NODAL AND INTERNODAL VESSELS OF ACANTHACEAE

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ABSTRACT

Nodal and internodal vessels are studied in 15 species belonging to 14 genera. Vessels fall under four categories, viz.: extremely short, very short, moderately short and medium sized. The perforation plates are simple and vary from 1-3 in number in both nodal and internodal vessels. The intervascular pitting is mostly simple, rarely scalariform, reticulate and bordered. The nodal and internodal vessels exhibit similarities and differences in size, shape and number of perforation plates. The average diameter of internodal vessels in herbaceous species and nodal vessels in woody species is more than that of nodal and internodal vessels respectively.

INTRODUCTION

Shah *et al.* (1966) found that nodal vessels in *Dioscorea alata* differ from internodal vessels in size, shape, distribution and inclination of perforation plates. Surprisingly, no comparative work has been carried out dealing with nodal and internodal vessels in dicotyledons. Recently, internodal vessels have been studied in dicotyledonous families by Inamdar and Murthy, (1977), Murthy *et al.* (1978), Aleykutty and Inamdar (1978), Shenoy and Inamdar (1979), Avita and Inamdar (1980), and Murthy *et al.* (1980). The present work has thus been carried out to make a comparative study of nodal and internodal vessels in 15 species belonging to 14 genera of Acanthaceae for the first time.

MATERIAL AND METHOD

The material for the present investigation was collected from different localities of Gujarat State. The nodes and internodes were macerated following the procedure of Jane (1956). The macerated material was washed thoroughly in water, stained with Delafield's haematoxylin and mounted in glycerine jelly. The minimum to maximum range in size of vessels with average mean values of 30 readings in brackets are given. The size, number and disposition of perforation plates and adjacent wall thickening in different species are charted in table 1. Classification of vessels is adopted from Radford *et al.* (1974).

OBSERVATION

Vessels of all four categories exhibit variation in their size, shape, dimensions, number and disposition of perforation plates and adjacent wall thickenings. The observations regarding the size, shape, perforation plates and adjacent wall thickening are described under different heads as follows :

On the basis of the length the vessels can be divided into four categories, viz.: i. extremely short (less than 175 μm), ii. very short (175 to 250 μm), iii. moderately short (250 to 350 μm), and iv. medium sized (350 to 800 μm).

Table 1—Showing the size of internodal and nodal vessels, number and disposition of perforation plates and ajacent wall thickening

Sr. No.	Names of the species		Size of the vessel elements in μm								Perforation plates and adjacent wall thickening									
			Extremely short L	Extremely short D	Very short L	Very short D	Moderately short L	Moderately short D	Medium sized L	Medium sized D	Number 1	Number 2	Number 3	Disposition M	Disposition Ob	Disposition Lat	Sp	Sc-al	Spi-ral	Re-ti
1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	*Acanthus ilicifolius* (L.)	IN	—	—	228-195 (212)	50-22 (40)	297-264 (279)	48-10 (29)	436-315 (381)	47-21 (38)	—	c	—	o	c	o	c	—	—	—
		N	—	—	234-186 (209)	50-21 (31)	314-255 (274)	53-36 (43)	—	—	—	c	—	o	c	o	c	—	—	—
2	*Adhatoda vasica* Nees.	IN	172-116 (145)	43-19 (28)	243-176 (200)	38-19 (28)	324-255 (276)	40-21 (29)	—	—	—	c	r	c	r	o	o	—	c	r
		N	—	—	166-140 (152)	41-33 (36)	238-203 (224)	28-21 (22)	—	—	—	c	—	r	c	r	o	r	c	—
3	*Asystasia gangetica* (L.)	IN	—	—	233-198 (212)	55-26 (40)	312-252 (276)	48-22 (29)	—	—	—	c	—	o	c	r	c	r	—	—
		N	126-83 (109)	31-19 (22)	245-195 (224)	36-19 (27)	—	—	—	—	r	c	—	—	o	c	c	r	—	—
4	*Barleria prattensis* Sant.	IN	—	—	—	—	321-303 (297)	38-10 (22)	467-355 (398)	31-24 (27)	—	c	r	r	o	c	c	—	—	—
		N	—	—	—	—	350-252 (283)	28-24 (22)	—	—	—	c	r	d	c	c	—	—	—	—
5	*Beloperone guttata* Branegee	IN	—	—	240-193 (214)	31-19 (21)	343-264 (285)	40-22 (29)	—	—	—	c	—	o	c	r	c	—	r	—
		N	—	—	234-193 (219)	41-14 (24)	329-248 (291)	40-21 (26)	—	—	—	c	—	—	r	c	c	—	—	—
6	*Blepharis maderaspatensis* (L.) Roth	IN	—	—	236-231 (233)	24-21 (22)	319-269 (293)	41-22 (34)	525-367 (415)	41-26 (36)	—	c	—	o	c	—	c	r	—	—
		N	172-116 (143)	36-19 (29)	217-194 (205)	48-16 (33)	313-255 (284)	26-22 (24)	—	—	—	c	—	o	c	o	c	—	—	—
7	*Crossandra undulaefolia* Salis.	IN	—	—	233-186 (200)	31-24 (26)	321-248 (290)	36-05 (21)	—	—	—	c	—	r	c	o	c	r	r	—
		N	169-107 (150)	33-21 (26)	243-183 (216)	36-19 (26)	—	—	—	—	—	c	—	r	c	o	c	—	—	—

