VESTURED PITS IN THE TRIBE CASSIEAE BRONN (LEGUMINOSAE)

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Summary

The woods of 15 genera of the tribe Cassieae and 4 genera of the Cercideae were studied for presence or absence of vestured pits. Vestured pits are absent from the subtribes Dialiinae, Duparquetiinae and Labicheinae and from all Cercideae studied. These results are compared with variation patterns in other wood anatomical features and discussed in terms of tribal delimitation and affinities between subtribes in this part of the Leguminosae.

Key words: Leguminosae, Caesalpinioideae, Cassieae, Ceratoniinae, Dialiinae, Duparquetiinae, Labicheinae, wood identification, vestured pits.

Introduction

Since I. W. Bailey's classical work on vestured pits in 1933, the Leguminosae have been regarded as a family in which all species have vestured pits except for those in *Cercis* L. and *Bauhinia* L. (tribe Cercideae). Recent reports confirm that *Koompassia,* another genus in Leguminosae, lacks vestured pits (Quirk, 1983; Quirk & Miller, 1983). The absence of vestured pits might initially suggest that *Koompassia* in subtribe Dialiinae of tribe Cassieae belongs in or is closely related to the tribe Cercideae. It is possible that other taxa in the subtribe Dialinae or even the tribe Cassieae might lack vestured pits. To answer this question, we examined taxa in the tribe Cassieae (Irwin & Barneby, 1981) and Cercideae (Wunderlin et al., 1981) for the presence of vestured pits. In each specimen numerous intervascular and vessel-ray pits were examined for vestures with the scanning electron microscope (SEM) and light microscope.

Materials and Methods

We obtained 84 specimens of 33 species representing 15 genera in the tribe Cassieae and 10 specimens of 9 species representing 4 genera in the tribe Cercideae (Table 1). Unavailable for study were specimens of the genera *Baudouinia, Eligmocarpus, Kalappia, Mendoravia,* and *Zenia* of the tribe Cassieae and *Adenolobus* of the tribe Cercideae.

In the previous study on *Koompassia* (Quirk & Miller, 1983) heavy encrustations were encountered on the pit membrane and/or chambers, especially in the heartwood. To avoid these encrusting substances, we selected sapwood specimens where possible. Bailey in 1933 noted that 'punctate appearances may be produced at times by extraneous or coagulated material which accumulates in the bordered pits during post mortem changes and particularly during the transformation of sapwood into heartwood.' The pseudovestures or vesture-like structures are soluble in mild solvents and are not an integral part of the cell wall (Bailey, 1933; Gale, 1982). Exley et al. (1974) and Gale (1982) evaluated various chemicals for cleaning the wood of encrusting debris. Sodium hypochlorite or household bleach was shown to be very effective in freeing open pits from encrustation (Exley et al., 1974) and not degrading vestures (Gale, 1982).

For SEM examination, heartwood or sapwood samples were split to expose radial and tangential faces. For examination of the heartwood specimens, one split face was bleached and one was not. The split surface was soaked in standard household bleach (0.5% sodium hypochlorite) until the surface lost its colour. The bleaching was then neutralised by flooding the treated surface with several changes of water. Specimens were examined both bleached and unbleached to confirm that sodium hypochlorite does not degrade vestures.

Hand and microtome sections of several species were examined in water mounts using a light microscope. Vessels having apparent vestured pits were photographed. Lens tissue was then used to draw off the water and sodium hypochlorite was wicked under the cover slip. The same unbleached vessel pits previously photographed were rephotographed after bleaching.

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* The Laboratory is maintained at Madison, Wisconsin, in cooperation with the University of Wisconsin, Madison, U. S. A.

Results and Discussion

We determined the presence or absence of vestured pits for all specimens examined using the SEM (Table 1). Genera with distinct vestured pits in the tribe Cassieae include *Ceratonia* (Fig. 5) in the monotypic subtribe Ceratoniinae and *Cassia, Chamaecrista,* and *Senna* (Figs. 6–10) in the subtribe Cassiinae. Genera without vestured pits in the tribe Cassieae include *Duparquetia* in the subtribe Duparquetiinae (Fig. 22), *Labichea* and *Petalostylis* in the subtribe Labicheinae (Figs. 23, 24), and *Androcalymma, Apuleia, Dialium, Dicorynia, Distemonanthus, Koompassia. Martiodendron,* and *Storckiella* in the subtribe Dialiinae (Figs. 11–21). In the tribe Cercideae all four genera (*Cercis, Griffonia, Bauhinia, Brenierea*) examined lack vestured pits (Figs. 25–30).

Vestures and pseudovestures

Many specimens in the subtribe Dialiinae appeared vestured when viewed under the light microscope, but SEM observation clearly showed that they lacked vestures. Pseudovestures or apparent vestured pits are seen in a vessel element of *Dialium* (Fig. 1) and in a vessel element of *Apuleia* (Fig. 3), which are water mounts of hand sections viewed at x 650. The identical vessel elements are free of pseudovestures after 7 minutes treatment with household bleach (Fig. 2, *Dialium;* Fig. 4, *Apuleia).* Split heartwood surfaces, gold-coated and examined in the SEM clearly showed no vestures in *Apuleia* (Fig. 12) nor in *Dialium* (Fig. 13).

We found that treating with sodium hypochlorite while viewing through the microscope caused considerable distortion to the hand and microtome sections. We might have a section with several vessel elements clearly showing pseudovestures only to find these elements were unrecognisable after bleach was applied, either because of movement of the elements, settlement of debris from the bleaching action, or actual maceration of the section. Rolling, curling, or some movement of the elements most often hindered obtaining light photomicrographs of the identical pits on the same vessel element both before and after bleaching.

