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ANATOMY OF SOME HIMALAYAN SPECIES OF *ATHYRIUM*[1]

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ABSTRACT

Anatomical studies on 20 Himalyan species of *Athyrium* have been carried out. The structure of the rhizome is dictyostelic with usually a binary leaf trace and extramarginal pinna supply. In case of *A. himalaicum* and *A. anisopterum* the leaf is single and at the base of the petiole instead of usual two leaf strands only one leaf strand is present which later on divides into two. Close anatomical similarities of *Athyrium* species with *Diplazium* and other allied genera give ample support to the earlier conclusion reached on cytomorphological grounds that the Athyrioid ferns constitute a coherent group, the members of which are closely allied to Thelypterioid ferns.

Athyrium Röth typifies the family Athyriaceae. Ching (1940) credited it with about 180 species but Copeland (1908, 1947) with the merger of *Diplazium* Swartz and other allied genera with it, raised the number to about 600 species. The members are cosmopolitan in distribution but these primarily prefer temperate climate and very few of them flourish in the tropics. From India nearly 37 species are recorded and almost all of them are met within the Himalayas. But the anatomy of all of these is still unworked out except for Bir's (1961) observations on *Athyrium japonicum* (Thbg.) (=*Diplazium japonicum* (Thbg.) Bedd.). With the increasing role of anatomy in fern phylogeny and taxonomy, the present work on the stelar anatomy of 20 species from the Himalayas was carried out.

MATERIAL AND METHODS

Anatomical material of *Athyrium pectinatum* (Wall.) Presl, *A.schimperi* Moug, *A.fimbriatum* (Wall.) Moore and *A. thelypteroides* (Michx.) Desv. was collected from Simla and Mussoorie between 1,200-2,100m. altitude in the Western Himalayas. For the rest of the species, namely, *A. attenuattum* (Clarke) Tagawa, *A. nigripes* Bl., *A. himalaicum* Ching ex Mehra & Bir, *A. anisopterum* Christ, *A. flabellulatum* (Clarke) Tard.-Blot, *A. filix-foemina* (L.) Röth, *A. rubricaule* (Edgw.) Bir, *A. setiferum* C. Chr., *A. parasnathensis* (Clarke) Ching, *A. foliolosum* (Wall.) Moore ex Sim, *A. subtriangulare* (Hook.) Bedd., *A.duthiei* Bedd., *A. spinulosum* (Maxim.) Milde, *A.clarkei* Bedd., *A. mehrae* Bir, and *A.puncticaule* (Bl.) Moore the material was collected between 1500-4200m. altitude of Darjeeling District and Sikkim state in the Eastern Himalayas. For information concerning exact localities, the refernce is

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made to Mehra and Bir (1960, 1964). In all the cases the material was fixed in standard solution of formalin acetic alcohol and microtomic sections were cut at 20μ after usual infiltration with wax. These were stained with safranin-fast green combination. With a view to follow up details concerning origin of leaf and root traces, stelar skeletons were extracted through maceration (for details see Bir, 1969).

Observations

Rhizome.—Broadly speaking on the basis of posture of the rhizome, *Athyrium* species studied here can be divided into two groups: (a) Widely creeping and branched rhizome: *A. pectinatum, A. schimperi, A. fimbriatum, A. subtriangulare, A. duthiei* and *A. spinulosum.* (b) Ascending rhizome: *A. clarkei, A. mehrae, A. anisopterum, A. himalaicum, A. puncticaule, A. flabellulatum, A. rubricaule, A. filixfoemina, A. foliolosum, A. parasnathense, A. setiferum* and *A. nigripes* or suberect in *A. thelypteroides* and *A. attenuatum.*