8	*Dicliptera verticillata* (Fork) Christens	IN	172-112 (153)	41-24 (31)	238-181 (209)	29-9 (22)	290-255 (274)	45-21 (31)	—	—	—	c	—	o	c	r	c	—	—	—
		N	174-69 (126)	36-19 (24)	250-178 (212)	34-22 (28)	—	—	—	—	r	c	—	r	o	c	c	—	—	—
9	*Dipteracanthus prostratus* (Poir.) Nees	IN	— —	— —	212-186 (198)	26-24 (25)	316-290 (293)	147-36 (55)	563-381 (455)	40-26 (28)	—	c	—	r	c	—	c	—	—	—
		N	—	—	241-191 (221)	36-19 (26)	346-264 (312)	33-14 (21)	—	—	—	c	—	r	o	c	c	r	r	—
10	*Hygrophila auriculata* (Schum.) Heine	IN	—	—	—	—	341-255 (321)	66-28 (45)	398-378 (388)	59-40 (48)	r	c	r	c	c	r	c	—	r	—
		N	—	—	—	—	338-255 (276)	43-19 (28)	—	—	r	c	—	o	c	o	c	—	—	—
11	*Justicia gendarussa* Burm. f.	IN	167-126 (152)	66-21 (38)	241-178 (210)	59-19 (29)	290-253 (272)	59-21 (38)	—	—	—	c	—	r	c	r	c	—	r	—
		N	162-150 (159)	55-40 (43)	216-179 (197)	62-26 (40)	303-250 (276)	48-31 (40)	—	—	r	c	—	r	c	o	c	—	r	—
12	*Peristrophe bicalyculata* (Retz.) Nees	IN	—	—	238-197 (218)	91-22 (53)	343-248 (293)	93-26 (53)	416-357 (370)	96-26 (53)	—	c	—	o	c	r	c	r	r	—
		N	147-105 (128)	31-14 (22)	243-183 (216)	45-16 (29)	—	—	—	—	—	c	—	r	c	o	c	r	r	—
13	*Pseuderanthemum bicolor* (Schrank.) Radlk. et Lindau.	IN	—	—	—	—	334-260 (205)	45-21 (38)	616-355 (279)	45-21 (33)	—	c	r	r	c	o	c	r	—	—
		N	—	—	234-178 (205)	50-31 (38)	317-264 (279)	44-12 (33)	—	—	—	c	—	r	o	c	c	—	—	—
14	*Ruellia tuberosa* L.	IN	—	—	—	—	314-297 (305)	45-40 (43)	513-350 (416)	43-9 (36)	—	c	—	o	c	—	c	r	r	—
		N	—	—	203-184 (193)	22-20 (21)	336-250 (286)	22-7 12)	—	—	r	c	—	r	o	c	c	r	—	—
15	*Seriocalyx scaber* Bremek.	IN	174-107 (145)	117-26 (74)	243-178 (212)	132-41 (55)	316-252 (291)	60-41 (52)	424-355 (397)	55-47 (52)	—	c	r	c	c	o	c	—	—	—
		N	167-143 (155)	40-22 (31)	245-207 (224)	45-43 (44)	322-255 (300)	66-31 (38)	—	—	—	c	r	r	c	c	c	—	—	—

Abbreviations : IN—internode; N—node ; L—length; D—diameter; Ob—oblique, Lat—lateral; Sp—simple pitted; Scal—Scalariform; Reti—Reticulate; C—common; O—occasional; r—rare.

Number in brackets indicate the mean value.

I SIZE OF VESSELS

(i) *Extremely short*

Internode—The length and the diameter range from 107—174 μm and 19-117 μm respectively. The shortest and the longest vessel is found in *Seriocalyx scaber*. The smallest diameter is noticed in *Adhatoda vasica* and the largest in *Seriocalyx scaber*.

