Table 1 *Effect of zinc deficiency on stomatal aperture, tissue hydration, water saturation deficit, water potential and proline content in leaves of cabbage plants grown in solution culture (mean values)*

	Treatment	
	Normal	Zinc deficient
Stomatal pore width (μm)	8	2
Tissue hydration (g water/ g dry wt)	6.76	3.43
Water sturation deficit (%)	5.63	10.49
Water potential (bars)	−5.7	−10.1
Proline (μ moles/g fresh wt)	0.473	1.142

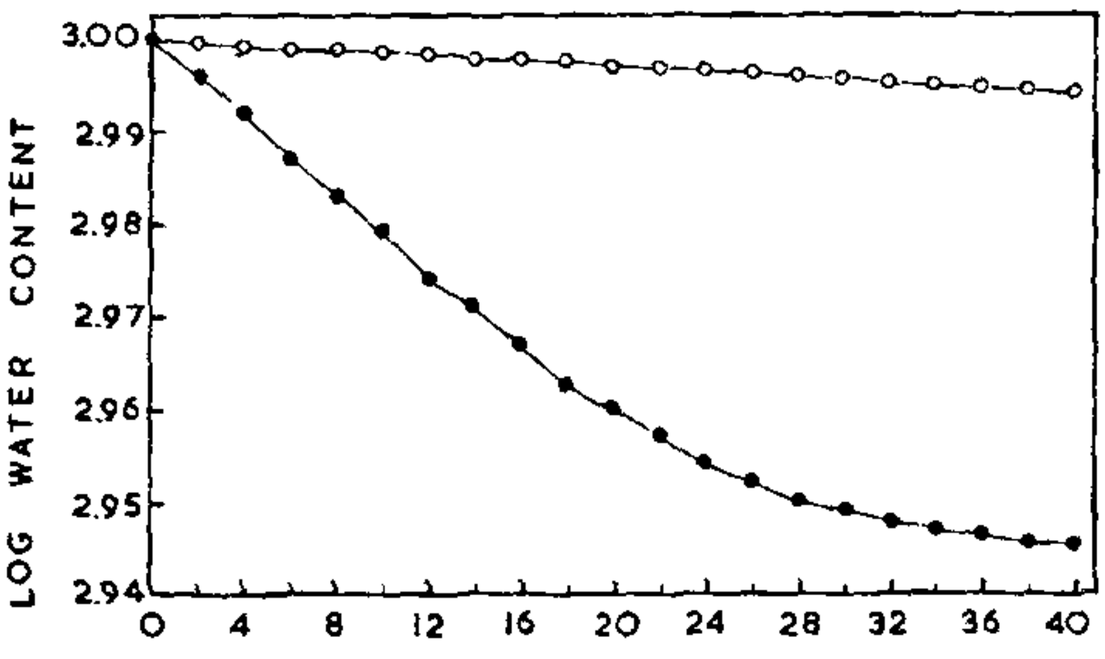

Figure 6. Water loss curves for zinc deficient (open circle) and normal (closed circle) leaves.

potential and accumulation of proline in leaves (table 1).

Compared to normal leaves, a large proportion of stomata in zinc deficient leaves remained closed and this was reflected in marked decrease in water loss (transpiration) by detached leaves of zinc deficient plants. Comparison of water loss curves of normal and zinc deficient leaves (figure 6) suggests loss of hydro-sensitivity of the stomata under zinc deficiency. This may be caused by poor mobilisation of starch to produce organic acids *via* PEP involving carbonic anhydrase[4]. Leaves of zinc deficient cabbage plants were found earlier to show low activity of carbonic anhydrase and increased accumulation of starch[1].

15 May 1983; Revised 13 August 1983

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ON FOLIAR SCLEREIDS IN *ASTEROPEIA* THOU.

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THE utility of foliar sclereids as diagnostic features and their value in assessing the affinities of taxonomic categories are well known[1]. The present paper deals with details of distribution of leaf sclereids and their typology in six species of *Asteropeia*, in addition to providing a key to the species and an evaluation of the totality of useful endomorphic features.

The six species of *Asteropeia* investigated possess diffuse foliar sclereids. Some species have only spheroidal or sub-spheroidal type of sclereids while others have both ramiform and sub-spheroidal types. Their location inside the mesophyll is found to be useful at species levels.

