ON THE PETIOLE STRUCTURE OF SOME *ADIANTUM* SPECIES

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Abstract

The exomorphic and structural details of petiole of six species of *Adiantum*, viz., *A. caudatum, A. edgeworthii, A. pedatum, A. philippense, A. pubescens* and *A. trapeziforme* have been given. Two types of vascular organisation have been observed. In *A. pedatum, A. pubescens* and *A. trapeziforme* the petiole receives two separate vascular strands from the rhizome which after entering the petiole merge to form a single strand. In other species it receives only a single vascular strand from the rhizome, which remains as such throughout. Although the fundamental pattern is only of two types, the shape of strands are markedly different in all the six species and form definite criterion for identification.

Introduction

The importance of petiolar structure in the taxonomy of ferns is already well known (see Tansley, 1907, 1908; Sinnott, 1911; Bower, 1914, 1923; Davie, 1918; Bir, 1962; Sen, 1964; Kato, 1972; Ogura, 1972; Lucansky & White, 1974; Lin & Devol, 1977, 1978; Khare & Shankar, 1984, etc.). However, in this connection it may be pointed out that a systematic and well illustrated account of petiolar structure of a number of taxa of Indian ferns is still lacking. To fill in this gap of our knowledge the exomorphic and internal details of petiole of six species of *Adiantum*, viz., *A. caudatum* L., *A. edgeworthii* Hook., *A. pedatum* L., *A. philippense* L., *A. pubescens* Sch. and *A. trapeziforme* L. have been investigated which form second part of our studies on *Adiantum*. The first part (Khare, 1984) deals with similar investigation on *A. capillus venaris* L. and *A. venustum* Don. In his monographs on *Adiantum* Nayar (1962a, 1962b) has mentioned the course of vascular bundle in the stipe of various Indian species and Singh *et al.* (1985) have studied the anatomy of three Rajasthan species but a detailed and comparative structural account is being given here for the first time.

Material and methods

Fresh material of *A. trapeziforme, A. caudatum, A. edgeworthii, A. philippense* and *A. pedatum* were obtained from the plants growing in the fern house of Botany Department of Allahabad University which were originally collected from Shankargarh, Vindhyachal, Pachmarhi, Almora and Rishikesh. The material of *A. pubescens* collected from South India was obtained from the herbarium sheets kept in the Botany Department Herbarium. Pieces of petioles were fixed in FAA but in case of *A. pubescens* dried petioles were first boiled in a mixture of glacial acetic acid and hydrogen peroxide (1:1) for about an hour before fixing in FAA. Hand or microtome sections in different planes were cut at 8-10 μm thickness and stained with safranin fast green combination. Transparencies were also made by clearing the petioles in 10% aqueous sodium hydroxide solution and chloral

hydrate and subsequently staining them with safranin. To confirm the nature of various depositions and cell substances special micro and histochemical tests were performed, e.g. lignin and cutin were tested by obtaining red colour with pholroglucinol and Sudan IV, tannin and starch by blue colour with ferric chloride and iodine solution respectively (see Johansen, 1940) and for phlobaphenes histological test was performed as suggested by Reeve (1951).

Observations

The petioles of *Adiantum caudatum*, *A. edgeworthii*, *A. philippense*, *A. pedatum* and *A. trapeziforme* are cylindrical and brown while that of *A. pubescens* is broadly triangular and more dark in colour. On the adaxial side of the petiole there is a prominent groove running from the base up to the tip where the first pinna is attahced. This groove is, however, present only near the base of petiole in *A. trapeziforme* higher up it becomes obscure and gradually absent. In *A. pedatum* the groove is shallow at the basc while towards the apical region it is more prominent and deep. The base of petiole of all the investigated species is usually covered by crowded scales. The marginal cells of scales of *A. pubescens* and *A. trapeziforme* are sometimes appendicular (Text-figs. 3J, 4B). The scales of *A. pedatum* and *A. pubescens* are composed of two parts the basal one with short thin-walled cells and the distal part with elongated thick-walled cells (Text-figs. 2 I, 3 I, J). Scales of other species have identical cells (Text-fig. 1F, M). In addition to scales simple, muticellular hairs are also found in *A. caudatum*, *A. edgeworthii*, *A. pedatum* and *A. pubescens* (Text-figs. 1 L, 2J). In *A. caudatum* hairs are present throughout the petiole while in other species they are found only towards the base. In surface view epidermal cells of petiole appear narrow and elongated with thick anticlinal walls and their outer walls show uni to multiseriate simple circular pits (Text-figs. 1A, G-2, H, 4A). Petioles of all the six species are devoid of stomata.