Node—The length varies from 69-174 μm and the diameter from 14-55 μm. The minimum and the maximum length of the vessel is recorded in *Dicliptera verticillata*. The smallest diameter is noticed in *Peristrophe bicalyculata* and the largest in *Justicia gendarussa* respectively.

(ii) *Very short*

Internode—The length and the diameter ranges from 173-243 μm and 9-59 μm respectively. The maximum and the minimum length is noticed in *Adhatoda vasica*. The smallest diameter is observed in *Dicliptera verticillata* and the largest in *Justicia gendarussa*.

Node—The length and the diameter varies from 140-250 μm and 14 to 62 μm. The minimum diameter is noticed in *Beloperone guttata* and the minimum in *Justicia gendarussa*.

(iii) *Moderately small*

Internode—The length varies from 248-343 μm and the diameter from 5 to 147 μm. The maximum length is observed in *Peristrophe bicalyculata* and the minimum in *Crossandra undulaefolia*. The maximum diameter is noticed in *Ruellia tuberosa* while the minimum is *Crossandra undulaefolia*.

Node—The vessel of maximum length of 338 μm is noticed in *Hygrophila auriculata* and that of minimum length of 203 μm in *Adhatoda vasica*. The largest diameter of 66 μm of a vessels is observed in *Seriocalyx scaber* and that of minimum of 12 μm in *Pseuderanthemum bicolor*.

(iv) *Medium-sized*

Internode—The length varies from 616-815 μm and the diameter from 9-96 μm. The maximum length is observed in *Pseuderanthemum bicolor* and the minimum in *Acanthus ilicifolius*. The maximum diameter is notied in *Peristrophe bicalyculata* while the minimum in *Ruellia tuberosa*.

Node—The nodal vessels falling in this category are not observed.

II SHAPE OF VESSELS

Internode—The shape of vessels differ even in the same species. The internodal vessels may be cylindrical (Pl. 1 : A, B, G, N), tubular (Pl. 1 : J, 0-Q), conical (Pl. 1 : E) and rhomboidal (Pl. 1 : C).

Node—The nodal vessels may be branched or unbranched. The branched nodal vessels exhibit a branching at different levels. The branching may be in the form of a small protuberance at midway of a vessel (Pl. 2 : A) at one end of a vessel (Pl. 2 : B), a small arm near one end (Pl. 2 : C), two unequal arms at one end (Pl. 2 : D) or two nearly equal arms at one end (Pl. 2 : E). Due to branching at different levels, the branched nodal vessels vary in their shapes.

The unbranched vessels also exhibit different shapes. They may be tubular

(Pl. 2 : F, N), fusiform (Pl. 2 : M), slipper shaped (Pl. 2 : K), weaver-bird's nest like (Pl. 2 : G).

III Perforation Plates

Internode—All the vessels manifest exclusively simple perforation plates. A vessel with two perforation plates is a common feature. The perforation plates vary in their arrangement. They may be one at each end (Pl. 1 : A, B, D, G, J, K, M, N), both at one end (Pl. 1 : I) and one at one end and other in the centre (Pl. 1 : C, F, H, L). The vessels with three perforation plates are occasionally observed in *Pseude-ranthemum bicolor* (Pl. 1 : P), *Peristrophe bicalyculata* and *Crossandra undulaefolia*. A vessel with single perforation plate which is seldom noticed in *Dipteracanthus prostratus* (Pl. 1 : O).

Node—Usually the vessels exhibit two perforation plates. But occasionally those with a single perforation plate are also observed (Pl. 2 : A, C, D, E, O). Vessels with three perforation plates are rarely observed.

IV End Wall

Internode—The end wall appears to be round or truncate (Pl. 1 : B, J, N) or elongated and tapering (Pl. 1 : E-H, K, O-R). In some cases the perforation plate is at the end of a vessel and the boundary is clear, therefore the term end wall stands as a synonym to the perforation plate while in others the perforation plate is only a part of the end wall (Pl. 1 : A, C, E, F, H, I, L, M, O-R) and therefore the term end wall as a synonym to the perforation plate is not applicable.

Node—The end wall in nodal vessels may be round (Pl. 2 : D, F, H, J, K) or elongated and tapering (Pl. 2 : A, C, F).

V Adjacent Wall Thickening

Internode—In all the investigated species simple pitting is commonly observed. The arrangement of simple pits may be either alternate (Pl. 1 : B, C, I) or opposite (Pl. 1 : F, H). Scalariform pitting is observed in *Dipteracanthus prostratus* (Pl. 1 : A), *Asystasia gangetica* (Pl. 1 : Q, R) and reticulate in *Peristrophe bicalyculata* (Pl. 1 : N).

