

Typology and taxonomic value of foliar sclereids in the Proteaceae III. *Petrophile* R. Br. ex Knight

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Abstract. The present study has revealed that 24 out of 39 taxa of *Petrophile* possess diverse types of sclereids. Further, it is observed that similar types of sclereids are present at the various sectional levels as recognised by Bentham. Their morphological aspects and systematic applicability have been discussed.

Keywords. Foliar sclereids; typology; *Petrophile*; Proteaceae.

1. Introduction

This genus is confined to Western Australia and closely allied to *Isopogon* R. Br. ex Knight. There are 36 species chiefly differing from its nearest ally *Isopogon* in having cone scales firmly attached to the receptacle opening simultaneously or by force for the emission of the nuts (Bentham 1870).

Despite the reported occurrence of sclereids in a few species of *Petrophile* (Jonsson 1878-79; Solereder 1908; Rao and Bhattacharya 1978; Rao and Das 1979; Metcalfe and Chalk 1950) there is no detailed study of their typology for taxonomic considerations.

2. Material and methods

Herbarium specimens (table 1) were provided by the Central National Herbarium (CAL), Howrah, India; the National Herbarium of New South Wales (NSW), Royal Botanic Gardens, Sydney, Australia and the Western Australian Herbarium (Perth), South Perth, Western Australia. The clearing technique is after Rao and Naidu (1981), and the categorisation of sclereids is after Rao and Bhupal (1973).

3. Observation

Cleared laminae of 68 specimens belonging to 39 species have revealed that sclereids are present in 21 species namely *P. acicularis*, *P. carduacea*, *P. conifera*, *P. crispata*, *P. divaricata*, *P. diversifolia*, *P. linearis*, *P. longifolia*, *P. macrostachya*, *P. media*, *P. multisecta*, *P. rigida*, *P. semifurcata*, *P. striata*, *P. teretifolia* and *P. trifida*. They are of diffuse pattern and form distinct idioblasts in the laminae. However, in a few species, namely *P. biloba*, *P. colorata*, *P. heterophylla*, *P. propinqua* and *P. squamata* palosclereids infrequently sheathing the veins are observed.

Table 1. Species of *Petrophile* investigated (Bentham's classification, 1870) and references to sclereid types.

Taxa	Typology
Section 1. Arthostigma	
<i>P. terretifolia</i> R. Br. (J Drummond 131445, NSW)	R
<i>P. longifolia</i> R. Br. (D Clyae 1258151, NSW)	R
<i>P. media</i> R. Br. (M E Phillips 1436, NSW; Fitzgerald <i>s.n.</i> , CAL)	R, I
<i>P. media</i> R. Br. var. <i>juncifolia</i> Lindl (E Pritzel 782, CAL; J H Maiden 75908, NSW)	R
<i>P. acicularis</i> R. Br. (H Sheth 75919, NSW; J Drummond 75985, NSW)	R
<i>P. linearis</i> R. Br. (J F Maiden 755959, NSW; B. Kaspiew 53, CAL; Max Koch 1917, CAL; E. Pritzel <i>s.n.</i> , CAL)	R
<i>P. linearis</i> R. Br. var. <i>anceps</i> R. Br. (J Drummond 75985, NSW)	R
Section 2. Xerostole	
<i>P. heterophylla</i> Lindl. (W. H. Archar 75987, NSW)	P
<i>P. biloba</i> R. Br. (J Drummond 131371, NSW; E Pritzel 503, CAL)	P
<i>P. propinqua</i> R. Br. (E Pritzel 592, CAL)	P
<i>P. propinqua</i> R. Br. var. <i>sericiflora</i> Benth. (Max Koch 1466, CAL; M E Phillips 1993, NSW)	P
<i>P. squamata</i> R. Br. (N Rainbow 55974, NSW)	P
<i>P. colorata</i> Meisn. (J Drummond 76984, NSW)	P
<i>P. striata</i> R. Br. (M E Phillips CBC-005512, NSW)	I
Section 3. Serrurioides	
<i>P. divaricata</i> R. Br. (Ashby 2683, NSW)	N
<i>P. serruriae</i> R. Br. (J H Maiden 75939, NSW; E Pritzel 577, CAL)	A
<i>P. inconspicua</i> Meisn. (J Drummond 76009, NSW)	A
<i>P. trifida</i> , R. Br. (J Drummond <i>s.n.</i> , NSW); E M Canning 7366, NSW)	F
Section 4. Symphyolepis	
<i>P. carduacea</i> Meisn. (M. E. Phillips CBC-034029, NSW)	R, S
<i>P. shuttleworthiana</i> Meisn. (E Pritzel 729, CAL)	A
<i>P. macrostachya</i> R. Br. (Phillips CBC-033565, NSW; E Pritzel 181, CAL)	R, S
<i>P. diversifolia</i> R. Br. (Julius Scott <i>s.n.</i> , NSW)	I
Section 5. Petrophile	
<i>P. biternata</i> Meisn. (J Drummond 113811, NSW)	A
<i>P. plumosa</i> Meisn. (J Drummond 113803, NSW; E Pritzel 730, CAL)	A
<i>P. erecifolia</i> R. Br. (Phillips CBC-037251, NSW; E Pritzel 761, CAL)	A
<i>P. erecifolia</i> R. Br. var. <i>scabriuscula</i> Maxim. (J H Maiden 76059, NSW; H Salsso 4195, NSW)	A
<i>P. chrysantha</i> Meisn. (J Drummond 13810, NSW)	A
<i>P. pedunculata</i> R. Br. (A A Hamilton 76149, NSW; R T Baker <i>s.n.</i> , CAL)	A
<i>P. pulchella</i> R. Br. (L A S Johnson 76181, NSW)	A
<i>P. sessilis</i> Sieb. ex Seholt. (J H Garfield 76259, NSW)	A
<i>P. fastigiata</i> R. Br. (J W Weingley CBC-036605, NSW)	A
<i>P. seminude</i> Lindl. (J H Nashell 76374, NSW; E Pritzel 576, CAL)	A
<i>P. circinata</i> Kipp. ex Meisn. (Phillips CBC-049148, NSW)	A
<i>P. drummondii</i> Meisn. (Anon. <i>s.n.</i> , CAL; D Clyne 125900, NSW)	A
<i>P. crispata</i> R. Br. (A C Beaugle Poole 119186, NSW)	R
<i>P. rigida</i> R. Br. (R Collie 76386, NSW; Max Koch 2111, CAL)	Spherocoical
<i>P. multisecta</i> F. Muell. (R B Bogaro 76287, NSW)	S
<i>P. conifera</i> Meisn. (M E Phillips 131135, NSW)	I
Section 6. Hebegyne	
<i>P. semifurcata</i> F. Muell. (A S George 82907, NSW)	G