Asteropeia, a genus of anomalous taxonomic status has c.7 species confined to Madagascar. The leaf specimens for this investigation were obtained as a gift through the courtesy of the Director, Museum National D'Histoire Naturelle, Laboratoire De Phanerogamie, (P), Paris. The following vouchered specimens have been examined:-

Asteropeia Thou: *A. ambylocarpa* Tul., Madagascar, R. Capuron 18.932 SF(P); *A. micraster* Hallier., Madagascar, Perinet 5586 SF(P); *A. multiflora* Thou., Madagascar, R. Capuron 8319 SF(P); *A. densiflora* Baker., Madagascar, R. Capuron 11.550 SF(P); *A. rhopaloides* H. Br., Madagascar, R. Capuron 8802 SF(P).

The leaf fragments were partially cleared by soaking in 5% sodium hydroxide overnight at 60°C. They were then thoroughly washed in water and treated by a mixture of trichloroacetic acid and phenol (2:1) for 10–15 min at 60°C[3] till they became perfectly transparent[2]. A few leaf fragments were hand sectioned and

also teared apart and mounted in lactophenol for camera lucida sketches.

Observations:

Diffuse sclereids occur in mesophyll as idioblasts in all specimens examined. Their relative abundance and distribution in the vicinity of the major veins are noteworthy. The sclereids of these taxa are of two main types: Spheroidal to sub-spheroidal sclereids and *ramiform* sclereids[4]. The morphological details of these forms are as follows:

Spheroidal to sub-spheroidal sclereids are observed in *A. ambylocarpa*, *A. multiflora* and *A. spherocarpa*. The sclereids are irregularly and shallowly lobed in sectional views. A striking feature in their distribution is the consistence of their occurrence at a specific level in the mesophyll. In *A. multiflora* they are confined to spongy parenchyma, whereas in *A. ambylocarpa* and *A. spherocarpa* they extend up to the palisade layer as well. In addition, the sclereids of the above said taxa show certain clear cut cytological differences as follows. In *A. ambylocarpa* they have a very thick secondary wall with a narrow or occluded lumen whereas in *A. spherocarpa*[5] they have a relatively thin secondary wall and an obviously large lumen.

