STUDIES ON FOLIAR SCLEREIDS

A Preliminary Survey

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The occurrence of sclereids distributed in the mesophyll of leaves has attracted the attention of many investigators. As far back as 1908, Solereder enumerated 84 families of dicotyledons in which several members manifested the presence of spicular cells or sclereids. Foster (1946) demonstrated that there are several types of sclereids. He pointed out the necessity for a detailed investigation of the sclereid morphology, which in addition to being of general interest has also taxonomic value.

During the course of his studies, on foliar sclereids in dicotyledons extending over several years, the writer has come across as many as 40 species in which they were not reported to occur previously. The present paper gives an account of this work.*

When one studies the foliar sclereids showing a great range of variation in their shape and size in such a large number of plants, the importance of analysing them into definite groups becomes apparent. In any one species, the shape of the sclereid varies so much that their designation into 'types' on the basis of shape and size alone can be one method of classification. A better method would be to divide them into groups on the basis of their ontogeny and their origin from epidermis, palisade cells or spongy cells. This of course would involve a detailed study of early stages of sclereid development, but would ensure a more precise method of classification. The author, therefore, proposes to recognise four main groups of sclereid development on the basis of ontogeny. Each group is next subdivided into types on the basis of the size and shape of the sclereids.

Group I

The sclereids included under this type are transformed epidermal cells. The upper or lower epidermal cell or cells become sclerosed, and show a conspicuously thickened wall and a small lumen. In some cases as in *Mærua arenaria* Hook. f. and Thoms., they become elongated externally into hair-like structures (Fig. 1).

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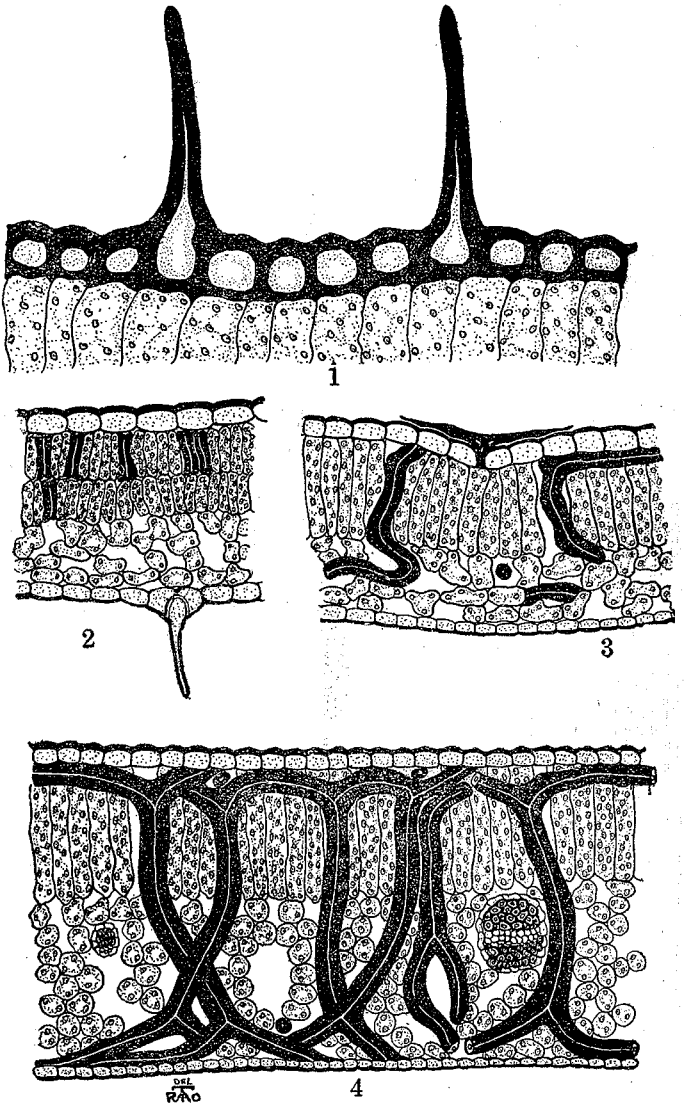
* The writer would feel grateful if any workers on plant morphology who casually come across foliar sclereids in some of the species occurring in their collections, give the author the benefit of examining such specimens. Their co-operation would be greatly appreciated and acknowledged.



