STUDIES IN THE GESNERIACEAE OF THE OLD WORLD XXXVI: FOLIAR SCLEREIDS IN NEW GUINEA AND PACIFIC CYRTANDRA

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ABSTRACT. The occurrence of foliar sclereids in *Cyrtandra* is summarised for five areas, from New Guinea to Hawaii; in a few 'species' variation in sclereids indicates a need for taxonomic revision. East of Borneo there is a decrease in the proportion of species which possess foliar sclereids, and in the complexity both of sclereid-pattern and sclereid-structure. A possible correlation between plant habit, leaf size and presence of complex sclereid-patterns is indicated.

In an earlier paper we noted that foliar sclereids in *Cyrtandra* have a rich and varied development in Borneo; but a very small sample had suggested that both frequency and diversity drop off rapidly in an easterly direction (Notes R.B.G. Edinb. 32: 12, 1970). We now report the results of a rather fuller survey of some New Guinea and Pacific material of the genus. The data are here grouped under five geographical areas: New Guinea, Solomon Islands, Fiji, S Pacific (excluding Fiji) and Hawaii. For some of these the classification of the genus is incomplete and specific determinations cannot be given for all the material used. Nevertheless we publish the present information because its interest stretches beyond the taxonomy of *Cyrtandra* into the little-explored field of the geographical distribution of anatomical features.

We are grateful to the Keeper of the Kew Herbarium for permission to examine the Fiji material preserved there.

NEW GUINEA. Schlechter published a revision of the New Guinea species of *Cyrtandra* in 1923 (in Bot. Jahrb. 53: 308–379) and recognized just over 100 species, if *Cyrtandropsis* be included. Nevertheless a large amount of the recently collected material cannot yet be satisfactorily determined and, furthermore, throws doubt on some of Schlechter's major groupings. It is largely this new material which has been studied for the occurrence of sclereids. The detailed observations may help in the much needed taxonomic studies, but for the moment we can report only on the variety and patterns of sclereids occurring in New Guinea.

The first point to be stressed is that out of 62 specimens examined no less than 54 lack sclereids altogether. Of the eight specimens with sclereids only one has them in both hypodermis and mesophyll. This is *C. wentiana* Lauterbach (*Versteeg* 1414), which has horizontal sclereids in the hypodermis and polymorphic sclereids in the mesophyll (fig. 1, C-E). The combination approximates to that distinguished as pattern 1 (vermiform in the hypodermis, polymorphic in the mesophyll) in the earlier paper; it was exemplified by two Bornean species, *C. quinquenotata* Kraenzl. and *C. gibbsiae* S. Moore. However the horizontal sclereids in *C. wentiana* differ from the vermiform sclereids of the Bornean species in two important points: the cell walls are

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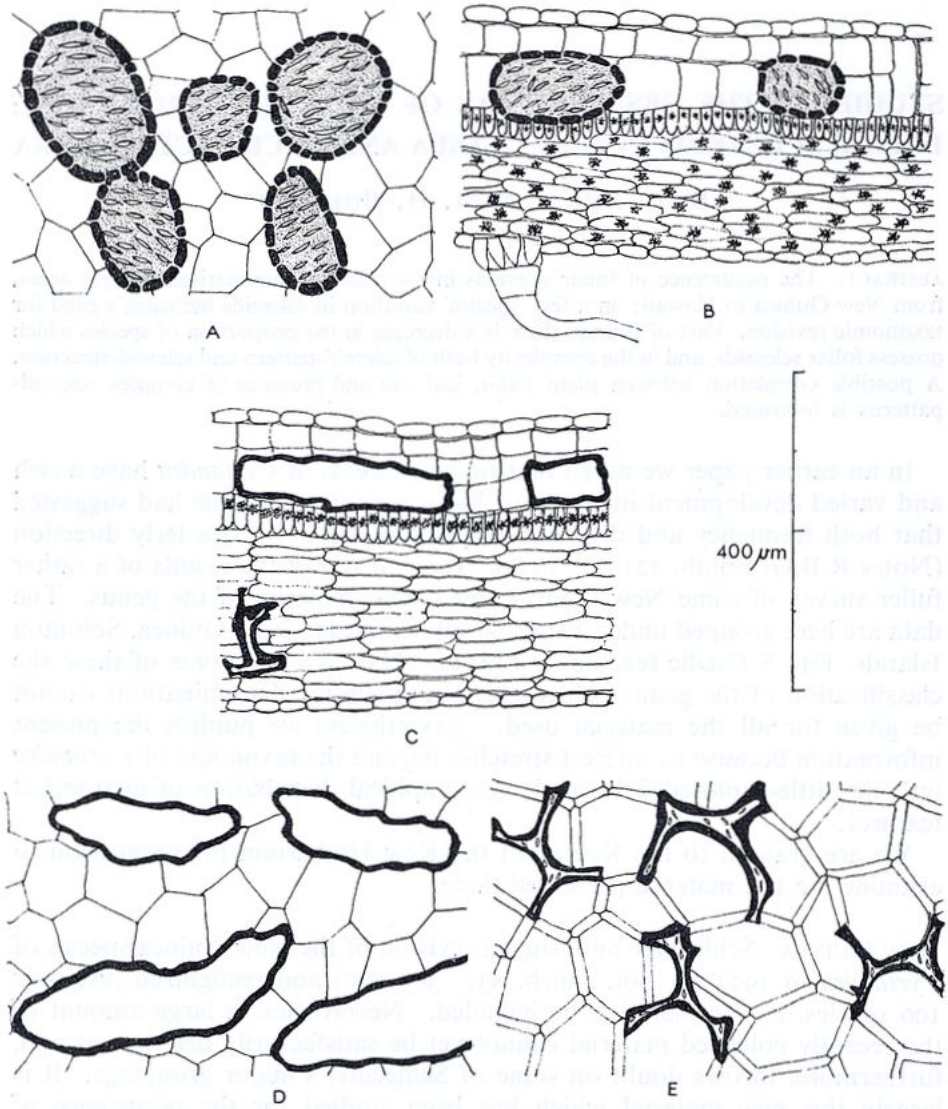