In a transverse section of the petiole of all the species epidermal cells throughout their length appear small, thick-walled, dark brown in colour and covered by a smooth and delicate cuticular membrane. The epidermis is followed by a wide zone of cortex composed of three or more layers of outer thick-walled cells and several layers of thin-walled parenchymatous cells constituting the inner cortex (Text-figs. 1B, 4 C). In *A. trapeziforme* at the base of stipe the entire cortex is made up of thick-walled cells. Microchemical tests reveal that the entire cortex is composed of cellulosic cells and the content of thick-walled outer cortical cells show presence of a polyphenolic compound phlobaphene. Thin-walled inner cortical cells usualy have starch grains (Text-fig. 1H). Except for *A. trapeziforme* where the cortical cells are almost rounded and have intercellular spaces between them in all the other investigated species they are polygonal and compactly arranged.

Petioles in *A. caudatum*, *A. edgeworthii* and *A. philippense* receive a single vascular strand from the rhizome which remain unchanged throughout their course in the petiole (Text-fig. 1C, I). In *A. caudatum* and *A. philippense* the xylem is exarch with several protoxylem points while in *A. edgeworthii* the exarch xylem is only diarch. In all the above three species the xylem is surrounded by phloem which occasionally show tannin filled cells (Text-fig. 1E, K). The endodermis is composed of single layered cells with obscure casparian thickening and pericycle is made up of two to three layers of thin-walled cells (Text-fig. 1D, J). The organisation of xylem strand in these three species is, however, different, it is almost 'V' shaped in *A. philippense* with free arms of 'V' widely stretched and turned outwards (Text-fig. 1 C,D, E) in *A. caudatum* it is also more or less 'V' shaped but the free arms of

Text-fig. 1

'V' are turned inwards (Text-fig. 1 I, J, K) while in *A. edgeworthii* it is almost semilunar in shape (Text-fig. 3A).

In other species, viz., *A. pedatum*, *A. pubescens* and *A. trapeziforme* the petioles receive two widely separated vascular strands from the rhizome (Text-figs. 2A, 3B, 4D). Each vascular strand is enclosed by a single layered endodermis with obscure casparian thickenings and some of the cells are filled with tannin. Pericycle is one to three layers in thickness and made up of thin-walled cells. The xylem is mesarch and surrounded by phloem. Although the fundamental organisation of the vascular strands received from the rhizome is similar in all the three species the shape of xylem strands as well as the general appearance of the entire vascular strand is different in all the three species. In *A. pubescens* the xylem is hippocampus-shaped and the two vascular strands appear slightly elongated (Text-fig. 3B, C). In *A. pedatum* although the xylem is hippocampus shaped like *A. pubescens* its adaxial arm is comparatively more turned inwards and the two vascular strands appear almost reniform in shape (Text-fig. 2A, B). In *A. trapeziforme* the xylem as well as the entire vascular strand appears somewhat 'C' shaped (text-fig. 4D, E). Soon after entering the stipe base the two separate vascular strands start coming closer to each other and get fused somewhere in the middle of the petiole to form a single strand for further upward course.

During the merger of the two vascular strands first the endodermis (Text-fig. 2C, 3D, G) and later at a slightly higher level the pericycle cells also fuse to form a single common endodermal and pericyclic layer (Text-figs. 2D, F, 3E, 4F). At still higher level the two phloem and xylem strands also join each other at their abaxial side. The distal arms of xylem and phloem, however, remain as such. Thus the single vascular strand resulted due to fusion of the two is almost 'V' shaped in *A. pedatum* (Text-fig. 2E, G) and *A. pubescens* (Text fig. 3F, H) with free arms of xylem strands turned inwards more in the former as compared to the latter. In *A. trapeziforme* the vascular strand as well as xylem is shaped like 'U' (Text-fig. 4G, H). However, the free arms of xylem are turned inwards in this species as well. In all the six presently investigated species xylem consists of only tracheids with protoxylem having annular or spiral thickening and metaxylem with scalariform thickenings. Phloem consists of sieve cells with occasional parenchyma. Phloem parenchyma and the cells of pericycle are sometimes filled with tannin. Groups of fibers in the phloem were found only in *A. pedatum*, *A. pubescens* and *A. trapeziforme* (Text-figs. 2B, F, G, 3C, G, H, 4E, H) in other species they were not observed.

