ON THE MORPHOLOGY AND ANATOMY OF TECTARIA CICUTARIA (L.) COPEL.

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INTRODUCTION

A study of the morphology and anatomy of the different Indian species of Tectaria Cav. belonging to Aspidiaceae (Copeland, 1947-49) has been undertaken here. The first of the series, a study of Tectaria amplifolia (Rao and Khare, 1964), has already been published. The present paper deals with another species T. cicutaria, which is available in the living condition in Lucknow.

MATERIAL AND METHOD

The vegetative as well as the fertile material was obtained from the potted plants. Microtome sections at 10-15μ thickness were prepared. Safranin, light green and orange G were used in combinations for staining. Ferric chloride-Tannic acid technique was also applied. Maceration, to clear the tissue, was done in a solution of nitric acid and potassium chlorate. Spore-morphology was studied by acetolysed spores (Erdtman, 1952). At least twenty measurements in each plane were taken and these were exclusive of the thickness of the perine.

GENERAL MORPHOLOGY

The plant is medium sized with large pinnately compound fronds. The rhizome (Fig. 1) is short, erect, covered with adventitious, sparsely branched roots, which are produced all round the petiole base (pt b). Both the rhizome and the petiole are clothed with multicellular dermal appendages (d a). The plant body is densely paleate, rather pubescent, covered with uniseriate but multicelled hairs. In a single hair there may be as many as 6-8 cells (Fig. 6). The cells of the hair are long and colourless with a prominent nucleus (Figl. 2-6). Dermal appendages (Figs. 7-9) are articulate, scale-like, multicellular and light brown in colour, one cell thick, broad at the base and tapering

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Towards the tip. Sometimes (Fig. 9 A and Photo 1) a small scale is seen cutting itself off from the main scale. The marginal hairs are few and very distant, the arrangement of cells is simple (Figs. 10, 11). The terminal cell varies in shape (Figs. 9 A, 10, 11). The uniseriate hairs are persistent on all plant parts as in the allied genus Cystopteris (Palser and Berick, 1941).

**Rhizome**

The rhizome as already stated is erect (Fig. 1), short, clothed with scale-like, articulate dermal appendages and uniseriate, multicellular, unbranched hairs. The rhizome in a transverse section (Fig. 12) is polystelic as in other allied genera like Peranema and Diacalpe and also as in Tectaria amplifolia (Rao and Khare, 1964). There are two to four main vascular bundles and the rest are the lateral bundles. A cleared mount of the rhizome shows the stelar network with main bundles anastomosing (Fig. 13). The main bundle (Fig. 16) is exarch protostelic and the xylem is slightly plate-like. Two protoxylem groups, occupying the opposite ends of the xylem, are present. The metaxylem has long scalariform and spiral tracheids (Fig. 14). The phloem surrounds the entire xylem, except at certain points, as a thin layer. Parenchyma occurs mixed with xylem as well as phloem, but more with xylem, the pericycle and endodermis are very distinct. The latter consists of thin-walled, elongated, barrel-shaped cells with casparian strips on the radial walls (Fig. 15). Outer tangential walls, sometimes, become thick-walled due to the deposition of phlobaphane. The ground tissue (Fig. 16) consists of parenchymatous isodiametric cells, the outer peripheral cells of the cortex are small, more compactly arranged and slightly thick-walled. These thick-walled cells gradually merge into thin-walled parenchymatous cells. Sections when tested with iodine show the presence of starch and some amyloids. Phlobaphane is also present in patches all over the cortex (Figs. 12, 16). Serial transverse sections (Fig. 17 A-D) and also the cleared mount (Fig. 13) of the dictyostele show that the petiolar trace has been derived from the main vascular bundle. Figure 17 A shows a transverse section of the rhizome with four main bundles (rh s). In Fig. 17 B one of the main bundles is giving rise to a petiole trace (pt tr) at the right. This single trace moves towards the petiole base (Fig. 17 C), the petiole trace divides repeatedly (Fig. 17 D) and that is how a polystelic condition is seen in a transverse section of the petiole at the base (Fig. 20). A reference to Fig. 13 shows, how due to the anastomosis of the stelar network adjacent transverse sections may show varying numbers of main bundles. All the smaller peripheral bundles seen in Fig. 12 are root traces.
TEXT-FIGS. 1–15
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ROOT

