ON THE MORPHOLOGY AND ANATOMY OF ARTHROMERIS WALLICHIANA (SPR.) CHING

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INTRODUCTION

The genus Arthromeris was instituted by J. Smith (1875). Species of ferns belonging to this genus were placed by earlier botanists under the genera Polypodium (Clarke, 1825), Pleopeltis (Moore, 1857; Beddome, 1883), and Phymatodes (Hooker, 1868). Only three species referable to this genus, i.e., A. himalayanse (Hook.) J. Smith, A. tenuicaudata (Hook.) Ching and A. wallichiana (Spr.) Ching have been reported by Mehra and Bir (1964) from Darjeeling and Sikkim Himalayas. Nayar and Devi (1964) have studied the spore morphology of these three species, but the anatomy of none of these species seems to have been worked out. The present paper deals with the morphology and anatomy of A. wallichiana (Spr.) Ching, collected by the junior author from Kurseong in Darjeeling area.

GENERAL MORPHOLOGY

The sporophytic plants of A. wallichiana are about a meter in height. They are terrestrial and epiphytic with long, creeping, stout rhizomes covered by broad, lanceolate scale-like, non-clathrate paleae and attached to the substratum by thin, branched, blackish roots. The paleae (Figs. 1, 2) have a narrow tip (Fig. 2) ending in a glandular hair. Papillate, hair-like structures (Fig. 3) are present in great numbers all over the body of the paleae. The articulate fronds are imparipinnate, and have long stipes. The pinnae

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have an entire margin and an acuminate tip. Very few short dermal hairs (Fig. 4) occur on the leaf surface and the texture of the leaf is coriaceous. The venation (Fig. 5) is reticulate with prominent main and lateral veins. The tertiary veins anastomose and form irregular areoles which contain simple or forked included veinlets ending in funnel-shaped hydathodes (Fig. 6) on the upper epidermis of the leaf, similar to those found in \textit{Microsorium} (Nayar, 1961 \textit{a}), \textit{Lemmaphyllum} (Nayar, 1964 \textit{a}), \textit{Pyrrosia} (Nayar, 1961 \textit{b}), \textit{Lepisorus} (Khare, 1965; Srivastava, 1966) and \textit{Crypsinus} (Srivastava, unpublished). Stomata (Figs. 7, 8) are confined to the lower surface of the lamina, the guard cells are surrounded by 1–3 subsidiary cells. The epidermal cells are sinuous, smooth-walled and devoid of pits. The sorus is large, round, exindusiate and present on either side of the midvein of the pinnae and close to it. Paraphyses are totally absent. The sporangia are long stalked with an incomplete annulus of 13–14 thick-walled cells and a stomium of 4–6 thin-walled cells. The spores are bilateral, monolete brownish with a double-layered, tuberculate to spinulose exine.

**ANATOMY**

The roots are thin, branched and blackish in colour. They have a diarch exarch stele. The rhizome is about 2 centimeters in diameter and is dictyostelic with a varying number of meristeleles arranged in a ring. The epidermis is single-layered pierced by the paleae stalks. The ground tissue is undifferentiated and is made up of thin-walled large parenchymatous cells (Fig. 10). Each meristele (Fig. 11) has a plate-like xylem composed of 25–40 tracheids and more or less lateral phloem. The endodermis and pericycle are clear. Sclerenchyma strands, though reported in all the species of \textit{Arthromeris} described by Copeland (1947, p. 209), were not seen in the species described in this paper, but a few isolated, lignified cells occur in the cortex near the endodermis of the meristeleles. A number of vascular bundles derived from the meristeleles of the rhizome and arranged in the form of a ring enter into the phyllopodium (Fig. 12). The two dorsal larger bundles continue into the petiole as the main lateral bundles. The phyllopodium has no sclerenchymatous tissue. The petiole is long, brown in colour, carries 10–15 vascular bundles (Fig. 13). The petiole (Fig. 14) has a single-layered epidermis followed by a broad sclerenchymatous outer cortex and a wider parenchymatous inner cortex. There are three main and a varying number of lateral vascular bundles. The lateral main bundles have an exarch xylem composed of 20–30 tracheids and have only one protoxylem point as in other polypodioid ferns but the main median bundle (Fig. 14) has a plate-like diarch xylem. Phloem
surrounds the xylem except at the protoxylem points, pericycle is 1–4 cells thick and the endodermis is heavily lignified.

A transverse section of the leaf (Fig. 15) in the apical portion of the pinna shows that the midrib has a T-shaped xylem, and the endodermis is heavily lignified.
lignified. The lamina (Fig. 16) shows a one cell thick upper and lower epidermis. The upper is thick and is succeeded by a hypodermis. The undifferentiated mesophyll contains sparsely distributed large air spaces. The lower epidermis is one-celled and bears the stomata.

