches the hemispherical, but never exceeds it.

The insertion of the stamens in *Santalum album, S. lanceolatum*, and *Fusanus spicatus* was examined microscopically by means of radial longitudinal sections of the perianth. It is essentially the same in each case. In no species are they continuous with the disc, but arise from the junction of the disc and perianth immediately below the summit of the disc. In *S. lanceolatum* the disc-margin is bearded with long hairs, *S. album* has few or none, *Fusanus spicatus* has none. In *Fusanus spicatus*, however, the disc is thicker than in *S. album* and *S. lanceolatum*, and for this reason its filaments appear, when viewed anteriorly, to arise from behind the disc, while, in *Santalum*, they appear continuous with it. In *Fusanus spicatus* the disc sometimes continues in growth after anthesis, and thus gives the character of a continuous free margin, but this not a rule.

Bentham's *Santalum* and *Fusanus* can, however, be distinguished by the following characters:—

Santalum—

(a) Perianth-tube campanulate or ovoid.
(b) Disc distinctly lobed between the stamens.
(c) Style elongated.

Fusanus—

(a) Perianth-tube crateriform, very shortly and widely subcampanulate or patelliform.
(b) Disc sinuately lobed between the stamens, but not conspicuously so.
(c) Style short or none.

We may now apply these distinctions to other genera of the Santalaceae, and observe how constant they are:—

1. *Thesium* . . . . The perianth is variable in shape. It may be saucer-shaped, cupular, campanulate or cylindrical above the ovary. It is divided to varying degrees. The epigynous disc is conspicuous or almost absent, prominently or obscurely lobed, flat or cupular. The style is either long or short.

2. *Buckleya* . . . . . Apart from the perianth variations due to sex, the disc is either angular between the stamens or produced into distinct but short teeth.

3. *Osyris.* The style is either short or long.

4. *Henslowia.* The disc is concave or convex..

5. *Leptomeria.* The disc is either distinctly lobed or only somewhat angular between the stamens.

It is therefore evident that the characters which might conceivably separate *Fusanus* from *Santalum* are not considered of generic importance in some other genera of the same family. Bentham and Hooker rightly divide the tribe *Osyrideae* on account of the stamens. They subdivide the larger half again on the character of the disc-lobes, but the artificiality of such a system should be apparent to any taxonomist, for what is of generic diagnostic importance in one half is of no account in the other; in other words, the differences are given as generic on the one hand, and specific on the other. De Candolle divided a similar section on the placentation of the ovules, and it will be agreed that this character is more basic than the variable one of disc-lobing. De Candolle's classification on the basis of placentation unites *Santalum* and *Fusanus*, and distinguishes them from all other genera of the tribe.

It is, therefore, more reasonable to accept *Santalum* in the wider sense of De Candolle and Mueller, and divide it into the following sections:—

Section I.—

Eusantalum: Style elongated. Perianth-tube campanulate or ovoid. Flowers 4-6 merous. Leaves opposite, rarely alternate. Lobes of the epigynous disc narrow or longer than broad. (To this section belong the species of *Santalum* in Bentham's sense of the genus.)

Section II.—

Eucarya (T. L. Mitch.) Gardner. Style very short or none. Stigma 2-3 lobed. Perianth-tube sub-campanulate or cupular to patelliform. Lobes of the epigynous disc broader than long. Leaves opposite, rarely alternate.

S. Murrayana (T. L. Mitch.), F. v. M.
S. acuminatum (R. Br.), D.C.
S. crassifolium (R. Br.), D.C.
S. spicatum (R. Br.), D.C.

Section III.—

Mida (A. Cunn.), D.C. Style none. Stigma 2-3-4 lobed. Perianth tube cupular or subpatelliform. Leaves alternate or opposite. Lobes of the epigynous disc broader than long.

S. fernandezianum, E. Phil.
S. salicifolium (A. Cunn.), Gardner.

SUMMARY.

The classification of the Santalaceae should be the subject of an early monograph. The family has not been critically reviewed. The confusion in nomenclature during the past must be largely attributed to Bentham and Hooker in adopting the lobing of the disc as an important generic characteristic for merely one section of the *Osyrideae*. It is suggested that some more fundamental point, such as the placentation of the ovules, as taken up by De Candolle, might be given due prominence in a future division of the tribe in question.

An investigation into the generic claims of *Fusanus* has been made, from a study of *Santalum album, S. lanceolatum*, and *Fusanus spicatus*, and the conclusion arrived at is that *Fusanus* cannot be separated from *Santalum* on any character that may be regarded as generic when regarding the Santalaceae as a whole. In several other genera, the distinctions which separate *Fusanus* are of no more than specific importance.

Bentham has been in error in describing the ovary of *Fusanus* as inferior, and has unfortunately been followed by some later taxonomists. "*Mida*" could only have been established as a genus in consideration of this error, since there appears to be no other ground for separation.

In consideration of the observations made, the writer considers that *Fusanus* is undoubtedly congeneric with *Santalum*, and that *Santalum* must be recognised in De Candolle's sense. *Fusanus* (*Eucarya*) and *Mida* must be given no more than sectional rank within this genus. *Santalum fernandezianum*, on account of its disc-lobes, and *S. salicifolium*, on account of its perianth-tube, afford additional evidence for the union of *Fusanus* (*Eucarya*) and *Mida* with *Santalum*.

In addition to the above, the plants belonging to "*Fusanus*" and *Santalum* (in the restricted sense) form a natural series. They are all plants of similar type and habit, leaf form and arrangement, inflorescence, timber structure and parasitism. This is borne out by such work as has been done by independent authors, and regarding root parasitism, *Fusanus* and *Santalum* can be sharply differentiated from the remainder of the Australian Santalaceae.*

The similarity of placentation, and the fruits of *Fusanus* and *Santalum* are in turn strong evidence for their generic unity.

* D. A. Herbert: *The Root Parasitism of Western Australian Santalaceæ.* Journ. Roy. Soc. W.A., xi. 127–149.

By Authority: FRED. WM. SIMPSON, Government Printer, Perth.