FIGS. 1–4.—Fig. 1. *Mærua arenaria*.—Part of T.S. through the adaxial region of the leaf, illustrating sclerosed epidermal cells and sclerosed hairs. ×172. Fig. 2. *Nyctanthes arbor-tristis* Linn.—T.S. of the leaf, illustrating sclerosed palisade cells. ×120. Fig. 3. *Olea glandulifera* L.—T.S. of the leaf, illustrating the elongated sclerosed palisade cell. ×120. Fig. 4. *Olea dioica* Linn.—T.S. of the leaf, illustrating criss-cross disposition of sclereids. ×172.

Group II

The sclereids of this group are transformed palisade cells, which may be elongated or not. In the early stages these cells show nucleus and cytoplasm, but very few chloroplasts. Following the impregnation of lignin and the consequent thickening of the cell wall, the nucleus degenerates. Such a type of sclereid has been noticed in species of *Olea* (Rao and Kulkarni, 1951). In some cases as in *Nyctanthes arbor-tristis* (Rao, 1947), isolated groups of sclereid idioblasts are seen (Fig. 2). The elongated sclereids are divided into the following types, depending upon their shape and size:—

Type I. Osteo sclereids or Fusiform sclereids.—Sclereids of this type exhibit a good deal of form variations, have limited growth and often show slender branches. They are seen in *Linociera* species (Rao, 1950 *a*). Ontogenetic studies have revealed that sclereids in *L. intermedia* are transformed palisade cells and the terminal appearance as reported by the writer (Rao, 1950 *a*) is due to differentiation of sclereid initial cell above the procambial strand.

Type II. Ophiuroid Sclereids.—The ophiuroid sclereids are elongated or columnar in shape with fusoid ends, sinuous or recurved in outline, and possess a narrow lumen or uniform width. The sclerosed wall is non-stratified and free from pits. This "cell form" (Fig. 3) is seen in *Olea glandulifera* Wall. and *O. cuspidata* Wall. (Rao, 1948).

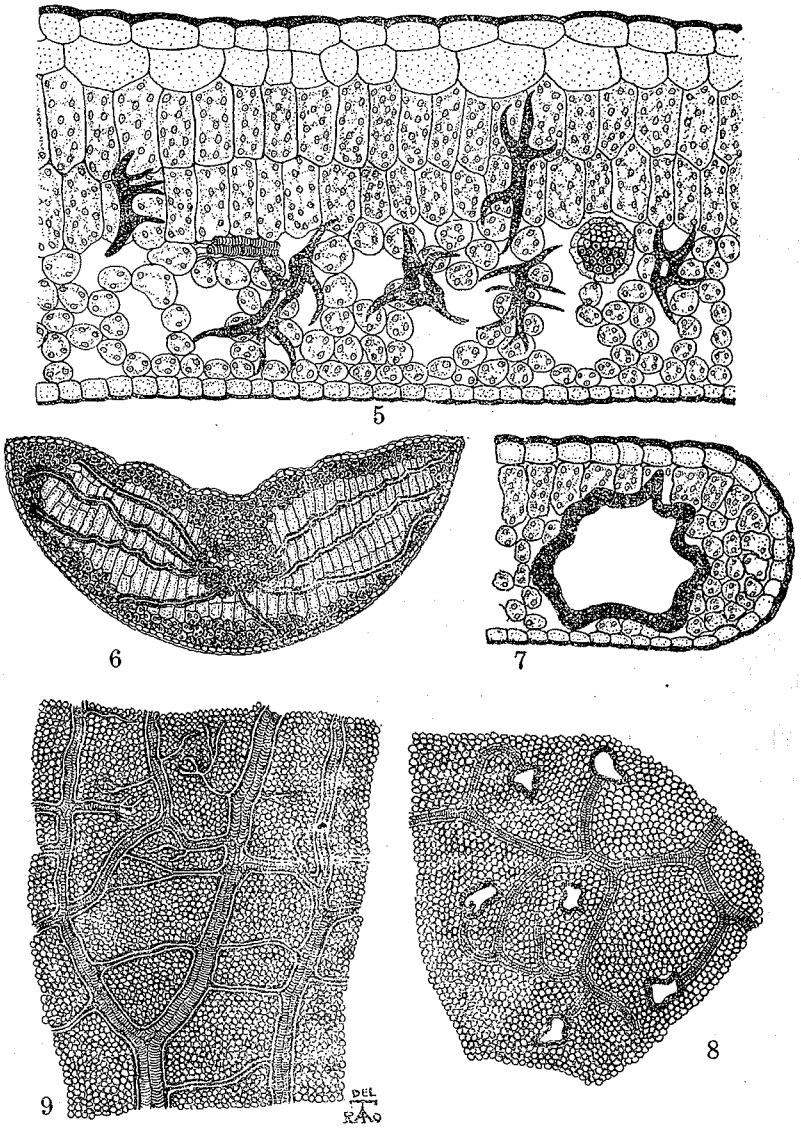
Type III. Branching Sclereids.—The sclereids resemble Type I, but they have a great tendency to fork and run in criss-cross manner throughout the mesophyll. Such sclereids (Fig. 4) are seen in *O. dioica* Roxb. (Krishnaswamy, 1942), *O. polygama* Wt. and *O. europæa* Linn. (Rao, 1948).