Node—In nodal vessels too, simple pitting is common in all species investigated. The arrangement of simple pits may be alternate (Pl. 2 : I, M) or opposite (Pl. 2 : A, L). Scalariform pitting is observed in *Crossandra undulaefolia* (Pl. 2 : F) and *Asystasia gangetica* (Pl. 2 : K). Bordered pits are observed in *Peristrophe bicalyculata* (Pl. 2 : N) which is a significant feature noticed here. The arrangement of border pits is opposite as well as alternate in the same vessel.

DISCUSSION

According to Metcalfe and Chalk (1950) the vessels in the Acanthaceae are typically very small (less than 50 μm mean tangential diameter). The present observations are at variance with those of these authors regarding the size (*see* Table 1). Diversity regarding size, shape, distribution, disposition and number of perforation plates have been noticed in nodal and internodal vessels. The present observations are in accordance with those of Shah *et al.* (1966). Branched vessels occur occasionally in nodes and rarely in internodes. The adjacent wall thickening is mostly simple, rarely border pitted in nodal vessel of *Peristrophe bicalyculata*, scalariform in *Dipteracanthus prostratus, Asystasia gangetica, Peristrophe bicalyculata* and reticulate in *Peristrophe bicalyculata.*

ABBE AND ABBE (1971) pointed out that differences in habitat have minor influence on dimensional characteristics of vessel members. This may be true for habitat, but not for habit. It has been observed that the average diameter of internodal vessels of herbaceous species is more than that of nodal ones. Whereas the average diameter of nodal vessels of woody species (shrubs and undershrubs) is more than that of internodal ones.

In conclusion it may be stated that : (i) single perforation plate is occasional in nodes and rare in internodes, (ii) three perforation plates are occasional in internodes and rare in nodes, and (iii) branching of vessels is occasional in nodes and rare in internodes.

Trend of specialization is towards vessels with mostly round or truncate end wall, simple perforation plate/s and simple pitted adjacent wall thickening.

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REFERENCES

ABBE, L. B. & ABBE, E. C. (1971). The vessel member of *Myrica esculenta* Buch-Ham. *J. Minnesota Acad.*, **37**(2-3) : 72-76.

ALEYKUTTY, K. M. (Sr. Avita) & INAMDAR, J. A. (1978). Studies in the vessels of some Capparidaceae. *Flora*, **167** : 103-109.

AVITA & INAMDAR, J. A. (1981). Diversity in the vessel elements of Ranunculaceae and Paeoniaceae complex. *Fedes Repert.*, **92**(5-6) : 397-411.

INAMDAR, J. A. & MURTHY, G. S. R. (1977). Vessels in some Solanaceae. *Flora*, **166** : 441-447.

JANE, F. W. (1956). *The structure of wood.* The Macmillan Co., New York.

METCALFE, C. R. & CHALK, L. (1950). *Anatomy of Dicotyledons. I.* Clarendon Press, Oxford, London.

MURTHY, G. S. R., ALEYKUTTY, K. M. (Sr. Avita), RAO, V. S. & INAMDAR, J. A. (1978). Vessels in the Oleaceae and Verbenaceae. *Feddes Repert.*, **89** (5-6) : 359-368.

MURTHY, G. S. R., INAMDAR, J. A. & RAO, V. S. (1980). Organographic study of vessels in some Solanaceae. *Phytomorphology*, **30** (2-3) : 149-158.

RADFORD, A. E., DICKSON, N. C., MASSEY, J. R. & BELL, C. R. (1974). *Vascular plant systematics.* Harper & Row Publishers, New York.

SHAH, J. J., POULOUSE, K. V. & UNNIKRISHNAN, K. (1966). Nodal vessels in *Dioscorea alata* L. *Curr. Sci.*, **35** : 183-184.