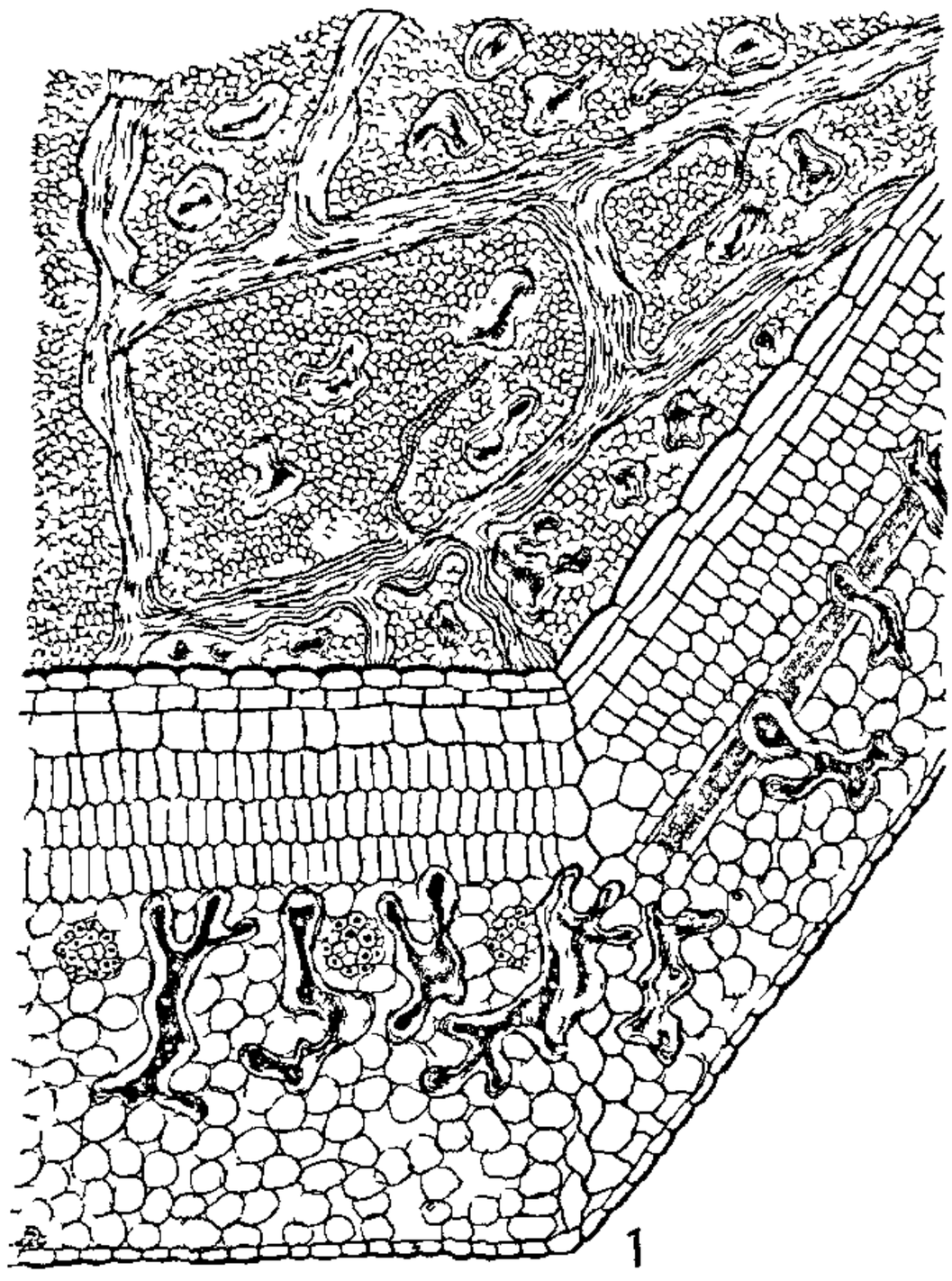


Figure. 1. *Asteropeia micraster.*: Semi-diagrammatic 3-D sketch, c. ×40 Sclereids sub-spheroidal (surface view) and ramiform in sectional view.

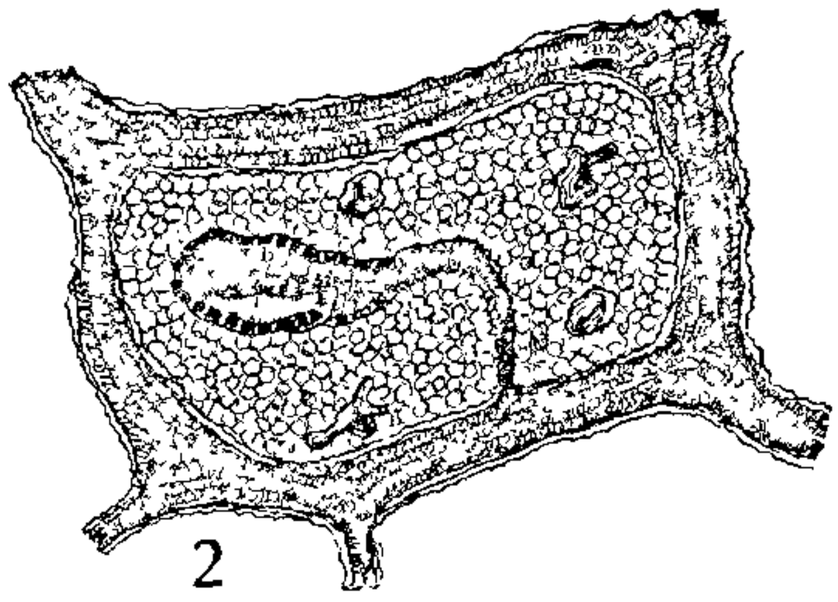
Ramiform sclereids are found in *A. densiflora*, *A. micraster* and *A. rhopaloides*. Further characterization at specific level is possible by observing their location in the mesophyll. In *A. rhopaloides* (figure 5) they are confined to palisade and spongy parenchyma whereas in *A. densiflora* (figures 2, 3) and *A. micraster* (figure 1) they are confined to a particular layer of the mesophyll. In *A. micraster* sclereids are spheroidal or sub-spheroidal in surface view but they are ramiform in sectional views (figures 1, 9, 10). They occur in the mid-mesophyll region. They have thick striated secondary walls with simple pits and a narrow lumina. In surface view they occur as scattered idioblasts in the areole and only infrequently they are observed in the vicinity of heavily sheathed vascular strands.

