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Development of the Stelar Cylinder in the Rhizome of Bolbitis and Egenolfia

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Bolbitis and *Egenolfia* are Lomariopsidoid ferns of doubtful systematic position, relegated to the Aspidiaceae by most pteridologists (Ching, 1940; Copeland, 1947). They are small or medium sized ferns with dimorphic leaves, acrostichoid distribution of sporangia and dorsiventral epigeal rhizomes which may either be short creeping or long and sometimes climbing vertically on supports. During the course of a morphological investigation of some species of *Bolbitis* and *Egenolfia* it was observed that the characteristic dorsiventral type of solenostele of the rhizome (Holttum, 1954; Nayar, 1960) develops from the juvenile protostele in an unusual manner in these genera. The common type of development of solenostele from the solid cylindrical protostele in ferns by the formation of a central shaft-like pith connected to the cortical tissue through leaf gaps, is described by many workers (Bower, 1935; Gwyne-Vaughan, 1901). A variation of this type of development is reported in *Danaea* (Brebner, 1902). The present observations are based upon ten species of *Bolbitis* viz., *B. costata* (Wall.) Ching, *B. crispatula* (Wall.) Ching, *B. deltigera* (Wall.) C. Chr., *B. diversifolia* (Bl.) Schott, *B. heteroclita* (Pr.) Ching, *B. presliana* (Fée) Ching, *B. semicordata* (Moore) Ching, *B. subcrenata* (Hook, et Grev.) Ching, *B. subsimplex* (Fée) Ching, *B. virens* (Wall.) Schott and five species of *Egenolfia* viz., *E. appendiculata* (Willd.) J. Sm., *E. asplenifolia* (Bory) Fée, *E. helferiana*

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(Kze.) C. Chr., *E. sinensis* (Bak.) Maxon and *E. vivipara* (Hook.) C. Chr. The observations were made by cutting serial transverse sections of young and adult rhizomes and foliar buds, and making drawings with a camera lucida, from which the stelar pattern is reconstructed to scale. These are then compared with the stelar cylinders obtained after prolonged boiling in strong KOH solution.

STELAR CYLINDER OF THE ADULT RHIZOME

The stelar cylinder of the adult rhizome in *Bolbitis* and *Egenolfia* is a hollow cylinder pierced on the dorsal surface by two alternating, closely set rows of large, prominently overlapping leaf gaps (Fig. 4-l), which dissect the stelar cylinder into a broad, gutter-shaped, root-bearing, ventral vascular strand (Fig. 4-d). In some species more than two rows of leaves are developed at maturity and then the dorsal strand is pierced by one or two rows of leaf gaps. Vascular connections to each leaf (each leaf trace, Fig. 4-f) consist of many cylindrical vascular bundles originating in succession from the lateral margins towards the abaxial end of the leaf gap. Vascular connection to a vegetative bud (Fig. 4-b) is associated with each leaf trace on its abaxial side, and a root trace (Fig. 4-r) originates along with the bud traces (either fused with the bud trace or sometimes independently) in all the species.

DEVELOPMENT OF STELAR CYLINDER OF RHIZOME

The juvenile rhizome has a solid, cylindrical, centrally placed vascular strand (Fig. 1-A). Leaf traces are single cylindrical bundles originating from the dorsal surface as superficial branches, unaccompanied by a leaf gap. Vegetative buds are absent. As the plant grows, the rhizome increases in thickness and the successive juvenile leaves increase in size. The stelar cylinder expands and successive leaf traces become alternately placed on either side of the dorsal median line (Fig. 1-B). Between the two rows of leaf traces a longitudinal groove is formed, which becomes progressively deeper and wider as the

rhizome elongates. Later, each juvenile leaf is supplied by two vascular bundles originating from the opposite margins of the median groove (Fig. 1-C). The stelar cylinder expands considerably and the dorsal groove becomes more and more prominent till the stele is gutter-shaped, and later the margins of the gutter approach each other and fuse, forming a hollow cylinder with the cortical parenchyma forming a central pith (Fig. 1-D). One or two elongated lacunae (Fig. 1-p) may occur laterally on the stelar cylinder. Soon the dorsal surface of the stelar cylinder opens as a leaf gap (Fig. 1-l) and a set of vascular strands (usually two or three on either side of the gap) are given off to a leaf, the leaf in question being markedly larger than the previously formed ones. Vascular connection to a vegetative bud and the accompanying root (Fig. 1-b & r) is usually associated with this leaf trace on its abaxial side as in the adult condition. Vascular connection to the next leaf in succession is established in a similar way by the formation of a gap close to the first gap on one side. Thereafter, leaves are formed alternately in closely placed rows, and their gaps are prominent and considerably overlapping so that the dorsal median region of the vascular cylinder appears like a zigzag narrow meristele (Fig. 1-d) connecting the two margins of the gutter-shaped ventral region (Fig. 1-v).