FIG. 1. A-B: *Cyrtandra victoriae* Gillespie, *A. C. Smith* 8801. A, a part of cleared leaf with tracheoids. B, T.S. of a leaf with tracheoid in hypodermis. C-E: *Cyrtandra wentiana* Lauterb., *Versteeg* 1414. C, T.S. of a leaf having horizontally placed ± vermiform sclereids in the hypodermis and polymorphic sclereids in the mesophyll. D, a part of a cleared leaf with ± vermiform sclereids in the hypodermis. E, a part of a cleared leaf with polymorphic sclereids in spongy mesophyll.

rough and lack pits: in the vermiform type they are smooth and markedly pitted.

The remaining specimens have sclereids either in the hypodermis or in the mesophyll: not in both. In the hypodermis the sclereids found (in *C. kaniensis* Schlechter and 2 other specimens—fig. 2) have been short and horizontal. In the mesophyll they are either horizontal and usually more or less shallowly lobed, or shortly lobed.

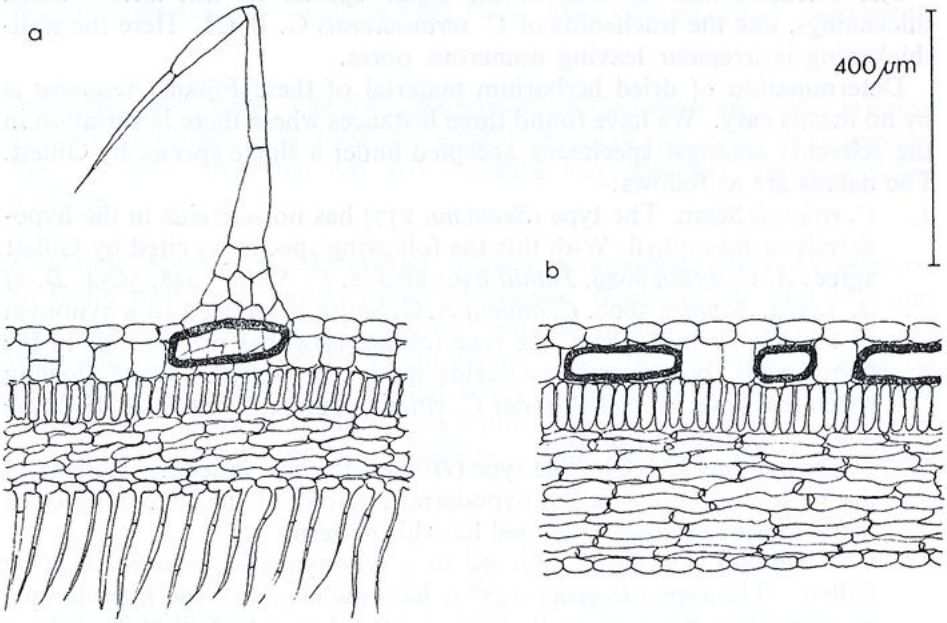

FIG. 2. Transverse sections of leaf: A, *Cyrtandra* aff. *victoriae* Gillespie (*Degener* 32057); B, *Cyrtandra* aff. *confusa* Schlechter (*N.G.F.* 45245).