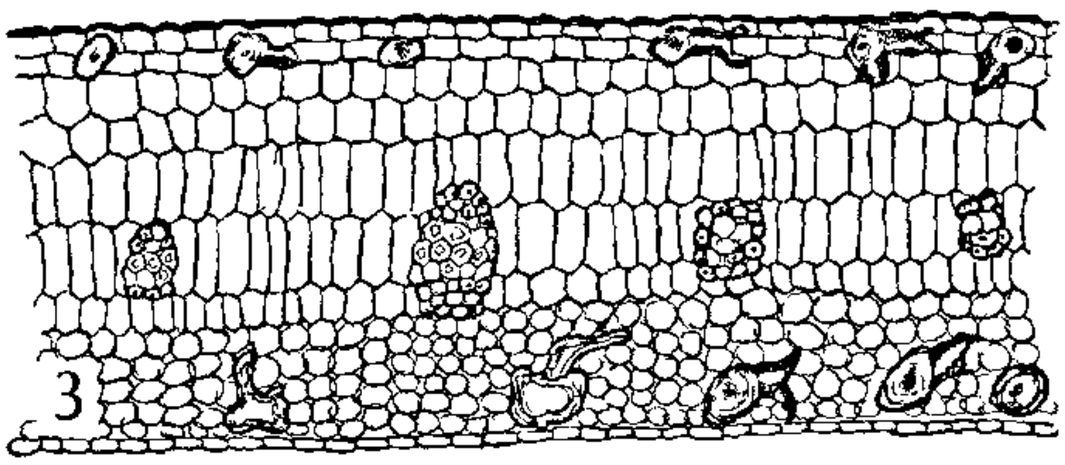
Key Character: Based on the internal distributional patterns and typology of the mesophyll sclereids, the following tentative key is prepared as an aid in the identification of the species of this genus:

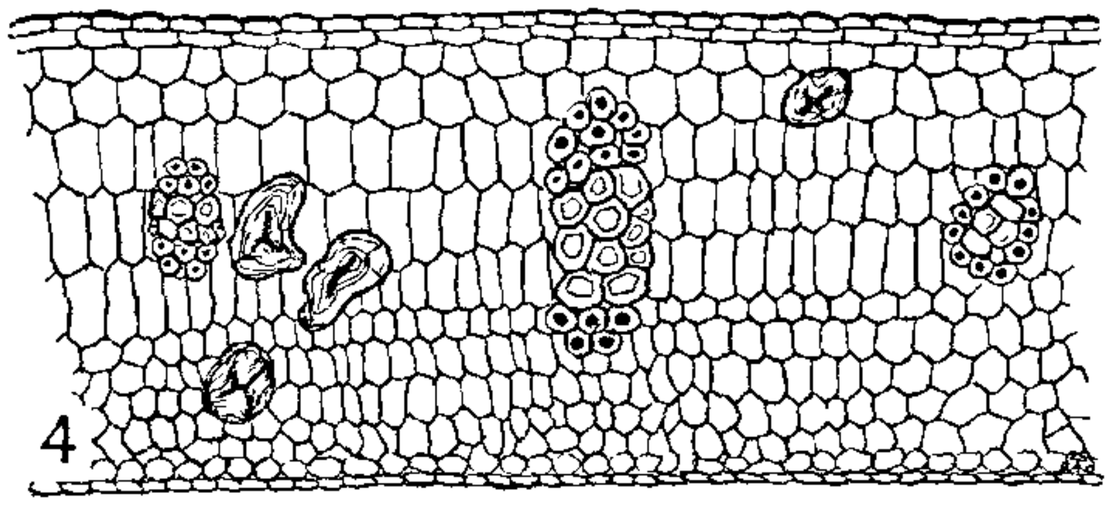
1a. Sclereids, spheroidal to lobed
  2a. Confined to palisade and spongy parenchyma.
    3a. Thin cell wall, broad lumen .....
    1. *A. spherocarpa*
    3b. Thick cell wall, narrow lumen.....
    2. *A. ambylocarpa*
  2b. Confined to spongy parenchyma.....
    3. *A. multiflora*
1b. Sclereids, ramiform
  4a. Confined to palisade and spongy parenchyma
    4. *A. rhopaloides*
  4b. Confined to a particular layer.
  5a. Hypodermal layer .....5. *A. densiflora*
  5b. Spongy parenchyma .....6. *A. micraster*

Veinlet termini: The veinlets syndrome in *A. micraster* and *A. densiflora* are of special interest (figures 2, 9, 10). Unlike the other species of this genus, the veinlets termini in both the species are characterised by helical brachy- and sclerotracheoids[6–7]. They have slightly thin or thickened cell walls and are very irregular in shape. In contrast to these tracheoides, there are also thick walled pseudo-terminal ramiform sclereids with wide lumen. Such instances are also recorded in *Boronella* of the Rutaceae[8], *Diospyros discolor* of the Ebenaceae[9], *Elytraria shaferi* of the Acanthaceae[10], *Mouriri guianensis* of the Melastomataceae[11] and *Popowia pisocarpa* of the Annonaceae[12].