Bailey (1933) stated that in a species with vestured pits the vesturing is present on every intervascular pit throughout the tree. In our experience, when examining longitudinal sections with the light microscope, it is not always possible to see vestures on every pit. Pit size, the condition of the sample, or the way in which the vessel wall was sectioned occasionally made additional searching necessary, and sometimes several vessel walls had to be examined to find evidence of vesturing. On the other hand, in the taxa that were not vestured, often sufficient pseudovestures were present to cause pits, especially in the heartwood, to look vestured (Fig. 29). Bleaching unmasked these as pseudovestures in Dialiinae, Labicheinae, and Cercidinae. No pseudovestures were seen in *Duparquetia.* Most pseudovestures found during the light microscope survey were in heartwood specimens.

From our experience with the swelling and distortion of the wood resulting from wetting and bleaching, it was questionable if we could obtain before and after bleaching photos with the SEM because of the need to coat the specimens with a metal. Figure 7 shows vestured pits of *Chamaecrista* taken on a normally prepared surface (a dry split face coated with 20 nm of gold). Figure 8 shows the identical vessel, same area of vestured pits, after bleaching with sodium hypochlorite. We are more than hesitant to say we are seeing the same pits. Comparison with the same area of pitting on the identical vessel segment in Figure 7 makes the distortion caused by the subsequent wetting-bleaching-redrying obvious. Nevertheless, vestures are readily apparent.

In the SEM survey we found that it was not a necessity to bleach the specimens to find proof that the sample lacked vestures. When unbleached specimens were examined, we always found areas where the encrusting substance had been pulled or broken away exposing the nonvestured pit. In some taxa of the Dialiinae the pit membrane sometimes had heavy encrustations. However, the matching bleached faces were clean and free of debris, and obviously free of vestures (Figs. 14, 16, 18, 20). Quantitatively, *Dialium platysepalum* and *Koompassia,* which are southeast Asian woods, are the most heavily encrusted of all the taxa examined.

Anatomical relationships

Based on the presence or absence of vestured pits and other wood anatomical features, we found that the tribe Cassieae is composed of at least two major groups. Group I, which is composed of the subtribes Ceratoniinae and Cassiinae, has vestured pits, nonstoried rays, and often septate fibres; whereas, Group II, which is composed of the subtribes Duparquetiinae, Labicheinae, and Dialiinae, has nonvestured pits, storied or nonstoried rays, and nonseptate fibres (Table 2).

Within Group I, subtribe Ceratoniinae is quite similar to subtribe Cassiinae. Only the presence of heterocellular rays and the lack of aliform or confluent axial parenchyma in Ceratoniinae separates Ceratoniinae from Cassiinae (Table 2). In fact, because of the wide variation of axial

Table 1. Occurrence of vestured pits in tribes Cassieae and Cercideae.

Species	Material	Vestures	Collections and Xylarium
Tribe CASSIEAE*			
Subtribe Ceratoniinae			
Ceratonia siliqua	heartw.	present	Crete (MADw 17878)
	sapw.	present	FIw 1972 (MADw 26447)
Subtribe Cassiinae			
Cassia fastuosa	heartw.	present	Krukoff 6989(MADw 12764) – Capucho 395 (MADw 32071)
C. ferruginea	heartw.	present	Brazil For. Serv. 3251 (MADw 13385)
C. grandis	heartw./ sapw.	present	L1. Williams 9126 (MADw 15926)
C. javanica	heartw.	present	SH 236 (MADw 21652)
Senna atomaria	juv.	present	Hansen & Nee 1450 (MADw 36722)
S. ruiziana	juv.	present	L1. Williams 7067 (MADw 321 11)
S. spinescens	juv.	present	Maguire 47013 (MADw 20120)
Chamaecrista apoucouita	juv.	present	Irwin 2400 (MADw 18496)
C. bracteolata	juv.	present	Irwin 2461 (MADw 18497)
C. desvauxii	juv.	present	Irwin et al. 9274 (MADw 36442)
Subtribe Dialiinae			
Androcalymma glabrifolium	heartw.	absent	Krukoff 9005 (MADw 18042)
Apuleia leiocarpa	sapw.	absent	Brazil For. Serv. 20 (MADw 13101) – Krukoff 5542 (MADw 19090)
	heartw.	absent	Field Museum 9058 (MADw 25189) – RBw 1678 (MADw 20435)
Dialium aubrevillei	sapw.	absent	Detienne 55 (MADw 36787)
D. dinklagei	sapw.	absent	Detienne 222 (MADw 36927)
D. guianense	sapw.	absent	Whitford & Silveira 60 (MADw 10757) – Krukoff 4908 (MADw 18581) – Krukoff 1589 (MADw 31866) – Krukoff 8430 (MADw 31868)
D. guineense	sapw.	absent	Detienne 154 (MADw 36871)
D. patens	sapw.	absent	KEP 32365 (SJRw 29145)
D. platysepalum	heartw./ sapw.	absent	F.R.I. Buitenzorg (MADw 7155)
„ „	heartw.	absent	F.R.I. Buitenzorg (MADw 7250) – F.R.I. Kepong (MADw 9126) – KEP 13308 (MADw 31878)
„ „	sapw.	absent	KEP 13308 (MADw 31878) – KEP 36606 (SJRw 29284) – KEPw 1929 (SJRw 32985) – KEP 72178 (SJRw 51735)
D. zenkeri	sapw.	absent	I.N.E.A.C. 3219 (MADw 17309)
Dicorynia guianensis	heartw.	absent	BBS 44 (MADw 3934) – Surinam (MADw 18472) – Beccari 784 (MADw 26254)
„ „	sapw.	absent	BAFOG 323M (SJRw 50940)
„ „	heartw./ sapw.	absent	BAFOG 325M (SJRw 50942)
D. paraensis	heartw.	absent	Ducke 51 (SJRw 20995)
Distenionanthus benthaminus	heartw.	absent	PRFw 22a (MADw 2449) – Minist. de Colonies 25 (MADw 6562) – Ivory Coast (MADw 14741) – Conserv. of For. (MADw 31819)
	heartw./ sapw.	absent	Detienne 60 (MADw 36792) – Vigne 1653 (SJRw 19737)

