TYPOLOGY OF SCLEREIDS

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ABSTRACT

A resume on the morphological types of sclereids has been given under various typological heads with example drawn from the published literature to enhance their utility as distinct types in detailed description of sclereids. Depending on the constancy of the body shape the sclereids are classified into two main subdivisions: Monomorphic and Polymorphic. With some reservation, within the scope of the two subdivisions many types are recognised. It is emphasised that each type is a descriptive unit recognised for purpose of cogency in understanding.

INTRODUCTION

In recent years the information on the main morphological types of sclereids and their variability has reached a stage of considerable interest in respect of other disciplines of Botany. The pioneer researcher in this field was Tschirch (1889) who for the first time recognised four main categories of sclereids: brachysclereids, macrosclereids, osteosclereids, astrosclereids. Subsequent workers have utilised the above categories while describing sclereids found in their studies (Solereder, 1908). In recent years a few workers have established the existence of different types of sclereids in several species of the same genus or several genera of a family by utilising a qualifying description to such forms which differ from the main categories recognised by Tschirch (1889).

Foster (1946), who rekindled interest on sclereid morphology taking the precaution of citing the voucher specimens has distinguished four types...
of sclereids in the genus *Mouriria*: parenchymatous cell form with or without radiating branches, ramified sclereids of stellate and fusiform branched or unbranched types and filiform or thread-like sclereids with or without forking. Following on the same lines Rao (1957 a) has recorded filiform branched or unbranched sclereids and polymorphic sclereids including spheroidal, fusiform and columnar sclereids with their modifications and stellate sclereids in 95 species of the genus *Memecylon*. Richter (1920) has recognised in the family Marcgraviaceae a few categories of sclereids: ophiurosclereids, librкосклериды, astrosclereids, palosclereids, rhizosclereids and idiosclereids. Working on the same family De Roon (1967) has adopted eight main categories of sclereids five of which already recognised by Richter (1920) and three of Tschirch (1889); brachysclereid, astrosclereid and oestosclereid. Singh (1967) has categorised four types of sclereids in 15 species of the genus *Fagraea*: aster, columnar, T-shaped and dendroid forms.


Paliwal and Kakkar (1970) have described three types of sclereids: filiform, stellate-polymorphic and brachysclereids in the laminae of five species of *Garrya* of Garryaceae.

In view of the introduction of varied descriptive terms from time to time an attempt has been made in the present study to classify them into
distinct categories with a view to enhance their utility as distinct morphological types, in detailed descriptions of sclereids.

**Sclereid Types and Classification**

Depending on the constancy of the body shape the sclereids may be classified into two main subdivisions: Monomorphic and Polymorphic. In the first, sclereids have a uniform simple base form with even or uneven or lobed outline, normally these do not show branching processes and even when they are there they do not change the body shape. In the second, sclereids have extreme complex base forms with uneven outline and constantly show regular branching leading to symmetrical or asymmetrical body shape.

**Monomorphic Sclereids**

A further subdivision is based on the outline of the base form in the mature stage: simple, even or lobed and simple with or without a tendency to branch. In the first category three distinct types are included: spheroidal-sclereid, vesiculose sclereid and vermiform sclereid; in the second, four distinct types: palosclereids, osteosclereid, fusiform sclereids and filiform.

All the types of monomorphic (Figs. 1–23) and polymorphic sclereids (Figs. 24–43) are shown diagrammatically.

The salient and distinguishing features of monomorphic sclereid types are mentioned below:

1. **Spheroidal Sclereid** (Figs. 1–7)

   This type, also known as stone cells (Schumann, 1889; Warming-Johnsen, 1909), grit cells (Eames and Mac Daniels, 1947) and brachysclereids (Tschirch, 1889), is characterized by simple base forms. Usually, it is spheroidal, globoid or orbiculate, pyriform or turbinate cell forms. It has been reported in almost all the vegetative and floral parts of several taxa. Their abundance is observed in roots and stems especially in the cortex or pith region. Turbinate base form is reported in a few species of *Capparis* (Rao and Mody, 1961), pyriform base form is observed in *Linociera lyzonica* L. (Bhupal, 1971). They may be observed as solitary idioblast or may lie loosely together in the form of concretions, nests or 'sclerocysts' (Rao, 1957 a) or agglomerate sclereids (Govindarajalu and Parameswaran, 1967). Under this category one can recognise two types of variations confined mainly to the thickness of the wall layers. In the first, sclereids have a thin wall with a wide lumen and in the
second, they have a thick wall, often striated with a narrow or occluded lumen.
2. *Vesiculose Sclereid* (Figs. 8–11)