The ontogeny of seemingly terminal sclereids in an otherwise diffuse patterns of sclereids recorded has



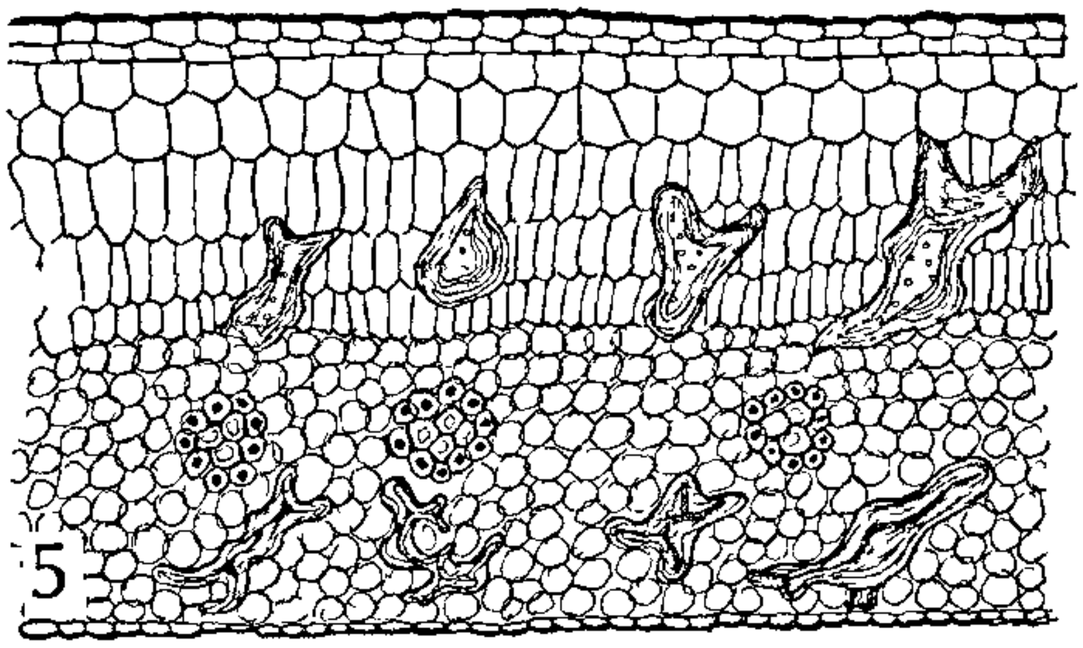


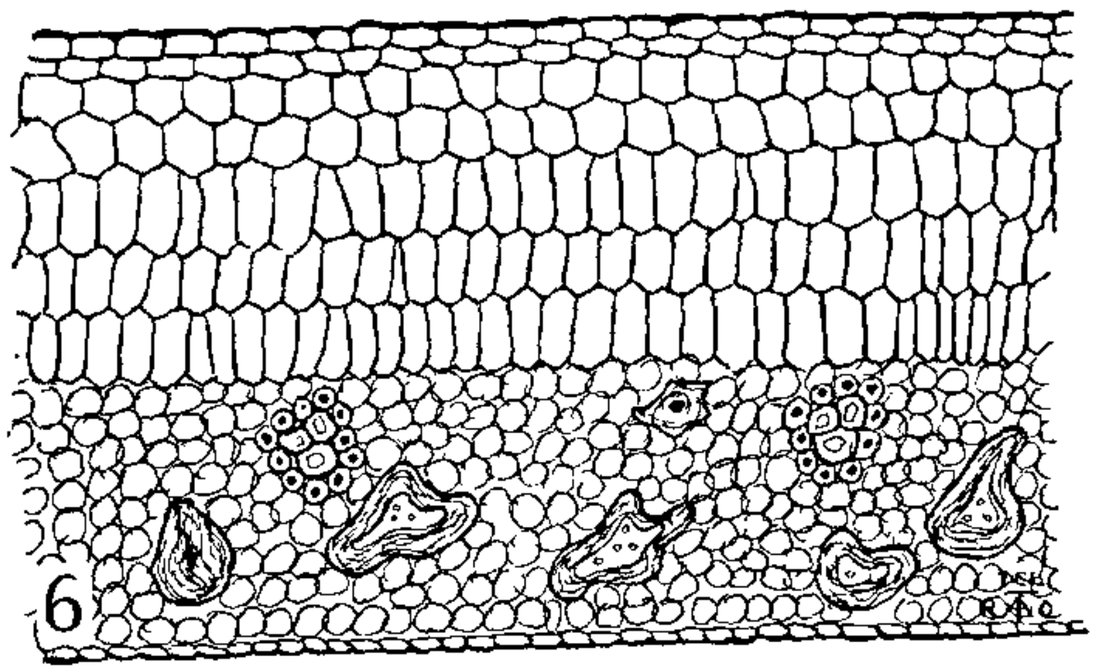


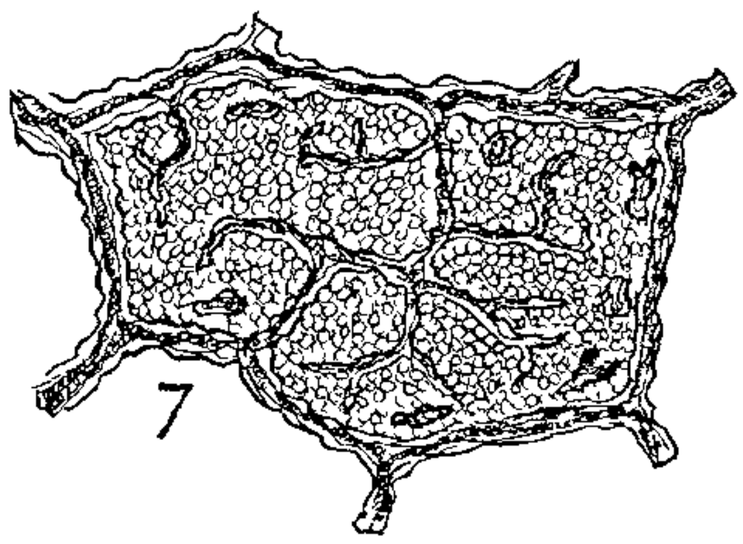
Figures 2–4. 2: *A. densiflora*; Terminal sclerotracheoid and diffuse sub-spheroidal sclereids near the vicinity of veins, × 35. **3.** *A. densiflora*; Transection of the lamina showing diffuse distribution of ramiform sclereids below the adaxial and abaxial epidermal layers, × 40. **4.** *A. ambylocarpa*; Transection of the lamina showing sub-spheroidal sclereids in the mid-mesophyll region, × 40.

revealed that they arise away from the procambial strand and their eventual terminal relationship is due to their close growth towards the vein endings.[9,13,14]

All the species of *Asteropeia* share certain common anatomical features such as adaxial and abaxial epidermal layers with prominent cuticular covering, well organised layers of adaxial hypoderm, multiple palisade layers, an extensive spongy tissue intercepted by vascular bundles surrounded by multiseriate sclerenchyma. The occurrence of foliar sclereids in all the species is an additional anatomical feature of this genus. However, there are certain differences in distribution pattern as well as the morphology of the