(Table I continued)

Species	Material	Vestures	Collections and Xylarium
Koompassia borneensis	heartw.	absent	Dentzman a1515 (SJRw 48025)
K. excelsa	heartw.	absent	Bur. of For. P.I. 291 (SJRw 2341) – Bur. of For. P.I. 4932TS (SJRw 5867) – A. Wilson (MADw 16568) – KEP 10634 (SJRw 28674) – KEP 4859 (SJRw 28675) – KEP 7701 (SJRw 28679) – SAN A3508 (MADw 31690) – Piccioli 366 (SJRw 33846) – KEP 67452 (SJRw 51726) – KEP A2675 (SJRw 51876)
„ „	sapw.	absent	Dentzman a1501 (MADw 14285)
K. malaccensis	heartw.	absent	Foxworthy (SJRw 6288) – For. Dep. Java (MADw 7248) – For. Dep. Java E550 (SJRw 8198) – For. Res. Office 26 Kuala Lumpur (SJRw 12599 & 12643) – KEP 4628 (SJRw 28676) – KEP 2498 (SJRw 33008) – F.R.I. Kepong (MADw 9125) – Fed. Malay States (SJRw 33940) – PRFw 9597 (MADw 16817) – For. Dep. Java (SJRw 39454) – KEP 64208 (SJRw 51723)
,, ,,	sapw.	absent	KEP 17281 (SJRw 29174) – KEP 72173 (SJRw 51734) – Craven & Schodde 1058A (MADw 29445)
Martiodendron elatum	heartw./ sapw.	absent	Capucho 477 (MADw 18067)
M. excelsum	heartw./ sapw.	absent	RBw 2677 (MADw 18069)
M. parviflorum	heartw.	absent	Stahel 145 (MADw 18045) – Lindeman 6837 (MADw 18216)
M. sp.	heartw.	absent	Curran 1918 (MADw 18044)
M. sp.	heartw.	absent	Colombia (MADw 19224)
Storckiella pancheri	heartw.	absent	New Caledonia 18205 (SJRw 14315)
Subtribe Duparquetiinae			
Duparquetia orchidaceae	juv.	absent	Cooper 64 (SJRw 13714)
Subtribe Labicheinae			
Labichea lanceolata	juv.	absent	Maslin 5436 (MADw 40846)
Petalostylis millefolium	juv.	absent	Maslin 5394 (MADw 40845)
Tribe CERCIDEAE**			
Subtribe Cercidinae			
Cercis canadensis	heartw.	absent	Koehler (MADw 2720)
C. occidentalis	heartw.	absent	Opdyke 1458 (MADw 12249)
C. siliquastrum	heartw.	absent	Chudnoff 34 (MADw 17419)
Griffonia simplicifolia	heartw.	absent	Vigne 2432 (SJRw 23234)
Subtribe Bauhiniinae			
Bauhinia cumingiana	heartw.	absent	Bur. of For. P.I. 17574 (MADw 5525)
B. malabarica	heartw.	absent	Drysdale C821 (MADw 1492)
B. retusa	heartw.	absent	Thompson C1160 (MADw 1493)
B. vahlii	heartw.	absent	FI 505 (MADw 26183) – Field Museum 3124 (MADw 32254)
Brenierea	twig	absent	Fosberg 52447

* After H.S. Irwin and R.C. Barneby (1981). – ** After R.P. Wunderlin, K. Larsen and S.S. Larsen (1981).

Table 2. Selected anatomical features in tribes Cassieae and Cercideae.

Scientific names	Vestured pits[1]	Septate fibres[1]	Rays			Axial parenchyma[3]
			Storied[1]	Type[2]	Width (cells)	
Tribe CASSIEAE[4]						
Group I						
Subtribe Ceratoniinae						
Ceratonia	+	+		Ht	2–4	Mar, Vas
Subtribe Cassiinae						
Cassia	+	+		Mostly Ho	1–4	Mar, Band, Vas, Ali, Con
Chamaecrista	+	+		Mostly Ho	1–4	Mar, Band, Vas, Ali, Con
Senna	+	+		Mostly Ho	1–4	Mar, Band, Vas, Ali, Con
Group II						
Subtribe Dialiinae						
Androcalymma	–	–	–	Ho	2–3	Band
Apuleia	–	–	+	Ht	2–4	Band, Ali, Con
Dialium	–	–	+	Ho	2–3	Band
Dicorynia	–	–	+	Ht	2–3	Band, Ali, Con
Distemonanthus	–	–	+	Ht	3–4	Band, Ali, Con
Koompassia	–	–	±	Ho–Ht	2–3	Band, Ali, Con
Martiodendron	–	–	+	Ho	2–3	Band, Ali, Con
Storckiella	–	–	±	Ho	1–2	Band
Subtribe Duparquetiinae						
Duparquetia	–	–	–	Ht+	2–3	Band
Subtribe Labicheinae						
Labichea	–	–	–	Ht+	1–2	Mar
Petalostylis	–	–	–	Ht+	1–2	Band, Vas, Ali, Con
Tribe CERCIDEAE[5]						
Subtribe Cercidinae						
Cercis	–	–	±	Ho	3–6	Mar, Vas
Griffonia	–	–	–	Ht+	2–3	Band
Subtribe Bauhiniinae						
Bauhinia	–	±	±	Ho–Ht+	1–2	Band, Vas, Ali, Con

[1] + = generally present, – = generally absent, ± = variable.
[2] Ho = homocellular, Ht =heterocellular rays with generally one row of upright cells, Ht+ = heterocellular rays with more than one row of upright ray cells.
[3] Mar =irregular marginal banded, Band = apo–paratrachealbanded, Vas = vasicentric, Ali =aliform, Con = confluent.
[4] Sensu Irwin & Barneby (1981).
[5] Sensu Wunderlin et al. (1981).