The term is proposed by Rao (1949) to a simple lobed sac-like base form. Usually it has uneven outline, thin wall with a broad lumen or rarely in a few forms the cell wall is thickened with a narrow lumen. This type of sclereid is reported in *Leucospermum conocarpum* R. Br. (Rao, 1950b), a few species of *Loranthus* (Rao, 1951a), *Schrebera swietenioides* Roxb. (Rao, 1949), *Linociera glomerata* Pohl and *Heptacynlum zenkeri* Engl. (Solereder, 1908) and *Cyrtandra horizontalis* L. (Bokhari and Burtt, 1970).

3. *Vermiform sclereid* (Figs. 12–15)

Bokhari and Burtt (1970) proposed this term for the simple cylindrical or tubular base form with rounded ends. It has a thin cell wall with distinct pores and lumen of uniform width. This type is exemplified in *Cyrtandra elatostemoides* Elmer, *C. quinquenotata* Kraenzlin (Bokhari and Burtt, 1970) and also in *Linostoma pauciflorum* Griff. and *L. persimile* Craib. of Thymelaeaceae (Rao and Bhupal, 1972); a few sclereids of this type display sigmoid or allantoid shape.

4. *Palosclereids* (Fig. 16)

The term is introduced by Richter (1920). It is a macrosclereid sensu Tschirch (1889) situated in the palisade parenchyma. The cell forms may or may not have the size and shape of the adjoining cells but they have slightly thickened or rarely thick striated walls, broad lumen and of the same height as the surrounding palisade cells and appear-rectangular in cross-section. They are formed in rows or in isolation. Typical palosclereids are reported in *Nyctanthes arbor-tristis* L. of Oleaceae (Rao, 1947) and in a few species of *Ruyschia*, *Souroubea* and *Norantea* of Marcgraviaceae (De Roon, 1967), *Frezierea undulata* Sw. of Theaceae (Solereder, 1908; Fig. 29 B, Metcalfe and Chalk, 1957; Fig. 44 B) and *Diospyros discolor* Willd. (Rao, 1951b) of Ebenaceae, where the sclereid is a transformed spongy cell occupying a palisade disposition.

5. *Osteosclereids* (Fig. 17)

The term was introduced by Tschirch (1889) to bone-shaped cells. It extends into the mesophyll in the form of a column, sometimes touching both the epidermal layers. This base form exhibits thick striated cell wall with a lumen of uniform or irregular width. The ends are flattened or rounded with a slight depression resembling a typical bone-shaped rod. Osteosclereids are reported in a few species of the genus *Camellia* (Tschirch, 1889).
Figs. 348, Barua and Wright, 1959; Figs. 1–8, 11); *Gordonia lasianthus* L. (Beauvisage, 1920), *G. obtusa* Wall (Rao, 1951 a); *Lacathea pubescens* L’Her (Beauvisage, 1920; Fig. 52); *Schima noroanhoe* Reinw (Beauvisage, 1920; Fig. 46), *S. wallichii* (Rao, 1953); *Nyssa caroliniana* Poir. (Solereder, 1908; Fig. 99 A; Metcalfe and Chalk, 1957; Fig. 24 B), *N. capitata* Walt, *N. javanica* (Bl.) Wang and *N. sinensis* Oliv. (Fam. Nyssaceae) (Rao and Mody, in press); *Hakea suavelons* R. Br. (Fam. Proteaceae) (Tschirch, 1881; Fig. 23); *Popowia pisocarpa* (Bl.) Endl. (Fam. Annonaceae) (Rao and Wee, 1966); *Mouriria cauliflora* DC., *M. pusa* Gards., *M. huberi* Cogn. (Foster, 1946, Figs. 35 and 37) and *Memecylon cuneatum* Thw. (Fam. Melastomataceae) (Rao, 1957 a; Fig. 35); *Marcgravia browneri* (Tr. et Pl.) Kr et Urh, *M. goudatiana* (Tr. et Pl. de Roon) (Fam. Marcgraviaceae) (De Roon, 1967) and the *Cyrtandra bracheia*, B. L. Burtt and C. adnata B. L. Burtt (Fam. Gesneriaceae) (Bokhari and Burtt, 1970) and in *Hamamelis mollis* Oliv. *Eustigma oblongifolium* Gard. et Champ., *Rhodoidea championi* Hook, f. *R. ovalifolia* Ridl., *R. subcordata* Exell, *R. teysmanni* Miq. of Hamamelidaceae (Bhupal and Kundu, 1971).