Group III

The sclereids of this group are formed by the transformation of spongy parenchymatous cells. They closely resemble those of Group II except for this difference. The following types of sclereids are noted under this group:—

Type I. Osteo Sclereids or Fusiform Sclereids.—The sclereids are short, have limited growth and possess uniform thickness and narrow lumen. They are seen in *Diospyros discolor* Willd. of Ebenaceæ (Rao, 1951).

Type II. Stellately Branched Sclereids.—The cells show deep forking in all directions resulting in irregular cell body. The forked branches are drawn out and possess fusoid ends. This cell form is seen in *Ternstræmia japonica* L. (Rao, in press) and *Azima tetracanth* Lamk. This type of sclereids were seen only once in a collection of *Azima tetracanth* Lamk. (Salvadoraceæ) made near Sreerangapatna, Mysore State (Fig. 5), but a second search for these sclereids in apparently the same species made in other localities failed to reveal their presence.



FIGS. 5–9.—Fig. 5. *Azima tetracanth.*—T.S. of the leaf showing forked bizzare forms of sclereids. ×240. Fig. 6. *Hoya pauciflora.*—T.S. of the leaf, illustrating the diffuse disposition of sclerenchymatous fibres. ×10. Fig. 7. *Schrebera swietennoides.*—T.S. of the leaf, illustrating vesiculose sclereid. ×430. Fig. 8. *Schrebera swietennoides.*—Cleared lamina, illustrating terminal or non-terminal vesiculose sclereids. ×100. Fig. 9. *Ochna squarrosa.*—Cleared lamina, illustrating the disposition of the sclerenchymatous fibres accompanying the veins. ×100.

Type III. Ophiuroid Sclereids.—These sclereids exhibit the same structure as those of Type I and Group II in that they are columnar, elongated, straight or recurved and without branching. They are disposed terminally at the ends of the marginal veinlets. Such sclereids are seen in *Memecylon heyneanum* L. (Rao, 1952).

Type IV. Polymorphic Sclereids (Branching form).—Sclereids of this type resemble those of Type III of Group II with regard to their distribution in the mesophyll in criss-cross manner, and the great range of variation in their cell form and branching. Forked sclereid cells having the shape of the letters H Y X T or L are very frequently met with. Elongated sclerosed cells (may be latex carrier in early stages) developed in a radiating manner around the vascular bundles and running the entire length of the aqueous tissue of the leaf are seen in *Hoya pauciflora* Linn. (Asclepiadaceæ) (Fig. 6). Sclerenchymatous fibres closely jacketing the veins of the leaf and often showing branches which ramify into the mesophyll are seen in *Ochna squarrosa* Linn. of Ochnaceæ (Fig. 9). The ontogeny of the sclereids in the abovementioned cases is still under investigation. They are tentatively placed under Group III on the basis of their general disposition within the spongy cells.

Group IV

This group is specially designated to include such cases where the sclereids take their origin in any of the two or all the three regions of the mesophyll. The following types are noted under this group:—

Type I. Vesiculose sclereids.—These are sub-spherical to polygonal in shape, but in several cases show deep constrictions imparting a lobed appearance (Figs. 7 and 8). Such a type is seen in *Scherebera swietennoides* Roxb. (Rao, 1949). Author's observations have revealed that these sclereids are formed not only by the transformation of palisade cells but also by spongy cells near the procambial strands.