Conclusion and discussion

Petioles of all the six investigated species show differences in their external as well as internal structure. Amongst the external characters they differed in the shape and colour of petiole, prominence of adaxial groove, presence or absence of hairs and cellular details of scales. Depending on the vascular patterns found in the petioles of these six

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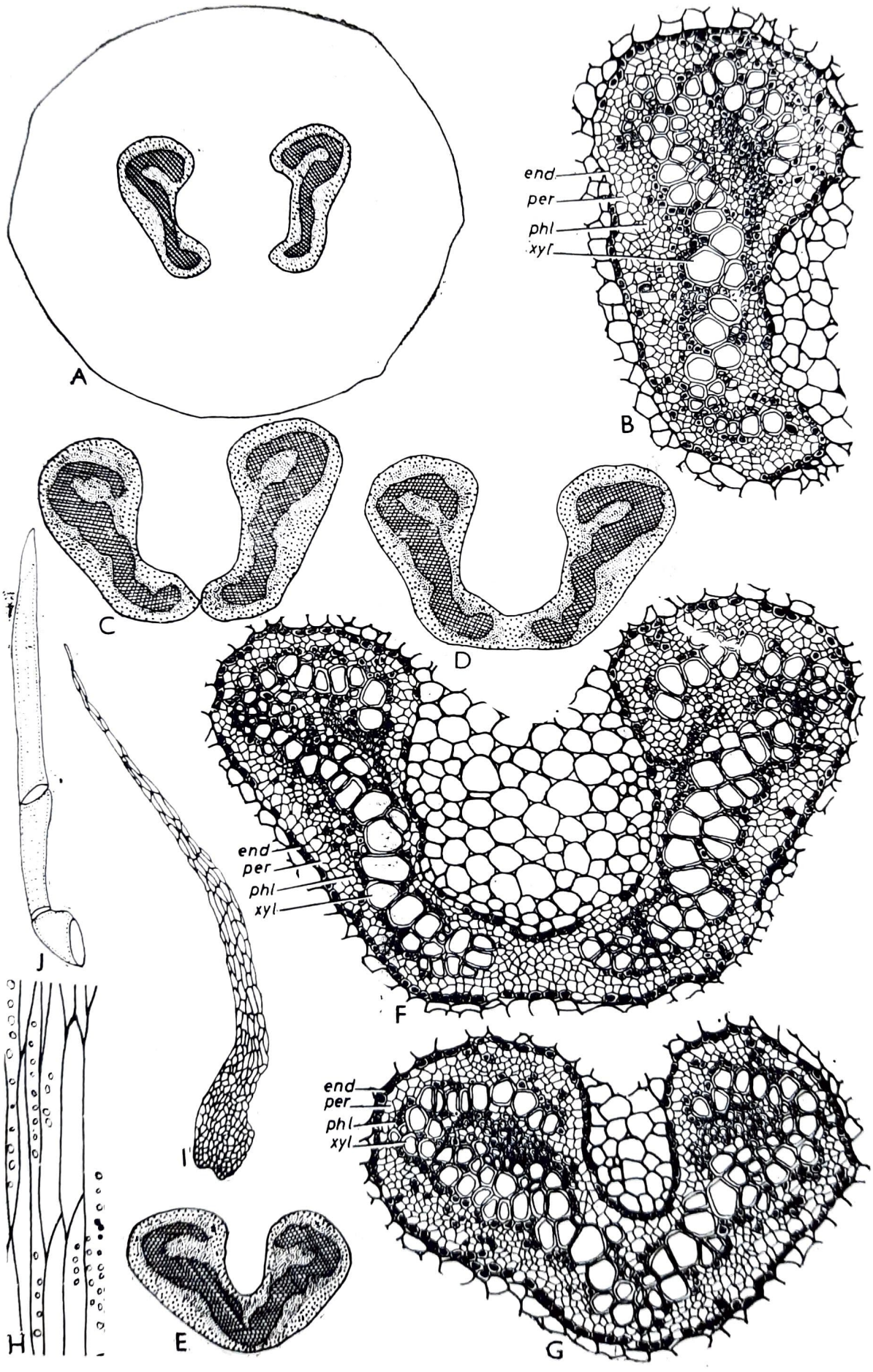
Text-fig. 1—A-F. *Adiantum philippense*. A. surface view of epidermis showing pits, B, a portion of epidermis and cortex of petiole in transection. C. diagrammatic transection of the petiole showing single vascular strand. D, the vascular strand in C magnified. E, structural details of D,F, scale from petiole surface. G-M. *A. caudatum*. G. surface view of epidermis showing pits. H, a portion of cortex of petiole showing starch grains. I, Diagrammatic transection of the petiole showing single vascular strand, J, the vascular strand in I magnified. K, structural details of J. L., hair from petiole surface. M, scale from petiole surface. In D, J line indicate endodermis (*end*), larger dots pericycle (*per*), finer dots phloem (*phl*) and hatched areas represent xylem (*xyl*). A, G×300, B.H.×450, C, F, I, M×45, D, J×75; E, K, L×150.