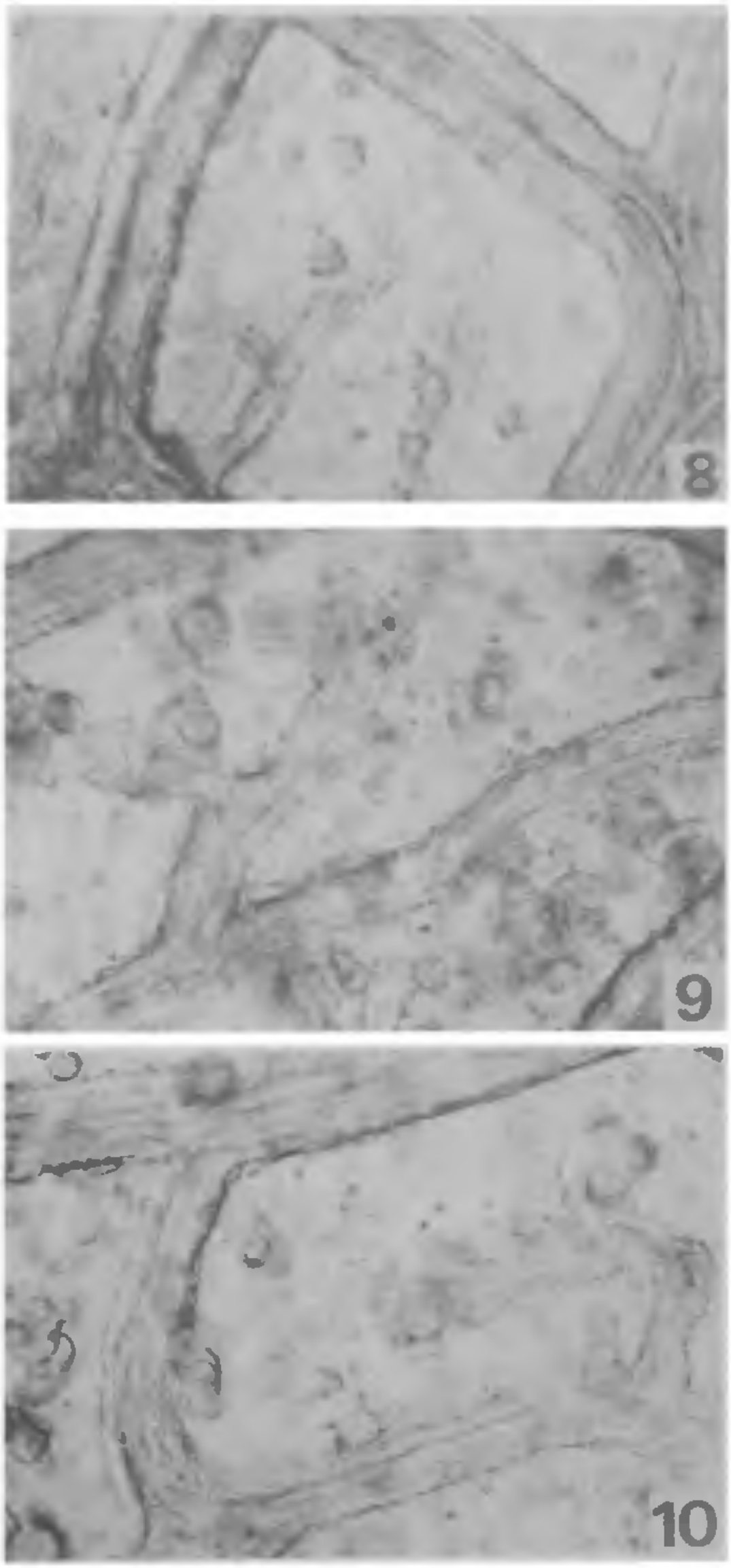




Figures 5–7. Transections of the laminae: **5.** *A. rhopaloides*. Two types of sclereids in the palisade and spongy regions respectively, × 75 **6.** *A. multiflora*. Sub-spheroidal sclereids in the spongy region, × 40 **7.** *A. ambylocarpa*; surface view showing scattered sclereids in the vicinity of viens, × 40.

sclereids which are helpful as diagnostic features to distinguish the different species of the genus. Diversity of opinion regarding the affinities of *Asteropeia*[19,20] is reflected in the different taxonomic treatments. The occurrence of sclereids in all the species and their morphology suggests a close link of *Asteropeia* to Theaceae, a family in which almost all members possess foliar sclereids[15]. However, *Asteropeia* has a syndrome of endomorphologic features that warrant assigning it to a separate family[16–18].

The authors wish to thank Dr N. Halle, Sous



Figures 8–10: Cleared laminae showing diffuse sclereids, each ×30. **8.** *A. rhopaloides*. **9 & 10.** *A. micraster*.

Directeur, Laboratoire de phanerogamie, Paris, for the gift of the leaf specimens for this study. Thanks are also due to Miss. M. Gregory, Jodrell Laboratory, Royal Botanic Gardens, Kew, England for literature and procuring technical advice. Further, we wish to thank Prof. D. A. Govindappa for facilities and the UGC New Delhi for financial help.

6 June 1983; Revised 2 September 1983

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