6. **Fusiform sclereid** (Figs. 18–21)

This type is referred to a short spindle or rod-like base form truncated both ways from a swollen middle portion. Under this category, Foster (1946) has recognised different variants based on the branch system in a few species of *Mouriri*. Further, he has observed in both the fusiform and branched variants, the ultimate ends of the cell body or its arms are blunt rather than acute. The sclereid wall is thick, striated, pitted and lumen is more or less uniform. They are reported to occur as solitary idioblasts or grouped in twos or threes in a few species of *Mouriri* (Foster, 1946), *Memecylon* (Rao, 1957), *Linociera* (Rao, 1950 a, 1957 b), *Limonium* (Rao and Das, 1968; Bokhari, 1970), *Scindapsus* (Rao, 1964), and *Rhaphidophora* where the linear type sensu Singh (1968) corresponds to the fusiform sclereids. Sometimes they group together to form a ‘sclerocyst’ as recorded in a few species of *Limonium* of Plumbaginaceae (Rao and Das, 1968) or more or less intimately grouped to form regular strands along the lateral margins of the leaves of *Maba nigrascens* of Ebenaeeae (Rao and Kelkal, 1951), *Exbucklandia populnea* (R. Br. ex. Griff.) R. W. Brown of Hamamelidaceae (Rao, 1968) and certain members of Myrsineae (Heberlandt, 1914). In the present study they are present in *Disanthus cecidifolium* Maxim. and *Hamamalis mollis* Oliv. of Hamamelidaceae, *Linociera ramiflora* (Roxb.) Wall., *L. macrophylla* Wall. of Oleaceae.
7. **Filiform sclereid** (Figs. 22–23)

This term is adopted by Foster (1946) to a series of slender greatly elongated accumulate fiber-like cells which are bent or twisted to various
degrees. Often they are found penetrating into the mesophyll in the most varied directions and extend beneath the epidermal layers. Sometimes they fork at one or both ends. They are reported in a few species of *Mouriri* (Foster, 1946), 82 species of *Memecylon* (Rao, 1957 a), 13 more species of *Memecylon* (Bhupal, 1971), in 17 species of *Olea* (Rao, 1948; Bhupal, 1971) 2 species of *Ligustrum* (Rao, 1953) and 13 species of *Linociera* (Rao, 1950 a, 1957 b and Bhupal, 1971), *Gymnacranthera forbesii* (King.) Warb. of Myristaceae, *Cyathocalyx ramuliflorus* J. Sinclair, *Desmos dasymaschulas* and *Phaeanthus ophthalmicus* J. Sinclair of Annonaceae (Rao and Wee, 1966).

**POLYMORPHIC SCLEREIDS**

Under this category is included a heterogeneous assemblage of extreme base forms varying in their body shape and mode of branching. In a broad sense they are grouped under four main categories: ramiform sclereids, astro-sclereids, polyramous sclereids and idiofibrosclereids. Each category conforms to one base form from which the other deviations can be traced.

1. **Ramiform sclereid**

The term is applicable to columnar base forms having ramifying ends. Under this category 2 types of sclereids are recognised: Rhinosclereid and I-shaped sclereids and their variants. The salient features of the above types are as follows:

Type (i) *Rhinosclereid* (Figs. 24-26).—The term proposed by Richter (1920) to such base forms which are more or less similar to palosclereids in shape and position but differ from them in possessing root-like branches towards the spongy cells and sometimes possess intraepidermal branches running parallel to epidermal layers or drooping down towards the palisade cell. The short or long columnar mainbody with rooting ends constitute the characteristic feature of this sclereid. Such types may be found disposed in any part of the mesophyll. This type of sclereid is reported in a few species of *Niebuhria* DC. of Capparaceae (Rao, 1958; Figs. 10–11); *Ruyschia, Souroubea* and *Norantea* of Marcgraveiaceae (De Roon, 1967); *Adinandra jackiana* Korth. and *A. dumosa* Jacq. of Theaceae (Beauvisage, 1920; Figs. 21 and 23), *Cleyera grandiflora* Hook. f. *et Thoms* (Solereder, 1908; Figs. 29 C and D; Metcalfe and Chalk, 1950; Figs. 44 C and D) and *Diospyros discolor* Willd. of Ebenaceae (Rao, 1951 b). In the present study they are recorded in *Eustigma oblongifolium* Gard *et Champ.* of Hamamelidaceae.
Typology of Sclereids

Type (ii) *I*-shaped sclereid (Figs. 27–29).—This type and its variants have a columnar body and exhibit interepidermal branchings of limited or extended length at the poles. They resemble typical I-girders as reported in *Mouriri pusa* Gardn. (Foster, 1946) and sometimes exhibit slight swelling in the midcolumn and also develop branches in the form of anchors as observed in *Memecylon seutellatum* (Lour) Naud (Rao, 1957 a; Fig. 34) and also in a few specimen of *Fagraea* (Singh, 1967). When the intraepidermal branching is confined to one pole, the resulting body is T-shaped Y-shaped as recorded in species of *Olea* (Arzee, 1953 a; Rao and Kulkarni, 1952) and a few species of *Fagraea* (Singh, 1967). The presence of I-shaped sclereids alternating with osteosclereids has been reported in *Memecylon cuneatum* Thw. (Rao, 1957 a; Fig. 35). Columnar branched sclereids are reported in *Mouriria cauliflora* DC. and *M. abnormis* Naud. (Foster, 1946) and also in *Olea dioica* Roxb. (Rao and Kulkarni, 1952) where the branch systems have extensive development. In the present study similar

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<th>TABLE I</th>
<th>Chart showing the sclereid types with the original term proposed by Tschirch (1889)</th>
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<td>Categories of sclereids proposed by Tschirch (1889)</td>
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<td><strong>BRACHYSCLEIREIDS</strong></td>
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<td><strong>FILIFORM SCLEREIDS</strong></td>
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cell forms are observed in *Osmanthus fragrans* Lour. and also by Griffith (1968).

2. **Astrosclereids** (Figs. 30–31)

The term as used by Tschirch (1889) in a broad sense is applicable to cell forms showing a good deal of diversity. This represents a large heterogeneous assemblage of sclereids having shorter or longer radiating branches. In view of the introduction of a few new descriptive terms for other forms of astrosclereids it is proposed to apply the term only to typical stellate forms. A typical astrosclereid has a thickened central part, small to wide lumen with number of arms of comparatively short length radiating in all directions.

In all reported cases, the astrosclereids conform more or less to the typical cell form as described above but this type is invariably modified by possessing an increase in the length of the radiating arms and falls into next category of sclereids: ophiurosclereids, librosclereids and trichosclereids.

**Type (i) Ophiurosclereid** (Figs. 32, 33).—This is nothing but a specialized form of astrosclereid. The sclereid in this case has a short central lumen, thick striated wall and displays long drawn out arms, sometimes laying parallel to the surface of the leaf. The extended arms are of varied length and sometimes the elongated arms extend in opposite directions. Johnsson (1880) introduced the above terminology in his study on the leaf anatomy of the Proteaceae. Richter (1920) has adopted this term in his study of the family of the Marcgraviaceae. Further its utility is shown by De Roon (1967) in his detailed studies on the foliar sclereids in the Marcgraviaceae.

**Type (ii) Librosclereids** (Figs. 34–36).—The term introduced by Richter (1920) to such type of astrosclereids which have elongated arms extending in opposite directions and reduced to four, three or two in numbers. The typical librosclereid is said to possess a small central part, with two small arms and two very long arms extending in opposite direction almost resembling a fibre. This type of fibre-like sclereids are reported in the stem and leaves of many species of Marcgraviaceae (De Roon, 1967), *Pelliciera rhizophorae* Tr. et Pl. of Pelliceriae (Solereder, 1908; Beauvisage, 1920) and many species of *Scindapsus* and *Rhaphidophora* of Araceae (van Tieghem, 1866; Richter, 1899; Bloch, 1946; Nicolson, 1960; Rao, 1964; Singh, 1968 and Bhupal, 1971).