Absence (A), Spheroidol or ovoid forms (S), Gnarlyform (G), I-shape (I), Ramiform (R), Fusiform (F), Nailform (N), Paloform (P).

3.1 Typology

The most commonly encountered sclereids conform to the following major types:

3.1a *Sub-spheroidal form*: They are observed in the laminae of *P. multisecta* (Bogero 76287, NSW) and *P. rigida* (R Collie 76384 NSW, figure 1). The sclereids chiefly conform to sub-spheroidal to sphero-conical or clavate shape. In *P. multisecta* sclereids are ovoid and appear in a row along the margin. They are more or less similar, in shape, thick-walled, and the lumen is of narrow or irregular width. The secondary wall is striated and displays many pits.



Figures 1–3. TS of the leaves of 1. *P. rigida* R. Br. (R Collie 76384, NSW) showing sub-spheroidal sclereids disposed in palisade layer ($\times 225$). 2. *P. acicularis* R. Br. (H Sheth 75919, NSW) showing two types of sclereids: Palosclereids in palisade and ramiform sclereids in mid-mesophyll region ($\times 225$). 3. *P. media* R. Br. (M J Phillips 1436, NSW) showing I-shaped sclereids in the palisade region ($\times 400$).

3.1b *Gnarlyform*: They have a central misshapen body with many protuberances of irregular shapes and sizes. These are observed in *P. semifurcata* (A S George 82907, NSW).

3.1c *Paloform*: They are in the form of rectangular cells and infrequently observed around the veins of all the species of the section *Xerostole* (figure 4) except *P. striata* (Phillips CBC-005512, NSW).

3.1d *I-shaped*: They are observed in the laminae of *P. conifera* (Phillips 131135, NSW), *P. divaricata* (Ashby 2683, NSW), *P. diversifolia* (Julius Scott *s.n.*, NSW), *P. media* (Phillips 1436 NSW, figure 3) and *P. striata* (Phillips CBC-005512, NSW). These sclereids are columnar with thick sclerosed walls. They have short spicules at the polar ends and are disposed parallel to one other. Their secondary cell-walls are striated and have many pits. The lumen is narrow or occluded at certain points. Under this category the sclereids of *P. divaricata* are very distinct in resembling round-headed nails (figure 9). They are closely disposed in the lamina, and often appear in rows.