SOLOMON ISLANDS (including Bougainville). There are approximately 15 species represented in the material examined. This consisted of 29 specimens, of which 19 lacked sclereids in the leaves. The sclereids present in the remaining 10 specimens fell into only two patterns, and only two types of sclereid were present.

In two specimens (*Kajewski* 1742 and *Corner* 119) there were osteosclereids in the hypodermis and vesicular sclereids in the mesophyll. The remaining eight specimens show only vesicular sclereids in the mesophyll.

The term 'vesicular' sclereids has been applied in the previous paper only to those found in *C. horizontalis* B. L. Burtt. In using the same term for the sclereids of certain Pacific species, it must be mentioned that they are larger and have more lobes than those of *C. horizontalis*. They are, indeed, somewhat intermediate between that type and short branched astrosclereids.

FIJI. The Fijian species of *Cyrtandra* have been recently revised by G. W Gillett (Contr. U.S. Nat. Herb. 37, 4: 107–159, 1967). To date we have examined 63 specimens representing 28 of the 35 species recognized by Gillett. Of these 28 species 16 are without sclereids.

Three patterns have been found in the Fijian material:

(a) large thin-walled tracheoids in the hypodermis, none in the mesophyll (3 species).
(b) no sclereids in the hypodermis, vesicular sclereids in the mesophyll (7 species).
(c) short osteosclereids in the hypodermis, vesicular sclereids in the mesophyll (2 species.)

The tracheoid-like sclereids of the Fijian species do not have banded thickenings, like the tracheoids of *C. sarawakensis* C. B. Cl. Here the wall-thickening is irregular leaving numerous pores.

Determination of dried herbarium material of these Fijian *Cyrtandra* is by no means easy. We have found three instances where there is variation in the sclereids amongst specimens accepted under a single species by Gillett. The details are as follows:-

1. *C. vitiensis* Seem. The type (*Seemann* 277) has no sclereids in the hypodermis or mesophyll. With this the following specimens cited by Gillett agree: *A. C. Smith* 8649, *Tothill* 649: also *A. C. Smith* 5048, 5654, *D. of A.* 14584, *Stauffer* 5800. *C. amicta* A. C. Smith is reduced to a synonym of *C. vitiensis* by Gillett; the type (*Smith* 5914) has no sclereids in the hypodermis, but vesicular sclereids in the mesophyll. The following specimens cited by Gillett under *C. vitiensis* agree: *Smith* 4244, *Gillespie* 4095: also *Greenwood* 319.
2. *C. chippendalei* C.B.Cl. The type (*Horne* 577) has vesicular sclereids in the mesophyll, none in the hypodermis. None of the remaining cited material that we have examined has this pattern.
   C. tomentosa A.C.Sm. is reduced to a synonym of *C. chippendalei* by Gillett. The type (*Degener* 14889) has tracheoids in the hypodermis, no sclereids in the mesophyll. Of the material cited by Gillett the following specimens agree: *Smith* 8549, 8720.
3. *C. victoriae* Gillespie. We have not been able to examine the type specimen (*Gillespie* 4088). However, in the material examined the commonest pattern (fig. 1B) is like that of *C. tomentosa*: tracheoids in the hypodermis, and no sclereids in the mesophyll. This pattern is shown by the following specimens cited by Gillett: *Smith* 5697, 5915, 8801; also by *Greenwood* 320, *Tothill* 643, *Smith* 5781, 5722, *Melville & Parham* M. 7133.

   One specimen cited by Gillett (*Smith* 5917) lacked sclereids in hypodermis or mesophyll. An additional specimen (*Degener* 32057) of this affinity has thick-walled horizontal sclereids in the hypodermis at the base of each hair (fig. 2A).

We are not here concerned with the taxonomy of the species, but the occurrence of different patterns of sclereids in a single species seems highly improbable. Thus the evidence from this source is very strongly against the reduction of *C. tomentosa* to *C. chippendalei*. Its affinity may be rather with *C. victoriae* Gillespie. It is, perhaps, unwise to be equally dogmatic in the case of *C. vitiensis* and *C. amicta*, since the loss of a feature like mesophyll-sclereids may be no more important taxonomically than the loss of epidermal hairs: nevertheless there is clearly a case for reinvestigation. It is also desirable for a further study to be made of the material at present placed under *C. victoriae*.