Text-fig. 2

species fall under two distinct categories. The first of *A. caudatum*, *A. edgeworthii* and *A. philippense* where it receives only a single vascular strand from the rhizome remaining as such throughout their course in the petiole and the second of *A. pedatum*, *A. pubescens* and *A. trapeziforme* where it receives two vascular strands from the rhizome. However, these two strands also unite to form a single strand for most of the upper part of the petiole. It was also observed that the species having single strand have exarch xylem and those with two strands later on joining to become one have mesarch xylem. Khare (1984) has also studied the vascular details of petiole in *A. venustum* and *A. capillus veneris* out of which the former fall to the first category and the latter to the second with the exception that unlike others it has exarch xylem. Nayar (1962a, 1962b) has also described two types of vascular pattern in the petiole of *Adiantum* species as presently observed, however, the structural details are lacking.

Material of *A. caudatum* and *A. philippense* were collected from different places like Shankargarh in Allahabad, Vindhyachal, Pachmarhi, Almora and Rishikesh and it was found that the vascular organisation of the petiole was similar showing the stability of this character. The petioles of various stages of development also show organisational similarity of the vascular pattern except for the amount of vascular tissues. The general shape of the vascular strand and that of xylem in particular which is markedly different in not only the six presently investigated species but also in that of two species, viz., *A. capillus veneris* and *A. vensustum* described by Khare (1984) shows the significance of this feature which can well be used for taxonomic purposes and the following key to distinguish these species may be made :

1. Petiole base with single vascular strand remaining as such throughout its course.
2. Xylem exarch and diarch.
   Xylem strand semilunar in shape.....*A. edgeworthii*
2. Xylem exarch with several protoxylem points
   Xylem strand almost 'V' shaped with free arms of
   'V' widely stretched and turned inwards.....*A. caudatum*
   Xylem strand almost 'V' shaped with free arms of
   'V' widely stretched and turned outwards.....*A. philippense*
   Xylem strand almost 'V' shaped.....*A. venustum*
1. Petiole base with two vascular strands uniting to form one during their upward course
2. Basal strands oval; xylem exarch and almost 'C' shaped : after fusion xylem 'V' shaped with free arms of 'V' turned outwards.....*A. capillus veneris*
2. Basal strands oval; xylem mesarch and hippocampus shaped: after fusion xylem 'V' shaped.....*A. pubescens*
2. Basal strands reniform; xylem mesarch and hippocampus shaped: after fusion xylem 'V' shaped with free arms of 'V' turned inwards.....*A. pedatum*
2. Basal strands 'C' shaped; xylem mesarch and 'C' shaped: after fusion xylem 'U'.. shaped.....*A. trapeziforme*