3.1e *Ramiform*: This type is present in the laminae of *P. acicularis* (Sheth 75919, CAL), *P. carduacea* (Phillips 34029, NSW), *P. crispata* (Poole 119186, NSW), *P. linearis* (Maiden 755959, NSW), *P. linearis* var. *anceps* (Drummond 75985, NSW), *P. longifolia* (Clyae 1258151, NSW), *P. macrostachya* (Pritzel 181, CAL), *P. media* (Phillips 1436, NSW), *P. media* var. *juncifolia* (Maiden 75908, NSW), and *P. terretifolia* (J. Drummond 131445, NSW). These sclereids are columnar, not much-elongated but often show spicules at the ends. Most of them are arranged parallel to the leaf-surface. They form distinct rows, and sometimes occupy the sub-marginal areas of the laminae. In *P. carduacea* sclereids are oriented at right angles to the surface. In *P. linearis* var. *anceps* sclereids show distinct patterns of disposition: marginal and central. Marginal sclereids are parallel to the surface whereas central sclereids are at right angles to the surface. This feature is of diagnostic interest. In *P. acicularis* sclereids of two types are encountered: Paloform at palisade and ramiform in the central spongy portions of the cylindrical lamina (figure 2).

3.1f *Fusiform*: These are represented only in the lamina of *P. trifida* (J. Drummond *s.n.* NSW). The cell form has a bulging body with fusoid ends. They are relatively small in size with thick cell walls, and lumina of irregular width.

4. Morphological features

The species and their sclereidal forms are recorded in table 1. On the basis of total absence or presence of sclereids within the sections one can differentiate the existence of two groups of species. Of the 39 species examined under this genus, 15 have no sclereids, while the other 24 possess diverse types of sclereids. Every section recognised by Bentham (1870) shows a few species with or without sclereids except the sections *Arthostigma* and *Hebegyne*, where all the species have sclereids in their leaves. These features are neither to be considered as events of phyletic importance nor as indicators of close relationship but confirm the distinctness of the groups of species. Groups based on presence or absence of sclereids or their types alone may prove to be of little

relation to the current systematic classification. More natural groups are formed when sclereids are considered together with morphological and other histological characters.

5. Systematic applicability

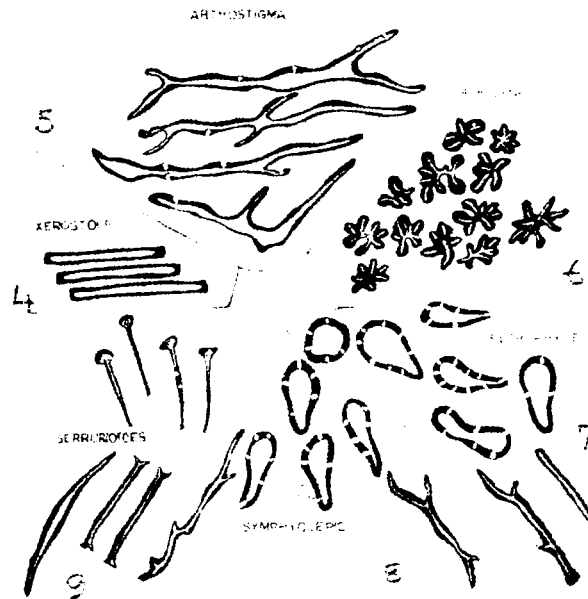
According to Bentham (1870) *Petrophile* consists of 35 species confined chiefly to Western Australia. The genus is divided into 6 sections by Bentham (1870): *Arthostigma*, *Xerostole*, *Serrurioides*, *Symphyolepis*, *Petrophile*, *Hebegyne*.

The present survey has revealed that foliar sclereids are not of generic significance but may be of diagnostic value at species levels. They provide very useful points that may be of some help in the future revision of this genus. Some of the findings of the present work are now discussed.

All taxa of the section *Arthostigma*, namely *P. teretifolia*, *P. longifolia*, *P. media*, *P. media* var. *juncifolia*, *P. acicularis*, *P. linearis* and *P. linearis* var. *anceps* exhibit ramiform sclereids. Thus, their common presence confirms this group as a natural one (figure 5).

All taxa of *Xerostole*, namely *P. heterophylla*, *P. biloba*, *P. propinqua*, *P. propinqua* var. *sericiflora*, *P. squamata* and *P. colorata* have palosclereids. The presence of distinct I-shaped sclereids in *P. striata* is undoubtedly a diagnostic character for this taxon within this section (figure 4).

Among the 16 taxa assembled under the section *Petrophile* it is possible to distinguish two sub-groups based on the presence or absence of foliar sclereids.