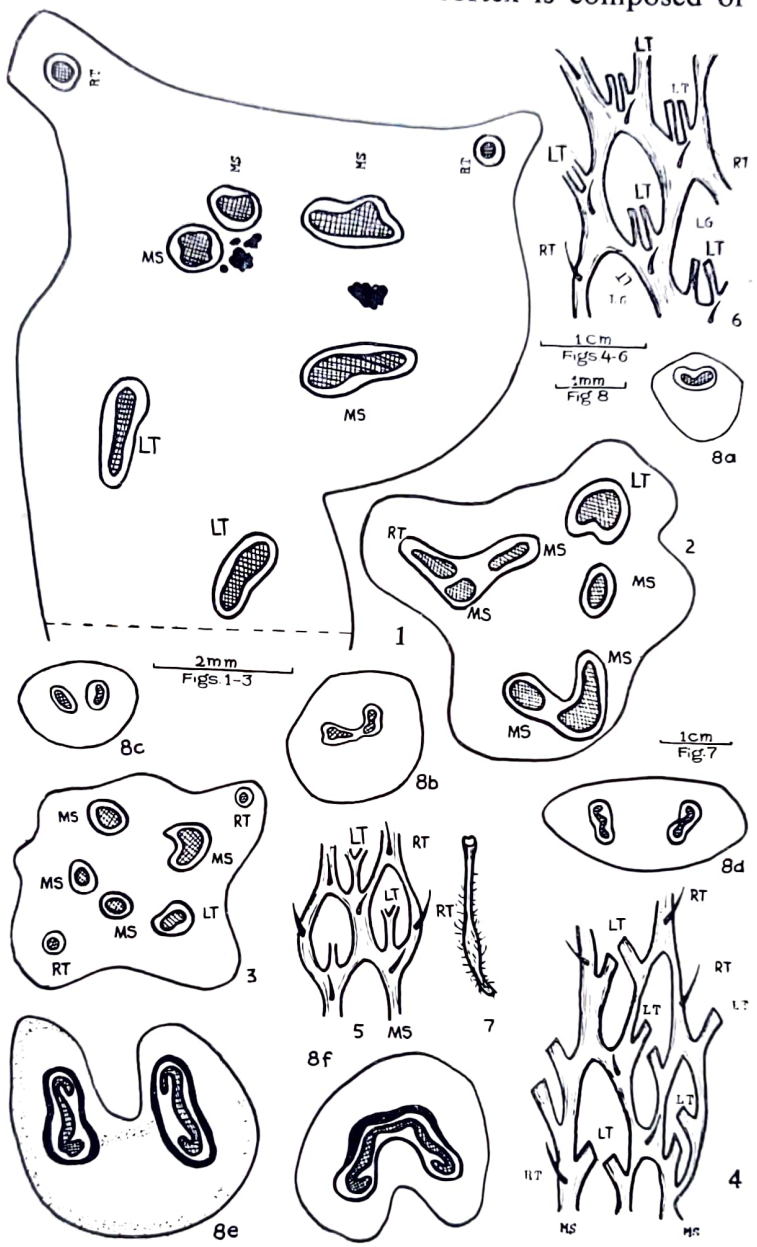
Whatever may be the posture, the rhizome is radial in symmetry and the structure is a finely dissected dictyostele with 3-5 or more cauline meristeles as seen in transection (Figs.1-3). In majority of the species the root trace departs before the opening of the leaf gap from outer face of the meristele and about the middle of leaf gap two leaf trace strands depart at the same or different levels (Figs. 4). The leaf gaps are elongated in species with creeping rhizome while these are short, several ones overlapping, in species with ascending or suberect rhizome. Often patches of sclerotic tissue are present in the ground tissue depending upon the habitat of the species.

The structure in *A. himalaicum* and *A. anisopterum* is rather interesting. The root trace abstricts off before the opening of a leaf gap but at a lower level than is usually the case. At the time of opening of leaf of gap a single vascular strand is detached off, which after traversing the cortex, enters the petiole either as such or after branching into two (Figs. 2, 3). A portion of extracted stele is enlarged in figure 5 to show the departure of leaf trace just at the base of leaf gap. One or two additional root traces may often be given off from meristeles enclosing the leaf gap. In *A. flabellulatum* the two leaf trace strands are separate from the very beginning but they depart very close to each other at the base of the leaf gap (Fig. 6).

Petiole.—The structure is characteristic of other Athyrioid genera. The two leaf strands are usually strap-shaped and unite upwards in the rachis into a single U-or V-shaped strand. In all the members of *Eu-Athyrium* group (*A. filix-foemina, A. himalaicum, A. foliolosum, A. rubricaule, A. fimbriatum* etc.) and *Lunathyrium* group (*A. thelypteroides*) the stipe becomes contracted at the point of attachment with the rhizome (Fig. 7). But such a pecularity of the stipe is not noticeable in representatives of *Athyriopsis* (*A. japonicum* (Thbg.) Copel) and *Pseudocystopteris* (*A. spinulosum* and *A. subtrianagulare*) groups. At first only a single small strand enters the petiole at the base in *A. anisopterum* and *A. himalaicum* (Figs. 5, 8a), then it divides into two strands which enlarge as the petiole thickens (Figs. 8 b-d). Further up, these strands assume the same shape as in other species, develop two xylem hooks and then higher up in the rachis these fuse into one U-shaped vascular strand (Figs. 8 e-f). The pinna trace in all the cases is always extramarginal. Often the leaf strands are accompanied by sclerotic patches on all the sides (Fig. 8e)

for providing mechanical strength. Sclerenchyma is well developed in the cortex of old petiole.

schimperi or *A. pectinatum.* The outer cortex is scherenchymatous and the inner cortex is composed of thin walled paren-



FIGS. 1-8. Fig. 1. *Athyrium pectinatum T.s. Rhizome* showing binary leaf trace. Figs. 2, 3. T.s. Rhizome of *A. himalaicum* and *A. aniosopterum* respectively showing single leaf trace. Figs. 4-6. A portion of the stelar skelton of *A. pectinatum A. himalaicum* and *A. flabellulatum* respectively enlarged to show few leaf gaps and leaf trace strands. Fig. 7. *A. himalaicum.* Basal portion of the stipe. It is contracted at the point of attachment with the rhizome. Figs. 8a-f. *A. himalaicum.* Course of leaf trace strands in the stipe and rachis (sections cut at successive regions from below upwards).