**SORUS**

The sorus (Fig. 5) is large, exindusiate, present on either side of the primary lateral vein of the pinnae, in a single row, and usually supplied by a plexus of veins. The sporangia (Fig. 17) are globose with a long stalk made up of two rows of cells and a short secondary lateral row developed from the base of the sporangial capsule to a short distance of the stalk. Paraphyses are absent.

**SPORES**

The spores (Figs. 18, 19, 24, 25) are monolete, bilateral, elliptical in equatorial view, and planoconvex in polar view. They are light brown in colour and measure on an average $37 \times 57 \times 35 \mu$ (P x E1 x E2) (range $35 \times 58 \times 32 \mu$ to $41 \times 69 \times 39 \mu$). The lesura is $40 \mu$ long. The exine (Fig. 20) is $3 \mu$ thick, double-layered. The endoexine is smooth, the equally thick ectoexine bears $5 \mu$ long pointed spines, sometimes even $4 \mu$ apart. They are pale in colour and more than one may be situated on circular cushions, which are irregularly distributed on the spore surface.

**DISCUSSION**

The genus *Arthromeris* was instituted by J. Smith in 1875. Beddome (1883) placed this species, i.e., *A. wallichiana*, in the genus *Pleopeltis* referring to it as a synonym of *Pleopeltis juglandifolia*. Bower (1928), however, does not mention the genus. Christensen (1938) recognizes the genus *Arthromeris* and places ten Asiatic species under it. Ching (1940) also recognizes the genus and regards it as comprising 13 species distributed in China, Himalayas and Tonkin to Formosa. Copeland (1947) and Holttum (1947) recognize the genus as comprising ten species ranging from Eastern Asia to Formosa. Mehra and Bir (1964) have reported from Darjeeling and Sikkim Himalayas, *A. wallichiana*, *A. tenuicaudata* and *A. himalayanse*. They have further referred to the following as the synonyms of *A. wallichiana*: *A. juglandifolia* (Copeland, 1947), *Polypodium juglandifolia* (Clarke, 1825), *Pleopeltis juglandifolia* (Moore, 1857; Beddome, 1883) and *Phymatodes juglandifolia* (Hooker, 1868).
The genus *Arthromeris* resembles very closely the allied genera *Phymatodes*, *Crypsinus* and *Microsorium*. Christensen (1938) considers *Arthromeris* as differing from *Phymatodes* chiefly in its imparipinnate leaves with pinnae articulated to the main rachis. According to Copeland (1947, p. 209), *Arthromeris*, *Crypsinus* and *Microsorium* share the following characters in general: (a) pinnate fronds, (b) reticulate venation with variously directed included veinlets and (c) round sori devoid of peltate clathrate paraphyses. *Microsorium* and *Crypsinus* differ from *Arthromeris* in having non-articulated leaf segments. The cartilagenous margin of the lamina is notched in *Crypsinus* but not so in *Microsorium* and *Arthromeris*. The species described in this paper shows *Microsorium* characters like round sori arranged on either side of the main vein of the pinnae, in a single row, and the absence of peltate paraphyses. But it differs from *Microsorium* in having imparipinnate fronds with pinnae articulated to the main rachis. *A. wallichiana* differs from *Crypsinus* in the above frond character although it shows other resemblances like non-clathrate palea. This articulation of the segments with the rachis, seen in the species described here, is a very important *Arthromeris* character according to Christensen (1938). The present study shows that *A. wallichiana* does not possess any sclerenchymatous strands in the rhizome while they are present in both *Crypsinus* and *Microsorium*. The spores of *Microsorium* have smooth exine and those of *Crypsinus* are densely spinulose. The spores of *Arthromeris* are also spinulose but the spines are raised on small cushions, a feature seen in the species described here (Nayar and Devi, 1964).

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**References**


EXPLANATION OF TEXT-FIGURES

Figs. 1-20. *Arthromeris wallichiana*. Fig. 1. Palea. Fig. 2. Tip of palea. Fig. 3. A portion of palea showing papillate hairs. Fig. 4. Hair on the lamina. Fig. 5. Venation and sori arrangement. Fig. 6. Hydathode in surface view. Figs. 7, 8. Stomata. Fig. 9. Cells of upper epidermis. Fig. 10. A portion of cortex of rhizome. Fig. 11. Meristele of rhizome. Fig. 12. Transverse section of phyllopodium (Topographic). Fig. 13. Transverse section of petiole (Topographic). Fig. 14. A portion of transverse section of petiole showing main median bundle. Fig. 15. Transverse section of leaf. Fig. 16. A portion of transverse section of lamina. Fig. 17. Sporangium. Figs. 18, 19. Polar and equatorial views of the spore. Fig. 20. Exine structure.

*(an—annulus; as—air space; c—cortex; ecex—ectoexine; end—endodermis; enex—endoexine; ep—epidermis; gc—guard cell; h—hair; ic—inner cortex; lep—lower epidermis; mes—mesophyll; oc—outer cortex; per—pericycle; ph—phloem; stm—stomium; uep—upper epidermis; xy—xylem.)*