parenchyma patterns and ray types in Cassiinae, some species of the *Cassia* complex are nearly indistinguishable from *Ceratonia.*

Within Group II, our investigation indicates that subtribe Dialiinae is composed of genera with a similar wood structure (Table 2). Baretta-Kuipers (1981), who studied the wood anatomy of Leguminosae, and Irwin and Barneby (1981), who revised the tribe Cassieae, both stated that Dialiinae constitute a natural group that belongs together. Of the eight genera examined in Dialiinae, seven have storied rays;

only *Androcalymma* has nonstoried rays. The ray type is either homocellular, heterocellular with one row of upright cells or homocellular to occasionally heterocellular, and the ray width is (1) 2–3 (4) cells. Axial parenchyma is more or less banded in all genera. Koeppen (1980) found four silica-accumulating genera in Dialiinae (*Apuleia, Dialium, Dicorynia,* and *Distemonanthus*). These four genera accumulate silica in axial parenchyma cells and/or marginal ray cells, but not in procumbent ray cells. The other genera in Leguminosae that accumulate silica do so in procumbent ray cells, but not in axial parenchyma cells. In addition, Koeppen (1980) noted that *Apuleia* (South America) and *Distemonanthus* (Africa) are the only genera in Leguminosae that contain the 'clinker' or irregular shaped silica bodies and the combination of prismatic crystals and silica bodies.

The wood in subtribe Labicheinae in Group II differs from the wood of Dialiinae. Subtribe Labicheinae has nonstoried rays that are heterocellular with generally more than one row of upright cells and are only 1–2 cells wide. The axial parenchyma is banded in *Petalostylis,* but *Labichea* has only irregular marginal bands. Both these genera are shrubs and only one specimen of each was available for study which might account for some anatomical differences. Nevertheless, we conclude that Labicheinae is a natural group, distinct from Dialiinae but allied to it.

The monotypic subtribe Duparquetiinae of Group II seems out of place in the tribe Cassieae. ***Duparquetia*** has nonstoried rays that are heterocellular with more than one row of upright cells and they are 2–3 cells wide. The axial parenchyma is banded. These features resemble Labicheinae, but *Duparquetia,* a bush-rope from Africa, has a definite liana-type wood structure. The rays are very high, the pore diameter very large, and the intervascular and vessel-ray pitting 12–16µm in diameter. These liana-type wood features and the absence of vestured pits, septate fibres, and storied rays are also found in *Griffonia,* an African shrub or climber in the tribe Cercideae, subtribe Cercidinae (Table 2). In fact, the wood anatomy of *Griffonia* and *Duparquetia* are so similar that it is difficult to separate them.

Originally Irwin and Barneby (1981) intended to establish for *Duparquetia* a monotypic tribe, but instead included it as an atypical subtribe in Cassieae. Wunderlin et al. (1981) stated that *Griffonia* is very distinctive and not closely related to the other genera in the tribe Cercideae. Based on these authors' findings and general morphological descriptions, we suspect that *Griffonia* and *Duparquetia* are not closely related even though the wood anatomy is quite similar. Apparently this is yet another example of convergent evolution of the liana-type wood structure.

If we compare the wood anatomy of Groups I and II to the only nonvestured tribe in Leguminosae (tribe Cercideae), we see only a superficial similarity to Group II subtribes and even less to Group I (Table 2). *Cercis* and *Bauhinia,* essentially the only genera available for comparison, have irregularly storied rays and the number of tiers (rows) of rays is 40–50 per cm. For the most part, Dialiinae has very regularly storied rays and the number of tiers (rows) of rays is 20–40 per cm. In addition, the rays in ***Cercis*** often span two or more tiers which was not observed in Dialiinae. Also, *Cercis* has some typical features of temperate zone woods, such as ring-porosity, spiral thickenings, and ulmiform latewood pore arrangement which was not observed in any Group II subtribes. The ray type and width and axial parenchyma patterns in *Cercis* are not particularly similar to any subtribe in Cassieae. The most similar is Cassiinae, but Cassiinae often has septate fibres, vestured pits, and nonstoried rays. *Bauhinia* and Cassiinae have a somewhat similar ray and axial parenchyma pattern. In addition, *Bauhinia* occasionally has septate fibres which seems to suggest a possible link between the two groups. The presence of fusiform parenchyma and two-celled parenchyma strands and large nonvestured intervascular pits in *Bauhinia* and not in Cassiinae, however, negates any close link.

Conclusions

The lack of vestures was always corroborated by examination of a bleached specimen. Genera without vestured pits include *Androcalymma, Apuleia, Dialium, Dicorynia, Distemonanthus, Koompassia, Martiodendron,* and *Storckiella* in the subtribe Dialiinae, and *Duparquetia* in the subtribe Duparquetiinae and *Labichea* and *Petalostylis* in the subtribe Labicheinae in the tribe Cassieae. In addition we confirm that all taxa in tribe Cercideae, *Cercis, Griffonia. Bauhinia, Brenierea,* are without vestures. Genera with distinct vestured pits are *Ceratonia* in the monotypic subtribe Ceratoniinae and *Cassia, Chamaecrista,* and *Senna* in the subtribe Cassiinae.

Our findings on the presence or absence of vestured pits, coupled with other anatomical data, indicate that the tribe Cassieae is not a natural group. We suggest that the subtribes Ceratoniinae and Cassiinae constitute a group with vestured pits while the subtribes Dialiinae, Labicheinae, and Duparquetiinae constitute another group without vestured pits. We also concur that the Dialiinae belong together and that the Labicheinae are probably related to Dialii-

nae. However, the absence of vestured pits by itself does not necessarily imply monophyletic derivation, since the nonvestured condition may be plesiomorphic (primitive) for the Leguminosae. *Duparquetia* (Duparquetiinae) is distinct from others and might be given tribal status. The similarity in wood between the nonvestured *Griffonia* (tribe Cercideae) and *Duparquetia* is apparently an adaptation to the liana habit. However, taxonomists should examine this relationship closely.