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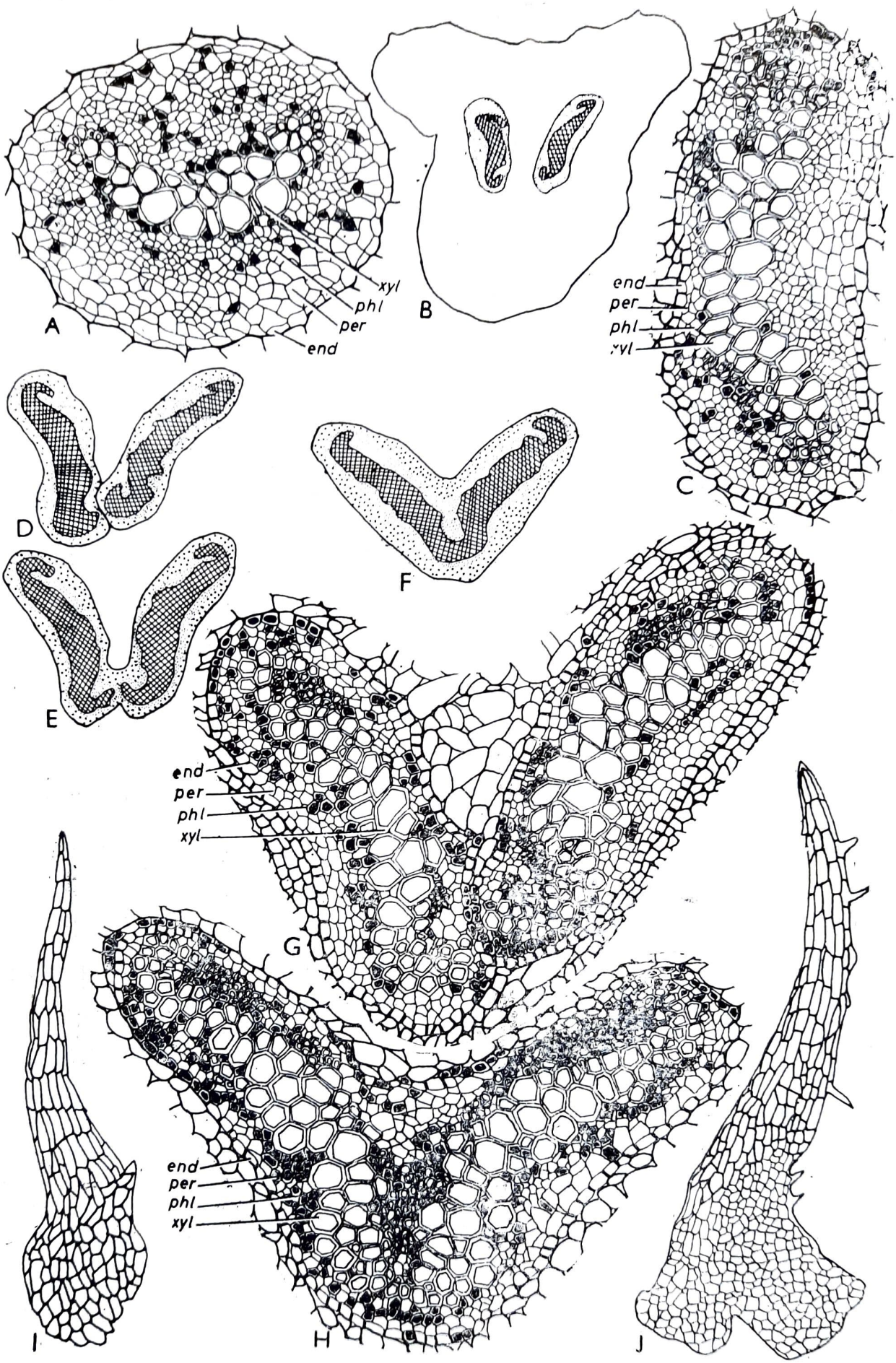
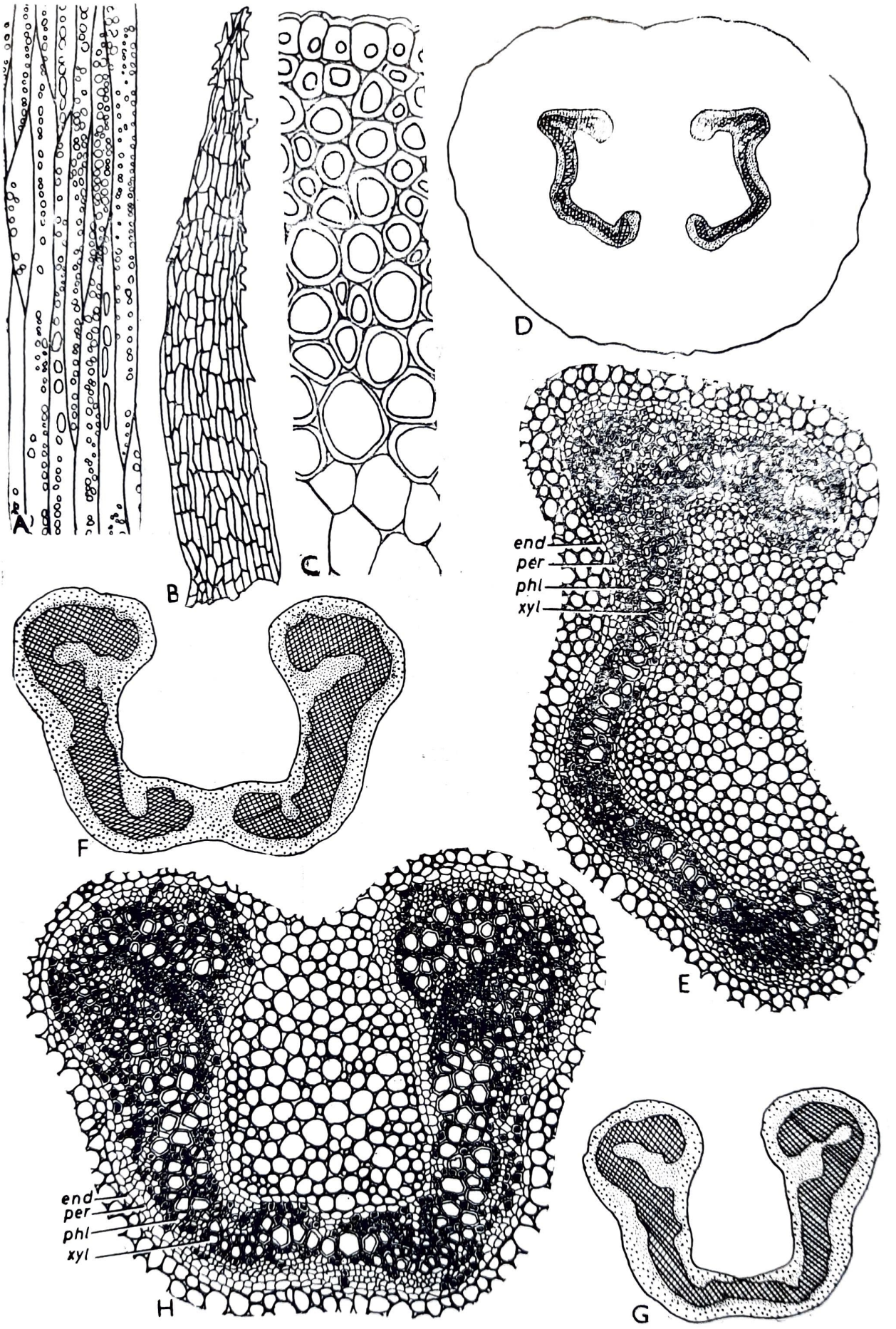
Text-fig. 2—A—J. *Adiantum pedatum*, A—Diagrammatic transection of the petiole at base showing two vascular strands. B, Structural details of one of the two vascular strands in A. C—E, Diagrammatic transection of petiole at various levels showing stages during the fusion of the two strands. F, G, structural details of D and E respectively H, surface view of epidermis showing pits I, J, scale and hair from potiole surface respectively. In A, C-E line indicates endodermis (*end*) larger dots pericycle (*per*) finer dots phloem (*phl*) and hatched areas represent xylem (*xyl*). A ×45, B, F, G X 120, C—E ×60, H ×300, I ×30, J ×225.