STELAR CYLINDER OF FOLIAR BUDS

Foliar buds are characteristic of most species of *Bolbitis* and *Egenolfia*. These buds occur on the dorsal surface towards the apex of the terminal pinna (in some species on the lateral pinnae also), replacing one of the main lateral veins of the lamina. In many cases these buds strike root and grow into young plants while still attached to the parent leaf. The vascular bundle entering the base of the rhizome of these young plants is a simple, cylindrical, solid strand (Fig. 2-A) resembling the protostele of the juvenile rhizome. Soon it expands considerably, becomes flattened and later gutter-like (Fig. 2-B), with its concavity facing the lamina of the parent leaf (ventral sur-

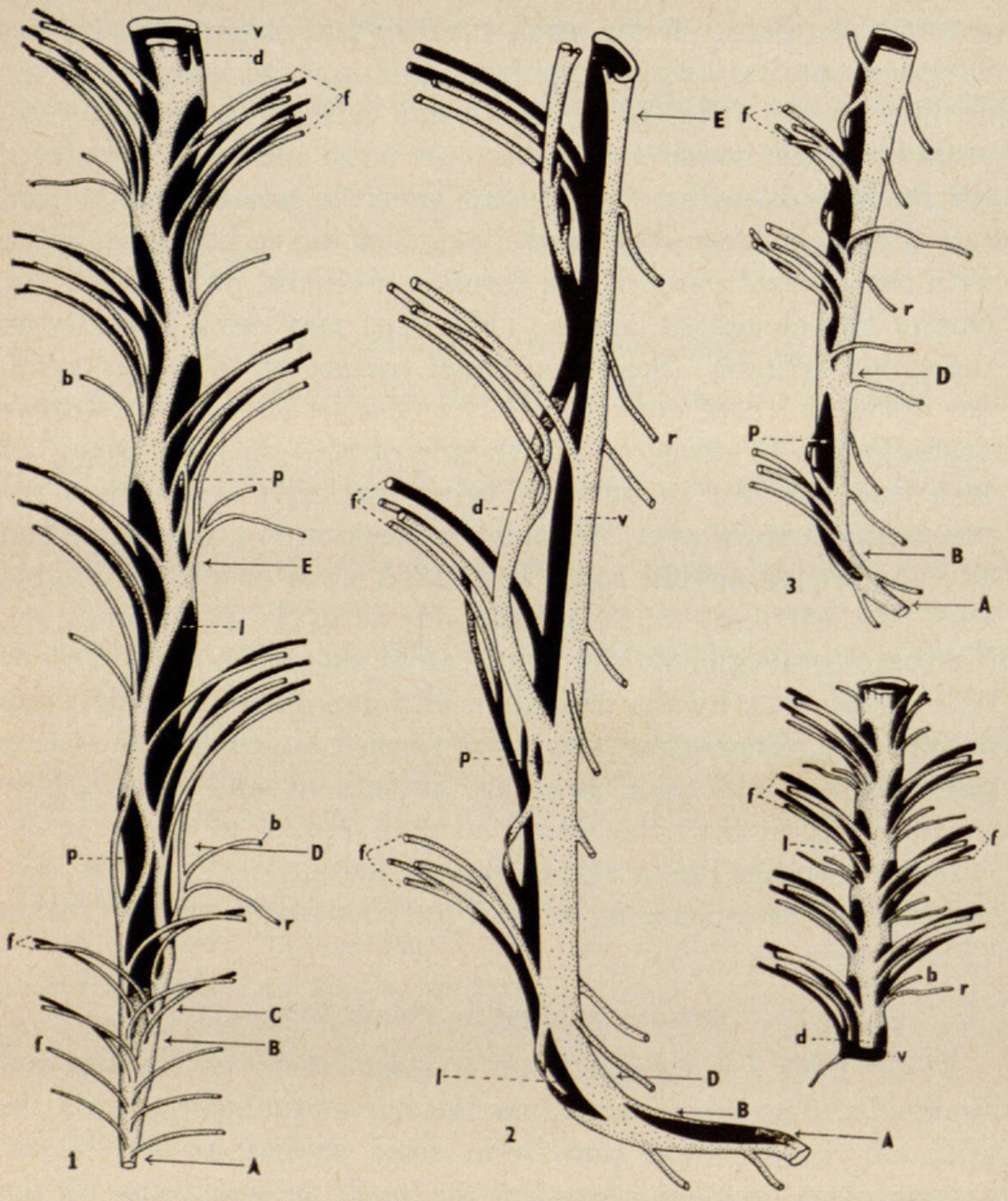

FIG 1. STELAR CYLINDER OF YOUNG RHIZOME OF BOLBITIS SUBCRENATA. FIG. 2. STELAR CYLINDER OF FOLIAR BUD OF THE SAME. FIG. 3. STELAR CYLINDER OF FOLIAR BUD OF EGENFOLIA APPENDICULATA. FIG. 4. A PORTION OF THE VASCULAR CYLINDER OF THE RHIZOME OF B. SEMICORDATA. A—CYLINDRICAL PROTOSTELE; B—DEVELOPMENT OF DORSAL GROOVE ON STELAR CYLINDER; C—FORMATION OF MULTIPLE TRACES TO LEAF; D—FORMATION OF HOLLOW CYLINDRICAL STELE; E—ADULT CONDITION OF STELE. l = LEAF GAP, f = LEAF TRACE, b = BRANCH TRACE, r = ROOT TRACE, d = DORSAL VASCULAR STRAND, v = VENTRAL VASCULAR STRAND, p = LACUNA.

face of the daughter rhizome). The margins of the gutter-like stele approach each other and fuse (Fig. 2-D) forming a hollow cylinder which usually develops one or two elongated lacunae generally on the opposite side (dorsal surface of the daughter rhizome). A large leaf gap (Fig. 2-l) is formed dorsally, opening up the stelar cylinder, and a pair of leaf trace bundles (Fig. 2-f) originates, one from either lateral margin of the gap. The leaf gap next in succession originates lateral to the first gap and successive leaf gaps are formed in alternate succession dissecting the vascular cylinder into a broad, ventral strand and a narrow dorsal one as in the adult rhizome (Fig. 2-E). In *Egenolfia* a vascular connection to the first leaf of the daughter plant originates before the stelar cylinder becomes siphonostelic. The protostelic vascular cylinder entering the bud becomes gutter-shaped, with its concavity facing the dorsal side (Fig. 3-B) and one or two vascular bundles are given off from either