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Legends to Figures 1–30.

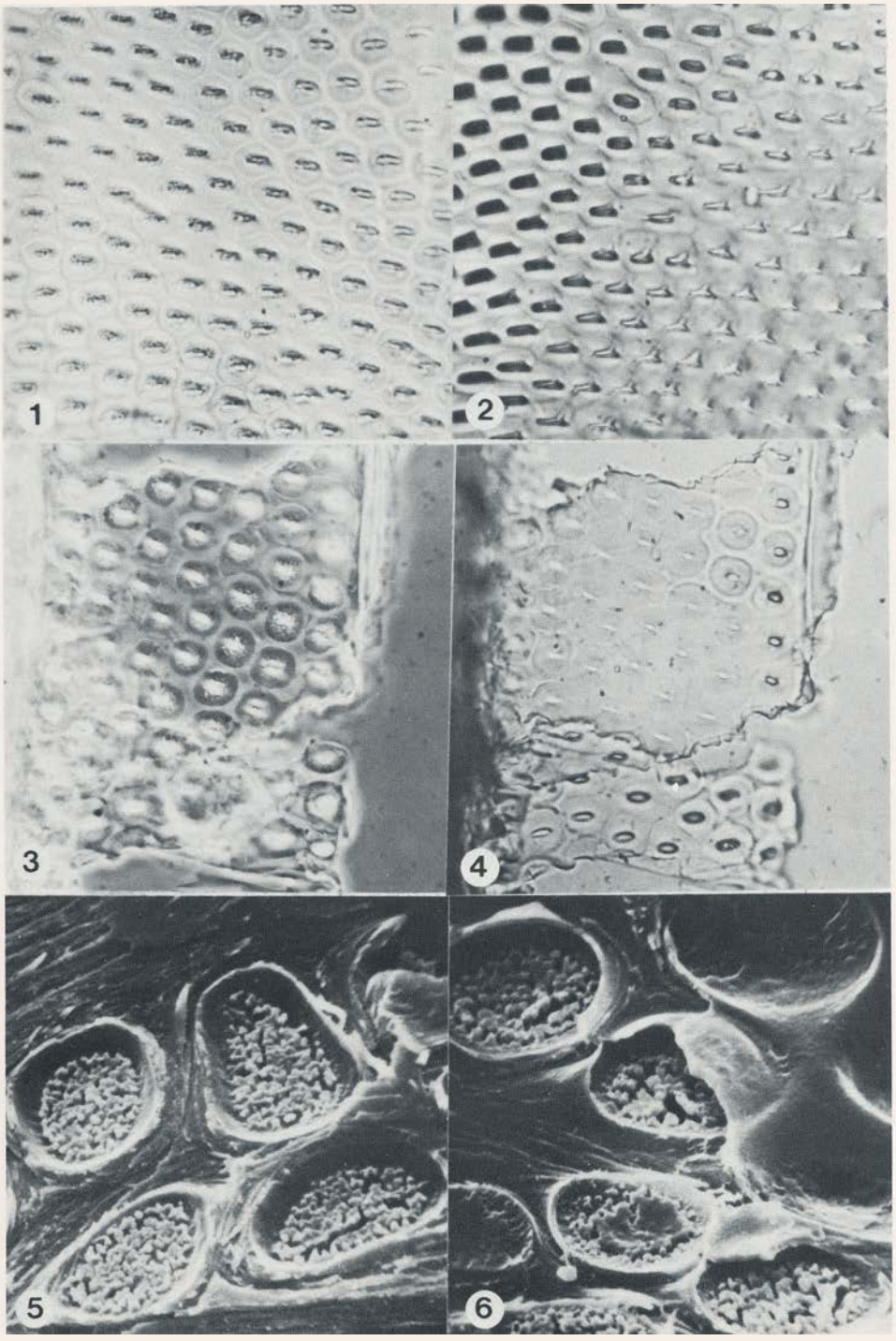
Fig. 1. *Dialium platysepalum* (MADw 91 26). Vessel segment with pseudovestures. Water mount; x 540. — Fig. 2. Identical pits after 7 minutes bleaching with sodium hypochlorite. Pseudovestures removed. Water mount; x 540. — Fig. 3. *Apuleia leiocarpa* (MADw 19090). Vessel segment with pseudovestures. Water mount; x 540. — Fig. 4. Identical pits after 7 minutes bleaching with sodium hypochlorite. Pseudovestures removed. Water mount; x 540. — Fig. 5. *Ceratonia siliqua* (MADw 17878). Vestured pits in sapwood; x 4100. — Fig. 6. *Cassia javanica* (MADw 21652). Vestured pits in heartwood; x 4100.

Fig. 7. *Chamaecrista apoucouita* (MADw 18496). Vestured pits in heartwood; x 4100. — Fig. 8. Identical pit area after bleaching with sodium hypochlorite; x 4100. — Fig. 9. *Senna atomaria* (MADw 36722). Vestured pits in unbleached juvenile wood; x 4100. — Fig. 10. Identical pit area in bleached juvenile wood; x 4100. — Fig. 11. *Androcalymma glabrifolium* (MADw 18042). Nonvestured vessel pits in heartwood; x 4100. — Fig. 12. *Apuleia leiocarpa* (MADw 20435). Nonvestured pits in heartwood; x 4100.