Lastly the author has noticed the presence of foliar sclereids in the plants listed below. They could not be placed in any of the four abovementioned groups since the ontogeny of the sclereids is still being studied. Pending the completion of these studies, they are listed below, with information on their shape and their disposition with reference to the veinlets:—

Family	Name of the plant	Shape of sclereids	Relation with veinlets
Proteaceæ	.. *Leucospermum conocarpum* R. Br.	Vesicular	Terminal and diffuse (Fig. 13)
	L. hypophyllum R. Br.	Polymorphic cell-form	do.
Loranthaceæ	.. *Loranthus cuneatus* Heyne.	do.	Crystal bearing terminal and diffuse sclereids in close contact with the foliar veins and veinlets (Rao and Kelkar, 1951)
	L. elasticus Desv.	Ophiuroid and polymorphic cell-form	Terminal and diffuse sclereids with crystals in their lumen
	L. Hookerianus W. & A.	Stellate	Mostly diffuse, rarely terminal
	L. longiflorus Desv.	Globular in groups or polymorphic cell-form	Rarely terminal and mostly diffuse sclereids with crystals
	L. obtusatus Wall.	Polymorphic cell-form	Veinlets free from sclereids. Diffuse sclereids in close association with the large foliar veins
	L. buddleioides Desv.	do.	Terminal sclereids

Family	Name of the plant	Shape of sclereids	Relation with veinlets
	L. tomentosus Heyne.	Polymorphic cell-form	Terminal and diffuse sclereids with crystals. Diffuse sclereids in close contact with the foliar veins and veinlets
	L. trigonus W. & A.	do.	do.
	L. Wallichianus Schult.	Stellate or irregularly branched cell-form	Terminal and diffuse sclereids with crystals
Anonaceæ	.. *Uvaria macrophylla* Roxb.	Sclerosed cells	Sclereids or sclerenchyma from the tips of the veinlets or from veins
Capparidaceæ	.. *Niebuhria apetala* Dunn.	Sagittal or stellate or lobed cell-form	Terminal sclereids
	Capparis moonii	Sac-like cells	do.
	C. orbiculata Wall.	Fusiform	do.
Leguminosæ	.. *Saraca Indica* L.		Sclerenchyma branching from the veinlets or veins
Ochnaceæ	.. *Ochna Squarrosus* L.		Sclerenchyma branching from the veinlets or veins

Ternstrœmiaceæ ..	*Gordonia Obtusa* Wall.	Polymorphic cell-form	Terminal and diffuse (Fig. 11)
	Ternstrœmia japonica L.	Stellate and polymorphic	Terminal and diffuse
Rhizophoraceæ ..	*Rhizophora mucronata* Lamk.	do.	Diffuse sclereids
Melastomaceæ ..	*Memecylon angustifolium* Wt.	Polymorphic cell-form	Mostly terminal sclereids
	M. amplexicaule Clarke	Ophiuroid cell-form	do.
	M. deccanense Cl.	do.	do.
	M. rostratum Thw.	do.	do.
	M. Talbotœnum Brandis	do.	do.
	M. Wightii Thw.	do.	do.
	M. Hookeri Thw.	do.	do.
	M. laveigatum Blume.	do.	do.
Sapotaceæ ..	*Mimusops elengei* L.		Sclerenchyma branching from the veins
	M. hexandra Roxb.	Sclerosed cells	Irregularly branched sclereids or sclerenchyma from the sides of the veinlets (Fig. 10)
	M. Roxburghiana Wt.	do.	do.

Family	Name of the plant	Shape of sclereids	Relation with veinlets
Ebenaceæ	.. *Diospyros discolar* Willd.	Osteo sclereids, or Fussiform	Rarely terminal and usually diffuse
Loganiaceæ	*Fagræa Obovata* Wall.	Stellate	Terminal and mostly diffuse.
Oleaceæ	.. *Olea cuspidata* Wall.	Ophiuroid cell-form	Diffuse sclereids with a tendency to incurve towards the veinlets
	O. dioica Roxb.	do.	do.
	O. europaea L.	do.	do.
	O. glandulifera Wall.	do.	do.
	O. polygama Wt.	do.	do.
	O. verucosa L.	do.	do.
	Ligustrum Perreottii Dc.	Ophiuroid	Diffuse sclereids
	L. Walkeri Dcne.	do.	do.
	Linociera courtallensis Bourd.	do.	Apparently terminal and mostly diffuse
	L. malabarica Wall.	do.	do.