LT., leaf trace; MS, cauline meristele; RT, root trace; LG, leaf gap. Black patches indicate the presence of sclerotic tissue.

Bulk of the pith of the rhizome and stipe is composed of thin-walled parenchymatous cells, frequently filled with starch grains in case of rhizome as in *Athyrium* chyma but in older rhizomes and stipes the proportion of thick-walled tissue is more in comparison to thin walled tissue.

Cauline meristele and leaf strands.—The

structure is similar to that seen in Aspidiaceous members (Figs. 9,10). The meristeles and vascular strands of leaf are delimited from the adjoining cortical and pith cells by a well-defined layer of endodermis, the cells of which bear usual Casparian thickenings on radial walls. This is followed by 2-5 layered pericycle composed of polygonal cells which are frequently filled with brown contents especially in case of petiolar strand of *A.pectinatum* (Fig. 10). The phloem consists of large-sized sieve tubes intermixed with phloem parenchyma cells occasionally full of contents. Phloem surrounds the xylem on all the sides but towards the ends it is only 2-layered. The main bulk of the stele is formed of tracheids and these are intermixed with groups of xylem parenchyma cells. Tracheids from the cauline meristeles are usually 2-4 (or rarely 6 mm.) long in the species with creeping rhizomes and 1-3 mm. long in species with ascending rhizomes. These tracheids have scalariform thickenings. Protoxylem is present in groups and is usually mesarch or rarely exarch in position (Fig. 9).

The leaf strands are ellipsoidal or strap-shaped in outline and have basically similar structure as the cauline meristeles (Fig. 10).

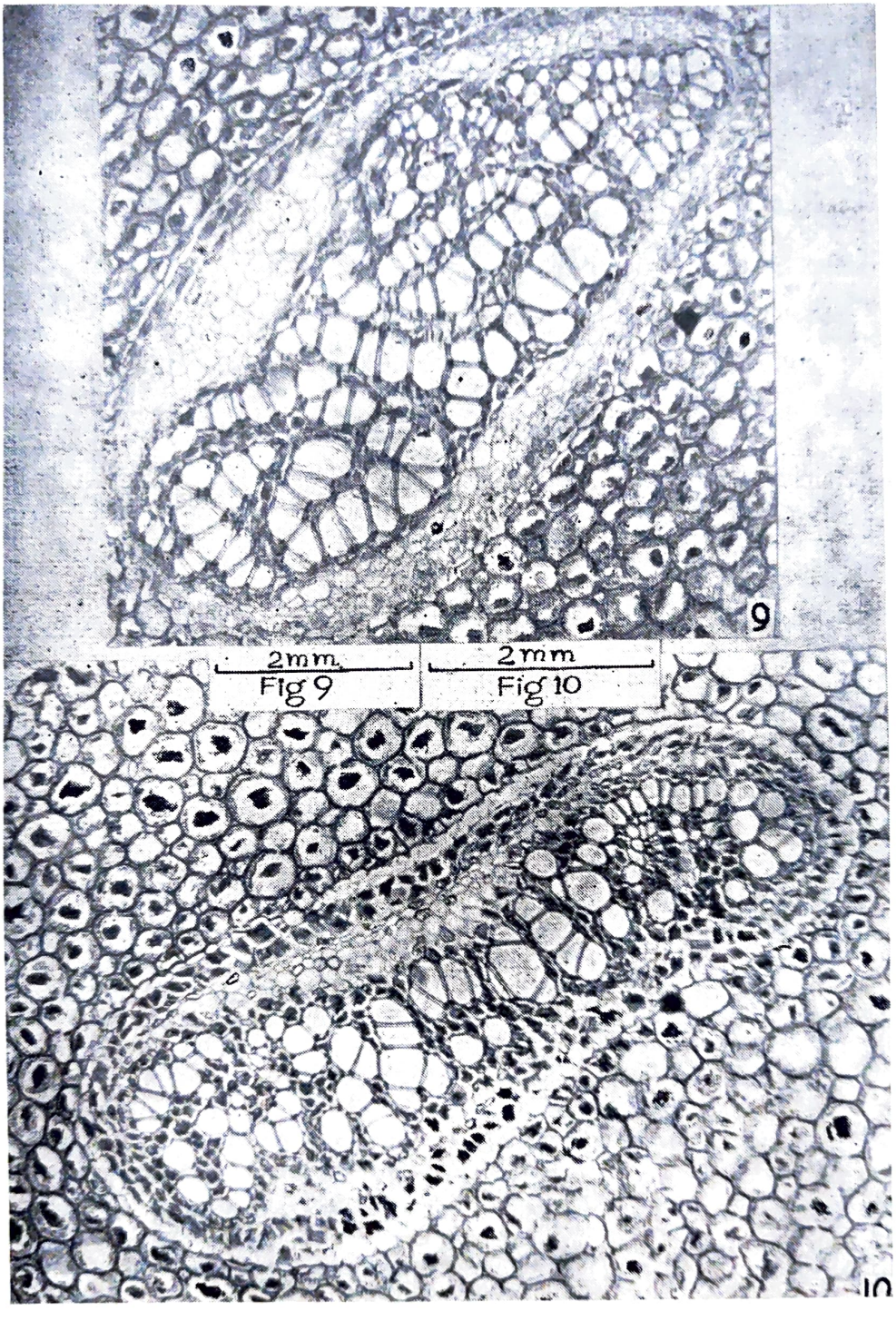
Root.—The structure is typically diarch and often the cortex is composed of inner thick-walled and an outer thin-walled zone of parenchymatous cells.