Fig. 13. *Dialium platysepalum* (MADw 3 1878). Pit membranes with encrusting substances and sievelike network on membranes, also open nonvestured pits in heartwood; x 4100. — Fig. 14. Ibid. Nonvestured pits in bleached heartwood vessel element; x 4100. — Fig. 15. *Dicorynia guianensis* (MADw 3934). Encrusted pit membranes and open nonvestured pits in heartwood; x 1650. — Fig. 16. Ibid. Nonvestured pits in bleached vessel element of heartwood; x 1650. — Fig. 17. *Distemonanthus benthamianus* (MADw 6562). Nonvestured heartwood pits, heavy encrustation; x 4100. — Fig. 18. Ibid. Nonvestured heartwood pits after bleaching; x 4100.

Fig. 19. *Martiodendron parviflorum* (MADw 18045). Heavily encrusted pit membranes in unbleached heartwood; x 1650. — Fig. 20. Ibid. Nonvestured open pits in vessel element of bleached heartwood; x 4100. — Fig. 21. *Storckiella pancheri* (SJRw 14315). Nonvestured pits in vessel element of heartwood; x 4100. — Fig. 22. *Duparquetia orchidaceae* (SJRw 13714). Large, open, nonvestured pits in heartwood; x 1650. — Fig. 23. *Labichea lanceolata* (MADw 40846). Nonvestured pits with wart-like protuberances in bleached vessel element of heartwood; x 4100. — Fig. 24. *Petalostylis millefolium* (MADw 40845). Nonvestured pits in vessel element of heartwood; x 4100.