L. Wightii C. B. Clarke	do.	do.
L. Zeylanica Gamble.	do.	do.
L. intermedia Wt.	Fusiform or lobed, cell-form	Apparently terminal (Fig. 12) and mostly diffuse sclereids
L. macrophylla Wall.	do.	do.
Scherebera swietennoides Roxb.	Vesicular sclereids	Terminal and non-terminal

SUMMARY

A classification of the foliar sclereids based on their ontogeny and general morphology is proposed and four main groups, each subdivided into several types, are recognised.

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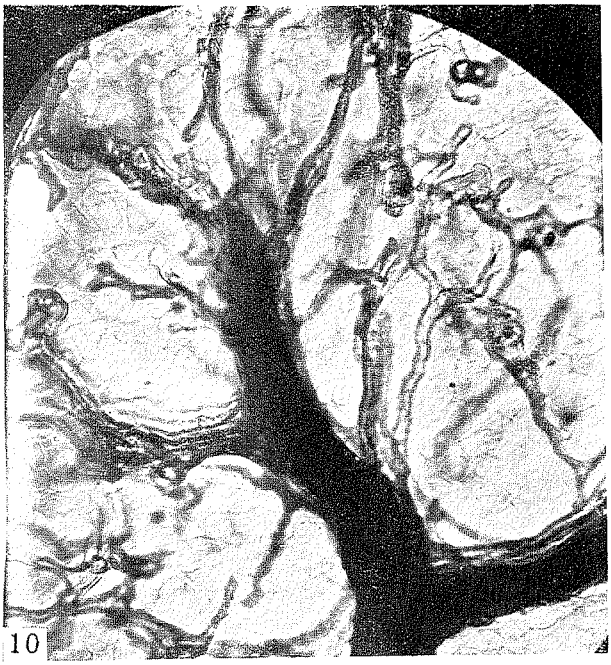
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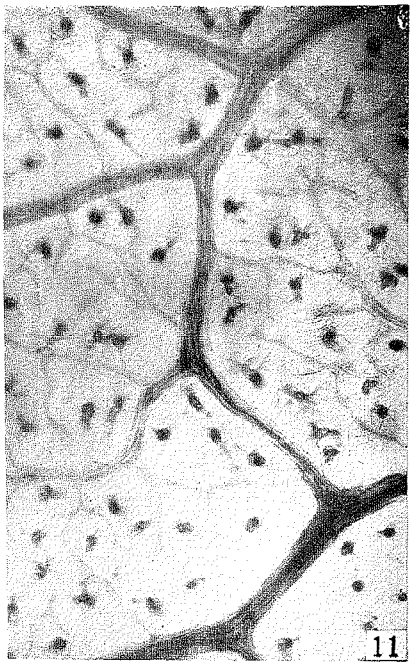
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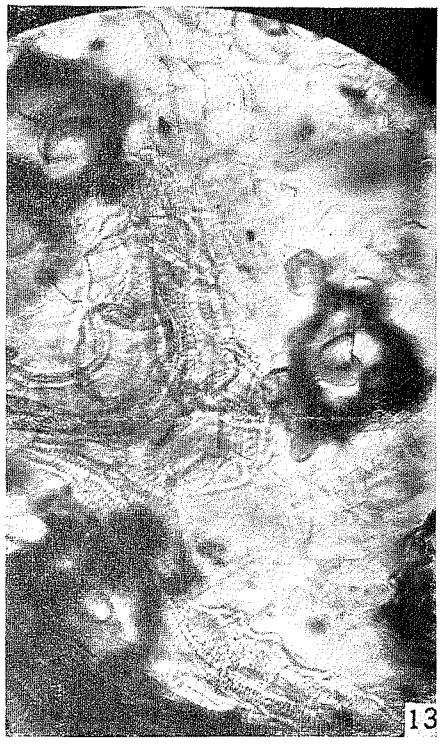
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EXPLANATION OF THE PLATE

Cleared leaves showing the close proximity of sclereids to the veins and vein ends.

Fig. 10. *Mimusops hexandra.* × 450. Fig. 11. *Gordonia obtusa.* Note the abundance of diffuse sclereids. × 50. Fig. 12. *Lionociera intermedia.* × 450. Fig. 13. *Leucospermum conocarpum.* ×450.