Text-fig. 3—A. *Adiantum edgeworthii* structural details of vascular strand of petiole in transection. B-J. *A. publes cens.* B, Diagrammatic transection of petiole at base showing two separate vascular strands, C, structural details of a vascular strand in B. D-F, Diagrammatic transection of the petiole at various levels showing stages during fusion of the two strands. G,-H, structural details of D and F respectively. I, J, scales from petiole surface. In B, D-F line indicates endodermis (*end*), larger dots pericycle (*per*), finer dots phloem (*phl*) and hatched areas represent xylem (*xyl*). A×225, B, I, J×30, C, G, H×150, D-F×60.



Text-fig. 4—A-H. *Adiantum trapeziforme*.A, surface view of epidermis showing pits. B, scale from petiole surface, C, a portion of epidermis and cortex of petiole in transection. D, Diagrammatic transection of the petiole at base showing two vascular strands. E, structural details of one vascular strand in D. F., G., Diagrammatic transection of petiole at various levels showing stages during fusion of the two strans, H, structural details of G. In F, G line indicates endodermis (*end*), larger dots pericycle (*per*), finer dots phloem (*phl*) and hatched areas represent xylem (*xyl*). A×300, B×30, C×450, D×20, E, H×100, F×60, G×45.

Adiantum is an old, isolated, genus of wide distribution with about 200 species of which Nayar (1962b) has collected 24 in India. Regarding the interrelationships of various species several groups have been made depending on various morphological features (see Nayar, 1962a, 1962b; Tryon & Tryon, 1982). In all the species two basic types of vascular patterns in the stipe as described here are found, however, their structural details are lacking which may well be added up alongwith other characters for taxonomic groupings.

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