**Type (iii) Trichosclereid** (Figs. 37, 38).—This base form is one in which 4 arms are found extending in opposite direction, showing a striking
resemblance to H-shape and always disposed parallel to the surface of the leaf. This type of sclereids is also indicated in the literature as poil interne en ‘H’ (van Tieghem, 1866, 1891), trichoblast (Sachs, 1882), sclereiden (Francken, 1890), internal hairs (De Bary, 1884, p. 222), trichosclereids (Bloch, 1946) and H-shaped sclereids (Rao, 1964; Singh, 1968). Recently the term trichosclereid is adopted in the studies on a few taxa of Araceae (Rao, 1964; Nicolson, 1960). The present study in agreement with the observations of Rao (1964), Nicolson (1960) and Singh (1968) has shown the presence of these cell forms in many species of Scindapsus and Rhaphidophora. In view of its distinct cell form the present work supports the usage of the term ‘trichosclereid’ as proposed by Bloch (1946) and adopted by subsequent workers. The advantage of retaining this term is two fold. It is non-ambiguous and self-explanatory. H-shaped sclereids can be considered as fibre-shaped sclereids with reservation. The present work holds the view that it is a modification of astrosclereid and strongly supports for the retention of the term ‘trichosclereids’ for H-shaped forms.

3. Polyramous Sclereids (Figs. 39-42)

This term is proposed to sclereids which differed from one another in shape and branching in one and the same leaf expanse. Richter (1920) introduced the term ‘Idiosclereid’ to such varied base forms. Tschirch (1889) included such bizarre sclereids under the category of astrosclereids. However, De Roon (1967) adopted Richter’s term and assigned only pure stellate forms to astrosclereids. Foster sees no justification of separating so-called ‘Idiosclereids’ as a district category. On the contrary Rao’s (1950 b) term ‘poly-morphric sclereids’ he considers’ seems entirely appropriate. ‘Further he says that’ in the leaf of Trochodendron it would be clearly impossible to separate typical stellately-branched astrosclereids form so-called ‘idiosclereids. All idioblastic ramified sclereids vary to some degree in the same population in one leaf, and the prefix ‘idio’ (= strange of peculiar) represents a salient feature common to all branched types of sclereids and for this reason is not an explicit term, from morphological viewpoint (Personal communication to Dr. B.C. Kundu). Rao (1957 a) distinguished bizarre forms from the pure stellate forms under the term ‘dendroid sclereids’ in the cleared lamina of Memecylon spthandra El. Bokhari and Burtt (1970) have reported astrosclereids and dendrosclereids in the mesophyll of Cyrtandra axillaris Cl. and only dendrosclereids in C. lambirensis B. L. Burtt. Similar type of dendrosclereids are reported in a few species of Boscia of Capparidaceae.
(Pestalozzi, 1898). Thus one could see in the studies of the above-mentioned authors an attempt to segregate pure stellate forms from the other bizarre forms.

4. *Idiofibrosclereid* (Fig. 43)

This term is proposed to extra xylary sclerenchymatous fibres closely associated with veins and veinlets and often leaving the veins to intrude into the adjacent mesophyll (Rao and Bhupal, 1971). This feature in the cleared leaf expanses is reported in various taxa of Angiosperms (Solereder, 1908; Metcalfe and Chalk, 1957). Rao (1960) has investigated the ontogeny and development of similar cells in *Manilkara hexandra* (Roxb.) Dubard. Structurally, these peculiar fibre like, base forms possess thick cell wall and lumen of irregular width. As a result of irregular branching especially in the mesophyll region they often appear as irregularly shaped sclereids. Recently they are recorded in *Cynometra cauliflora* L. and *C. polyandra* Roxb. of Caesalpinoideae; *Loropetalum chinense* Oliv., *Trichocladium ellipticum* E. et K., *Distylium indicum* Benth., and *Sycopsis griffithiana* Oliv. of Hamamelidaceae; in *Linostoma decandrum* (Roxb.) Wall. ex Endl., *L. pauciflorum* Griff., *L. persimile* Craib. and *Enkleia malaceensis* Griff., *E. siamensis* (Kurz.) Nevling of Thymelaeaceae (Rao and Bhupal, 1972).

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### Typology of Sclereids

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