Fig. 25. *Cercis siliquastrum* (MADw 17419). Pits in vessel element of heartwood; x 4100. — Fig. 26. *Griffonia simplicifolia* (SJRw 23234). Pits in vessel element of heartwood; x 4100. — Fig. 27. *Bauhinia malabarica* (MADw 1492). Pits in vessel element of heartwood; x 4100. — Fig. 28. *Bauhinia retusa* (MADw 1493). Non-encrusted pit membranes in heartwood; x 4100. — Fig. 29. *Bauhinia vahlii* (MADw 32254). Encrusted pits in vessel element of heartwood; x 1650. — Fig. 30. *Brenierea brieyi* (Fosberg 52447). Open pits in vessel element from twig of herbarium material; x 4100.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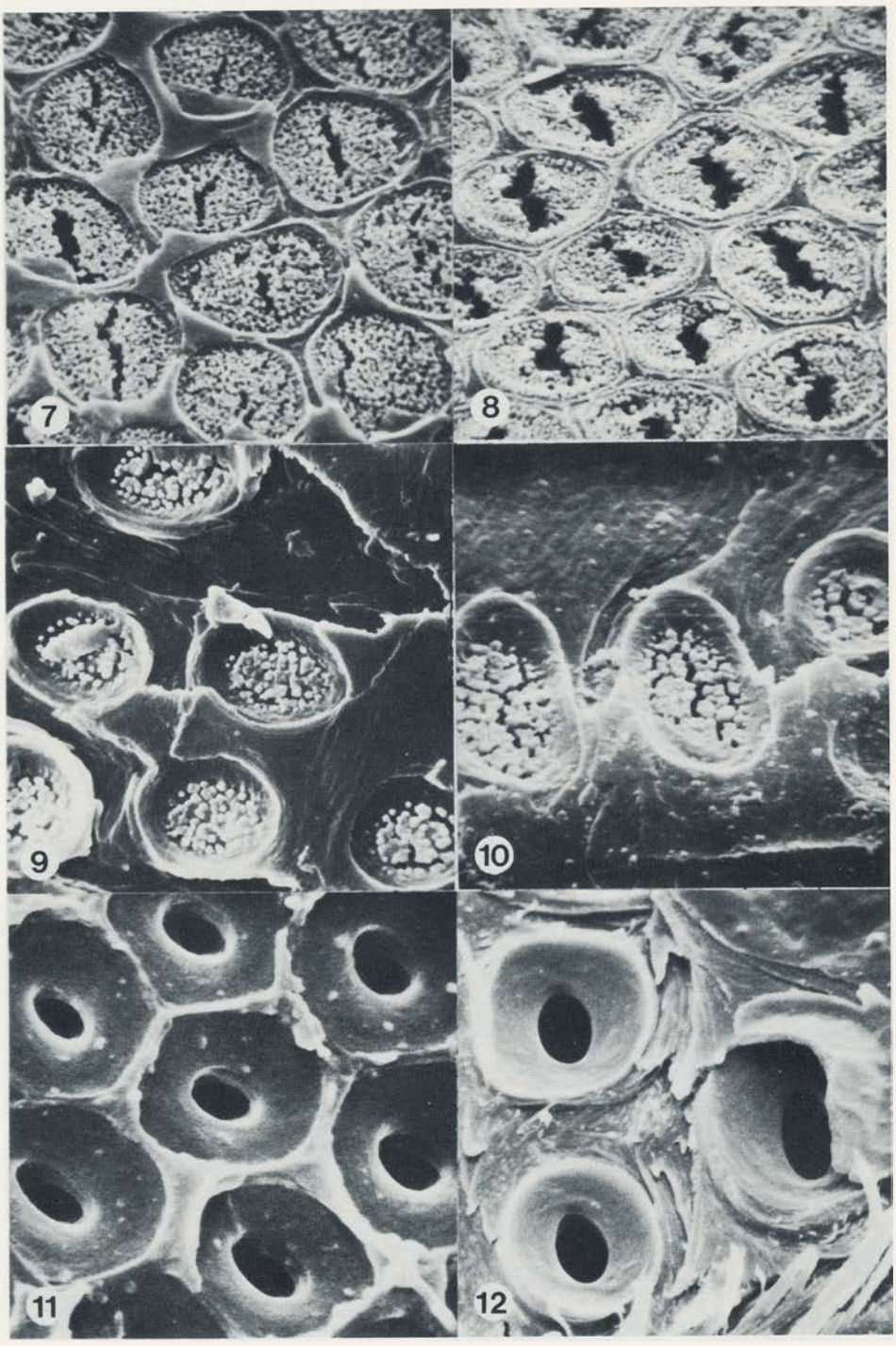
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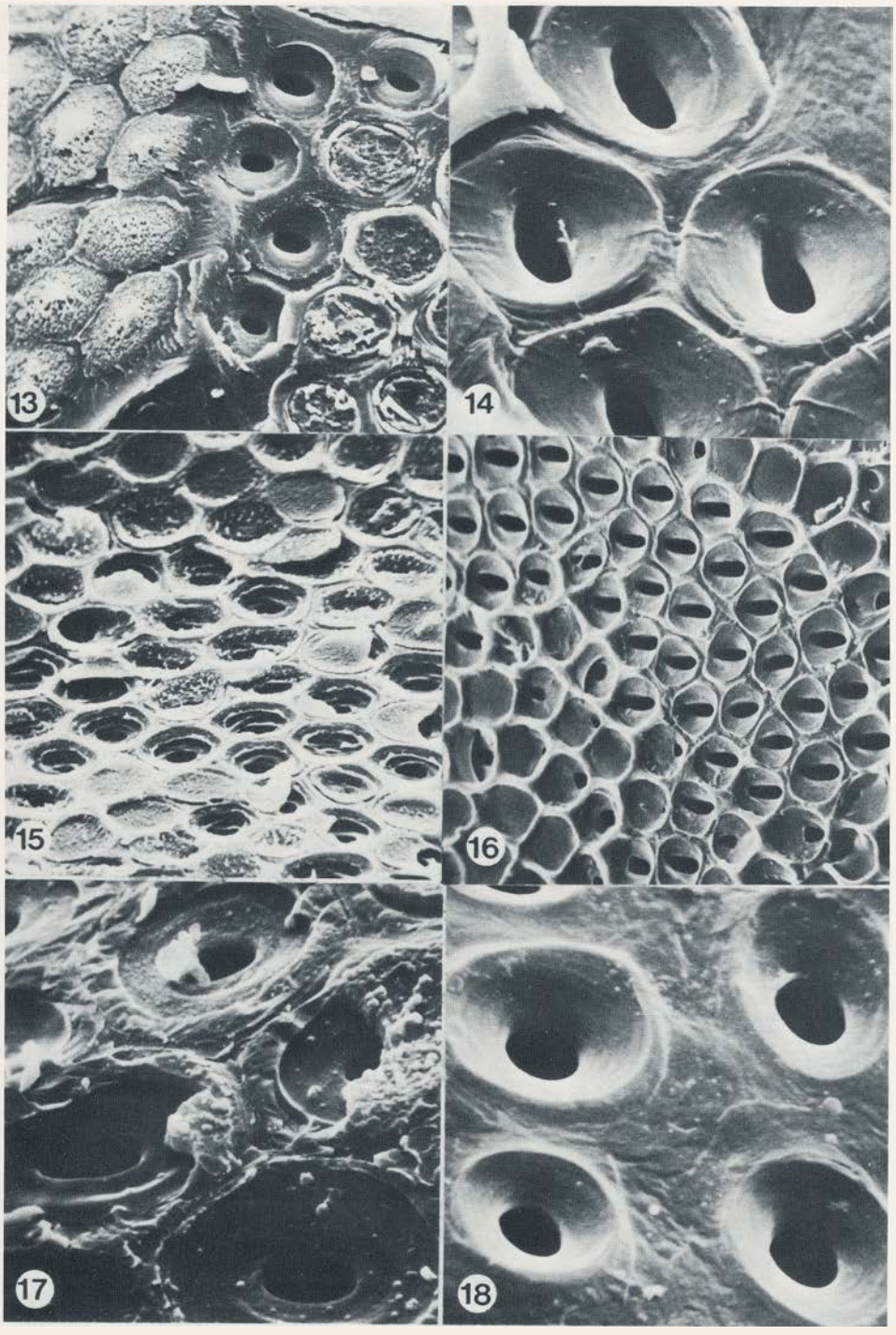
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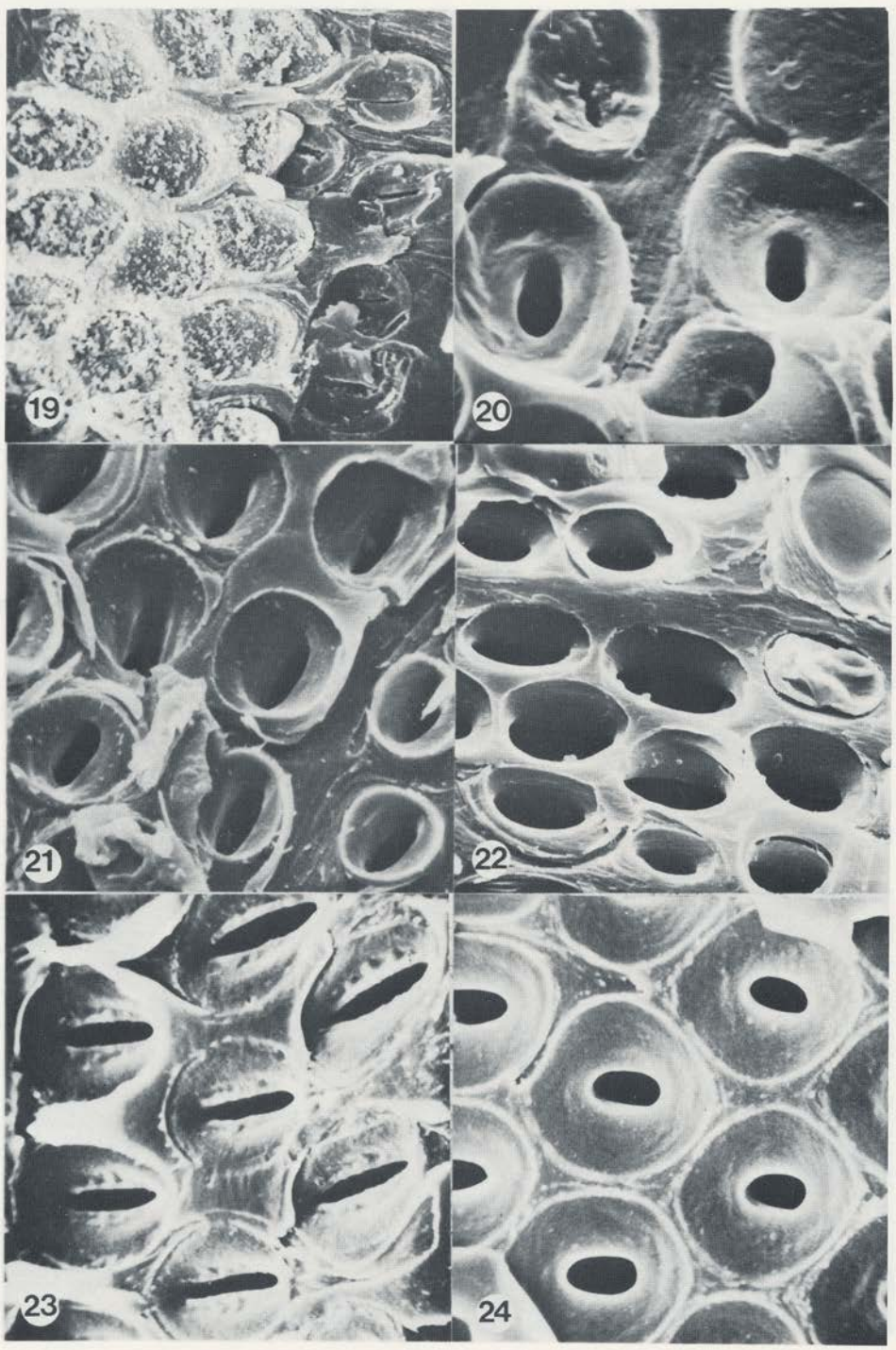
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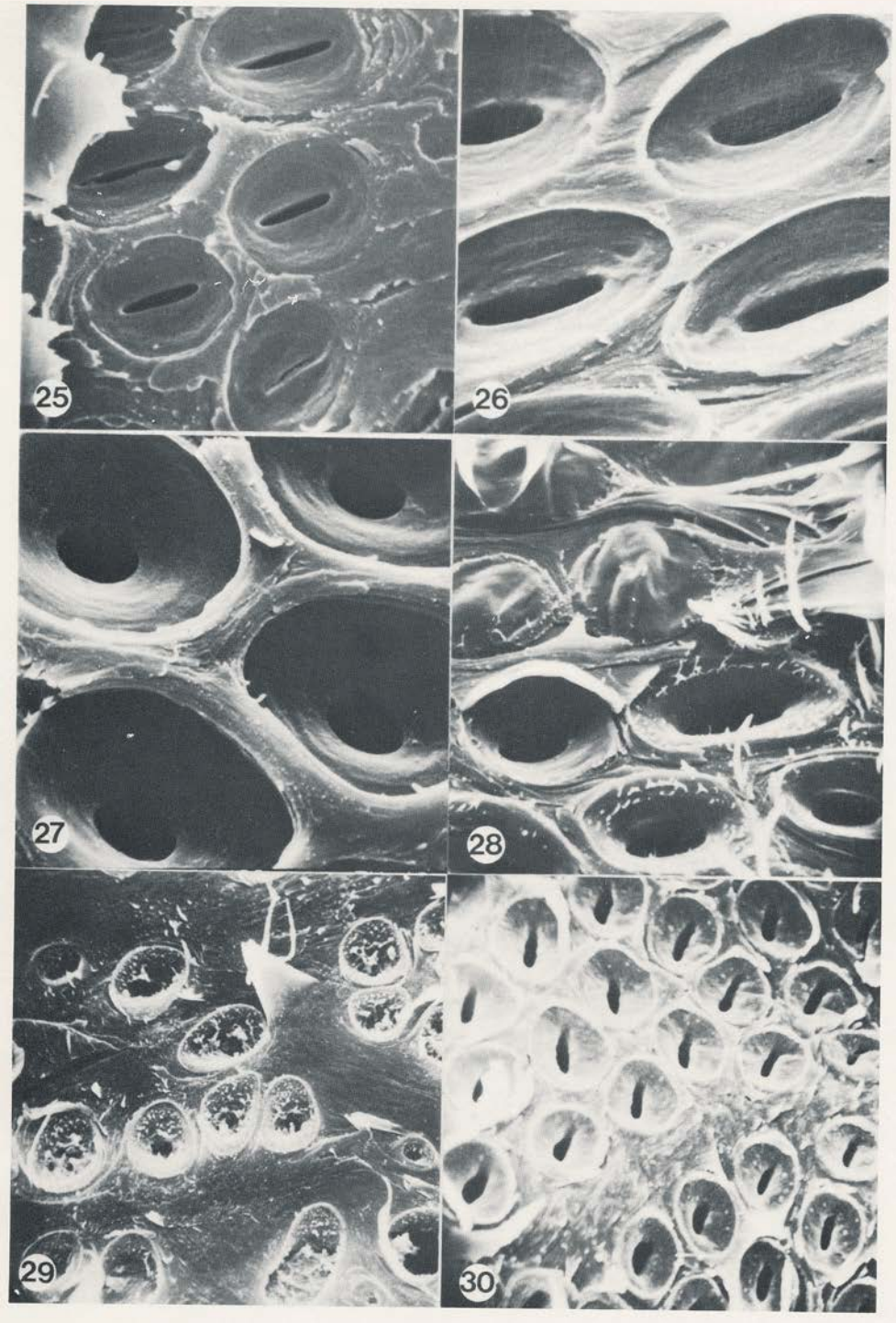
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