If we compare the sclereid patterns with Gillett's arrangement of the species, we find that the three species with large tracheoid-like sclereids in the hypodermis are placed consecutively, *C. muskarimba* A.C.Sm., *C. victoriae* and *C. tomentosa* (included in *C. chippendalei*) at the end of his second group. The species with vesicular sclereids in the mesophyll are scattered through groups 1, 2 and 3, as are those without any sclereids at all. The two species with osteosclereids in the hypodermis and vesicular in the mesophyll are

widely separated: no. 2, *C. occulta* A. C. Sm., and no. 19, *C. involucrata* Seem.

S PACIFIC (excl. Fiji). The S Pacific species of *Cyrtandra* are under revision by Prof. G. Gillett. The relatively small sample (19 specimens in 14 species) that we have examined has not included any specimen showing foliar sclereids.

HAWAIIAN ISLANDS. H. St. John has made a monographic study of *Cyrtandra* on Oahu where he records some 130 species (Bernice P. Bishop Museum Bull. No. 229, 1966). There are only another dozen or so species on the remaining islands of the Hawaiian group. The small amount of material immediately available suggests that sclereids occur too rarely in this area for them to offer much aid to the taxonomy. Out of 25 specimens examined, no less than 22 were without sclereids: these belonged to the following species:

C. cordifolia Gaud.
C. garnotiana Gaud.
C. gracilis Hillebr.
C. grandiflora Gaud.
C. kalichii Wawra
C. kealii Wawra
C. lessoniana Gaud.
C. lysiosepala C.B.Cl.
C. oenobarba H. Mann
C. paludosa Gaud.
C. stupantha St. John & Storey
C. triflora Gaud.
C. wawrae Hillebr.

However foliar sclereids are not altogether absent from Hawaiian *Cyrtandra*. The records we have made are :—

C. gayana Heller (*Heller* 2495); short osteosclereids in the 2–3 layered hypodermis.

C. latebrosa Hillebr. (*Hillebrand* s.n.): short, vertical, more or less rounded sclereids in the 2–3 layered hypodermis; broad polymorphic sclereids in the mesophyll.

C. sp. (*Heller* 2624): short horizontal sclereids in the lower layer of the 2-layered hypodermis; polymorphic in mesophyll.

GENERAL DISCUSSION

Foliar sclereids in *Cyrtandra* may be divided roughly into two main groups: those that show intrusive growth (the vermiform sclereids, dendrosclereids, astrosclereids, and polymorphic sclereids), and those that do not do so (tracheoids, osteosclereids and vesicular sclereids). However the distinction is not clear-cut. The larger vesicular sclereids found in some Solomon Island species show, as noted above, an approach to rather simple astrosclereids: nor is the distinction between the polymorphic and vesicular types absolute. Much more detailed studies, including developmental stages, are needed: the categories used in our papers are descriptive and provisional. Vesicular sclereids in the mesophyll are the most widespread type in the Pacific: they are also the least highly differentiated as they amount to little more than normal spongy mesophyll cells that have become sclerified. It may be significant that they are less common in Borneo, where sclereid development and diversification appears to reach its peak.

Osteosclereids, a very common form of hypodermal sclereid in Borneo, are found in the Solomon Islands, Fiji and Hawaii; they must surely occur in some of the New Guinea species, although not yet found.

In New Guinea only one species, *C. wentiana*, with more of less vermiform sclereids in the hypodermis, has so far been found with sclereids showing intrusive growth: further east this type is lacking from our records.

Both in Borneo and New Guinea it is species with unbranched stems, and often with large leaves (± 50 cm long), that show the strongest development of foliar sclereids. Plants of similar habit but smallish leaves (e.g. *C. adnata* B. L. Burtt, stems to 40 cm high, leaves about 10 cm long) may have sclereids, but much-branched shrubs tend to be without them. Such shrubs form a significant proportion of the *Cyrtandra* flora in the Philippines and New Guinea, but only a tiny proportion in Borneo. To emphasise this too much is to oversimplify. There are large-leaved shrubs in the Pacific which are not very much branched, yet they lack foliar sclereids. This is even more true of Borneo, where some plants without sclereids agree in habit and leaf-size with those that have a well-developed pattern of sclereids. However, the sclereid-less species often have thin membranous leaves, and sometimes a strongly mamillate surface, suggesting that quite different factors, or different responses, are at work moulding the architecture of the leaf. Meanwhile enough is known to say that there is a definite geographical patterning of sclereidal development, but that its investigation must not be divorced from a general consideration of habit and leaf size.