Discussion

Basically the stelar organization of the rhizome of the Himalayan species of *Athyrium* is similar to that of *Diplazium marginatum* (cf. Bower, 1928) and other Athyrioid ferns (author's observations). There is invariably the emergence of a basal root trace before the opening of the leaf gap and the abstriction of a root trace immediately after the opening of the leaf gap in some species is a minor departure from normal condition because of the overcrowding of leaf bases and very small size of the leaf gap. Further the stelar organization shows resemblances with *Diplazium petri, D. aridum* (cf. Tardieu-Blot, 1932), *Cystopteris* species (Bir and Trikha, 1970), *Cornopteris birii* and *Diplaziopsis javanica* (cf. Bir, 1965).

The binary leaf trace and the extramarginal condition of the pinna supply in various species of *Athyrium* investigated are similar to those seen in case of *Diplazium centrochinense, D. aridum, D. opacum, (Cornopteris opaca), D. megaphyllum, Athyrium fragile, A umbrosum* (cf. Tardieu-Blot, 1932) *A. japonicum* (cf. Bir, 1961) and various other Himalayan species of *Diplazium, Cystopteris, Diplaziopsis* (cf. Bir, 1965). The presence of a single leaf strand instead of usual two leaf strands at the base of the petiole in *Athyrium himalaicum* and *A. anisopterum* is a modification of normal condition in conformity with the small size of the rhizome of these species and is of no phylogenetic importance. The structure of stipe (presence of two leaf strands) is also like Thelypterioid genera as *Cyclosorus* and *Thelypteris* (author's observation). Similarly, the structure of leaf strand and cauline meristele is like other Athyrioid (as *Diplazium, Diplaziopsis, Cystopteris* etc.) and Thelypteriod ferns.

Therefore, the close similarities of anatomical features of *Athyrium* with *Diplazium* and other allied genera support the earlier conclusions arrived at on cytomorphological grounds that Athyrioid ferns constitute a coherent group. Furthermore, these are related to Thelypterioid ferns.



FIGS. 9, 10. *Athyrium pectinatum.* Fig. 9. T.s. Rhizome showing structure of cauline meristele Fig. 10. T. s. petiole showing structure of leaf strand.

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STUDY ON THE INHERITANCE OF ANTHOCYANIN PIGMENTATION IN *PENNISETUM GLAUCUM* (L.) R. Br.[1]

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ABSTRACT

The present investigation consists of the study of inheritance of the anthocyanin pigmentation in some vegetative parts of *Pennisetum glaucum* (L.) R. Br.

Different plant parts showed the different behaviour with regard to the inheritance of the anthocyanin pigmentation. Node, leaf margin and leaf midrib showed the monogenic dominance over the green colour while internode and leaf lamina showed monogenic inheritance with one gene difference.

A number of workers have studied the inheritance of qualitative characters in pearl-millet (cf. Athwal et al., 1966a and b; Ahluwalia and Shanker, 1964; Gill, 1969; Singh et al., 1969a and b). No detailed studies have been made on the inheritance of pigmentation in pearl-millet. Recently Singh et al. (1969a & b), Gill (1969) have given the information of the inheritance of pigmentation in some plant parts.

Present paper deals with the inheritance studies of the anthocyanine pigmentation in the nodes, internodes, leaf lamina, leaf-

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