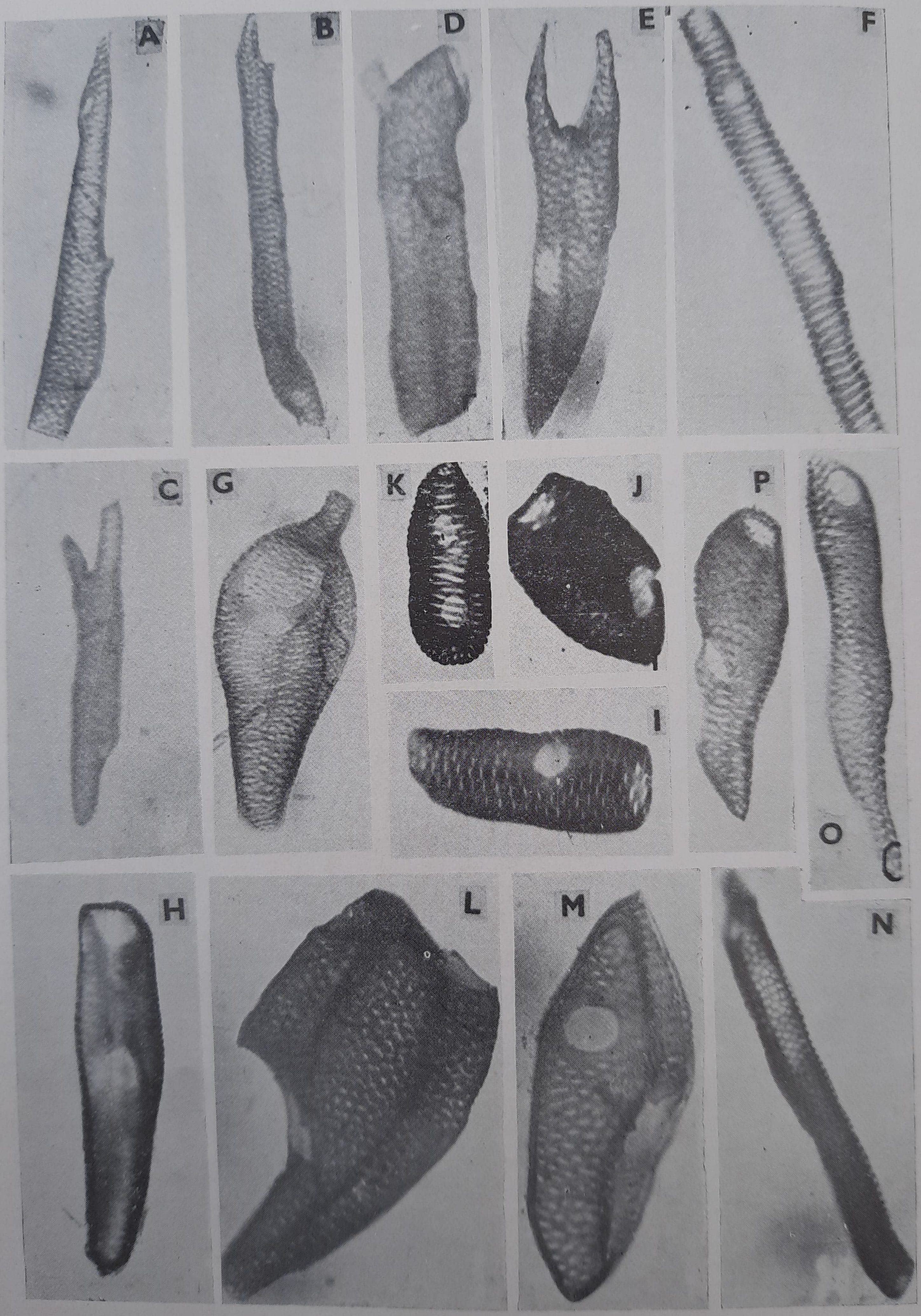
SHENOY, K. N. & INAMDAR, J. A. (1979). Vessel elements in the Convolvulaceae. *Histochemistry, Developmental and Structural Anatomy of Angiosperms—A symposium.* : 237-244.

EXPLANATON OF PLATES

PLATE 1

A—R	: Internodal vessels	
A, O	: *Dipteracanthus prostratus*	×314; ×340
B, P	: *Pseuderanthemum bicolor*	×214; ×214
C, H, M	: *Seriocalyx scaber*	×274; ×214; ×228
D, G, K,	: *Ruellia tuberosa*	×314; ×314; ×314
E	: *Adhatoda vasica*	×214


A
B
C
D
E
F
G
H
I
J
K
L
R
Q
P
O
N


A
B
D
E
F
C
G
K
J
P
I
O
H
L
M
N

F, I, J	: *Acanthus ilicifolius*	: ×214; ×228; ×228
L	: *Crossandra undulaefolia*	×314
N	: *Peristrophe bicalyculata*	×228
Q, R	: *Asystasia gangetica*	×340; ×910

PLATE 2

A—P	: Nodal vessels	
A—E	: *Peristrophe bicalyculata*	×450
M, N	: *Perist ophe bicalyculata*	×910
F	: *Crossandra undulaefolia*	×500
G	: *Hygrophila auriculata*	×340
H	: *Seriocalyx scaber*	×365
I, J	: *Barleria prattensis*	×365
K	: *Asystasia gangetica*	×450
L	: *Justicia gendarussa*	×450
O, P	: *Ruellia tuberosa*	×525