Figures 4-9. Typology of sclereids in different sections of *Petrophile*: Semi-diagrammatic sketches. ($\times 400$). 4. *Xerostole* - paliform; 5. *Arthostigma* - ramiform; 6. *Hebegyne* - gnarled; 7. *Petrophile* and 8. *Symphyolepis* - spheriform to ramiform; 9. *Serrurioides* - nailform, ramiform, fusiform.

Sclereids are absent in 12 taxa, namely *P. biternata*, *P. chrysantha*, *P. circinata*, *P. drummondii*, *P. erecifolia*, *P. erecifolia* var. *scabriuscula*, *P. fastigiata*, *P. pendunculata*, *P. plumosa*, *P. pulchella*, *P. seminuda* and *P. sessilis*. In the remaining 4 species, namely *P. conifera*, *P. crispata*, *P. multisecta* and *P. rigida* the I-shaped sclereids, ramiform sclereids, the thick ovoid or spheroidal sclereids and the sphero-conical sclereids, respectively, are of diagnostic value (figure 7).

Of the 4 species in the section *Serruroides*, the nail-shaped sclereids of *P. divaricata* and the fusiform sclereids of *P. trifida* form distinct diagnostic cell-shapes which distinguish them from one other, and also from the two other taxa of this section which lack sclereids (figure 9).

In section *Symphyolepis* there is no difference between *P. carduacea* and *P. macrostachya* in their ramiform and spheroidal sclereids. *P. diversifolia* possesses distinct I-shaped sclereids whereas *P. shuttleworthiana* is devoid of sclereids (figure 8).

P. semifurcata is placed under a monotypic section, *Hebegyne* because of the formation of the fusiform ending of the style. Furthermore, the gnarlyform sclereids found in this species in all probability supports a distinct place for this species under this section (figure 6).

6. Taxonomic considerations

(In *P. acicularis* R. Br. the bract and style are similar to those of *P. media* R. Br. but the longitudinal ribs of the cone scales are always more prominent and the leaves more slender (Bentham 1870). Likewise the ramiform sclereids of *P. acicularis* are similar to those of *P. media* but the branching system of the sclereids in both of them are different and appears to be of diagnostic value in distinguishing them from one other.

In *P. circinata* the cone scales appear to be deciduous and the involucre large and persistent as in *Isopogon latifolius* R. Br. The perianth, style and nut are characteristic of those of *Petrophile*. The lamina of *P. circinata* is devoid of sclereids whereas in *Isopogon latifolius* there are polymorphic sclereids showing extended arms of unequal size (Rao and Das 1981).

P. erecifolia R. Br. is considered a distinct species despite its resemblance to *P. inconspicua* Meisn. or to *P. chrysantha* Meisn. The laminae of these species are devoid of sclereids and this feature is significant in the problem of their synonymy.

Regarding the species-specific status of *P. media* R. Br. and its variety *juncifolia* Lindl. the sclereidal features are more or less similar with differences only in the thickness of the walls. So they provide no additional evidence supporting their recognition as distinct taxa.

The absence of sclereid in *P. propinqua* R. Br. and its variety, *sericiflora* Benth. is a significant endomorphic feature, supporting their close relationship.

In the present study it has been found that the lamina of *P. inconspicua* is devoid of sclereids. Regarding this species Bentham (1870) is of the opinion "that it has so much of the character of *Isopogon*, that I should at once have transferred it to that genus were it not for the uncertainty which prevails about the shape and indumentum of the nut, besides that the style is much more that of the section *Serruroides* of *Petrophile* than of *Isopogon adenanthoides* Meisn. which is the nearest to the present species in *Isopogon*". *P. inconspicua* Meisn. is a very distinct species in lacking foliar sclereids whereas *Isopogon adenanthoides* Meisn. possesses gnarlyform sclereids in the laminae (Rao and

Das 1981). This point is significant in distinguishing the two species from each other despite their close resemblance.

The presence of ramiform sclereids in *P. linearis* R. Br. and its var. *anceps* R. Br. indicates their close alliance.

Bentham regards *P. crispata* R. Br. very closely allied to *P. drummondii* Meisn. and *P. rigida* R. Br. and perhaps a variety of the latter. The absence of foliar sclereids in *P. drummondii* and their presence in *P. crispata* and *P. rigida* deserve special attention in deciding their taxonomic status in future revision.

Bentham is of the opinion "that *P. conifera* Meisn. is very nearly allied to *P. rigida* R. Br., but they differ from each other with tomentose branches and longer cones". Their differentiation can also be observed in sclereid topology. In *P. conifera* Meisn. sclereids are I-shaped whereas in *P. rigida* R. Br. they are sub-spherical to conical base forms.

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