margin to supply the first leaf. Soon afterwards the margins of the gutter unite to form the hollow, cylindrical stelar cylinder (Fig. 3-D) but generally an elongated dorsal lacuna (Fig. 3-p) is formed close to the point of fusion of the margins. After the formation of a hollow cylindrical stelar cylinder the adult condition is reached by the development of large leaf gaps in two alternating closely placed rows on the dorsal surface, but bud traces do not occur associated with the leaves though a root trace (Fig. 3-r) often is attached abaxially to each leaf trace.

Thus the stelar cylinder of the adult rhizome of *Bolbitis* and *Egenolfia*, whether developing from the protostele of a vegetative bud or the juvenile sporeling, is formed by flattening of the solid cylindrical protostele, accompanied by upward curving of the margins of the flattened strand and their final merging to form a hollow cylinder. The pith is connected to the cortical tissue and is clearly cortical in origin.

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A New Species of Pyrrosia from India

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During a fern collecting tour of northeastern India, organized by the National Botanic Gardens (Lucknow) in May and June, 1961, I collected a narrow-leaved species of *Pyrrosia* in Manipur. The specimen did not tally with any of the species described previously. It was sent to Professor R. C. Ching (Peking Academy of Science), who confirmed that it is new, and suggested the name *Pyrrosia nayariana*, in honor of Dr. B. K. Nayar in recognition of his contributions towards a better understanding of the phylogeny of ferns, especially of the Indian species of *Pyrrosia*.

PYRROSIA **nayariana** Ching et Chandra, *sp. nov.*

Rhizoma breviter repens 2–3 mm. crassum, radicibus fasciculatis nigris firmis, dense paleatum, paleis peltatis lanceolatis 2–3 mm. longis dentatis; folia conferta lineari-oblanceolata 15–20 cm. longa, vix. 1.0 cm. lata, sessilia vel subsessilia, apice acuta, basi gradatim attenuata, supra glabra, hydathodis punctatis in apice venulis ultimis liberis, subtus dense tomentosa, pilis stellatis triformibus, inferioribus densis ramis elongatis gracilibus glomeratis, superioribus floccosis ramis brevibus latis cymbiformibus, alteris ramis gracilibus acicularibus; folia fertilia saepe paullo