The roots are thin, dark brown and sparsely branched. They arise from the rhizome all round the petiole base, like other members of the family Aspidiaceae. In a transverse section of the rhizome (Fig. 12) root traces are present in great numbers along the periphery. A transverse section of the root (Fig. 18) shows a thin-walled outer cortex (oc) and a thick-walled inner cortex (ic). Young roots (Fig. 19) show very slightly thickened inner cortex. The endodermis is thin-walled, single-layered and encloses a 2-4 cell thick pericycle. The stele is diarch with few large metaxylem tracheids and two spreading-out protoxylem patches. Phloem is mixed with parenchyma. No root hairs are seen.

LEAF

The leaf is pinnately compound like that of T. amplifolia but slightly smaller with varying number of pinnae, generally two to three pairs. The lamina is hairy on both the sides. These hairs are uniseriate and multicellular.

The petiole is long, cylindrical, covered by hairs all over and also by scales in the lower parts. The transverse section (Fig. 20 and Photo 2) of the petiole shows three main vascular bundles (mb) derived from those of the rhizome. A section at the base (Fig. 21) shows an outer zone of small thick-walled cells with no air-spaces and an inner zone of large thin-walled, closely-packed cells. The outer zone continues to be thick-walled but at the extreme tip of the petiole (Fig. 23) it becomes almost thin-walled. This sclerization of the outer zone imparts a brown colour to the lower parts of the petiole. A transverse section (Fig. 22) in the middle shows the same tissue as above but with further sclerization of the outer cortex and the outer wall of the endodermis. The vascular bundles are monarch with scalariform tracheids mixed with xylem parenchyma. The phloem is also mixed with parenchyma and surrounds the xylem core except at some protoxylem points. In general, the vascular bundles are all exarch (Photo 3). The pericycle is very distinct and the endodermal cells have casparian thickenings on their radial walls. In a transverse section of the tip of the petiole (Fig. 23) there are only three main vascular bundles but the sclerization of the outer zone of the cortex is very much reduced.

Serial transverse sections of the petiole, taken from the base upwards, show a definite pattern in the origin of the pinna trace. At the very base (Fig. 20) in a transverse section there are three main bundles (mb) and 2-4
lateral bundles (l.v.b). At a little higher level (Fig. 24) one of the main lateral bundles cuts off a small bundle (stippled) which moves outwards (Fig. 25) to enter into the pinna. The other main bundle on the opposite side repeats the same process to supply the pinna on the other side. The lower median main bundle does not cut off any pinna trace but cuts only lateral traces. At the extreme tip of the leaf the three main bundles (Fig. 26) fuse together (Figs. 27, 28) to form a shallow plate-like bundle. The departure of the leaf trace and the pinna trace sequence in this species is essentially like what is found in *T. amplifolia* (Rao and Khare, 1964).

A transverse section of the terminal pinna (Fig. 29) shows that there are uniseriate hairs above and below the midrib as well as the lamina. The mesophyll is undifferentiated and has large air-spaces. The stomata are present in great numbers on the abaxial side. The mesophyll cells are compact above the vascular bundle and the rest of it is loosely arranged with large air-spaces (a sp). The vascular bundle (Fig. 30) has a clear endodermis enclosing the distinct pericycle, and a plate-like exarch xylem with compactly arranged scalariform tracheids. The phloem is mostly on the abaxial side.

The guard cells are big and are surrounded generally by four (Fig. 31) subsidiary cells which are sinuous-walled epidermal cells. In some stomata, almost the entire stoma may be situated within a single subsidiary cell (Fig. 32) while a part of it may be surrounded by two subsidiary cells. This was the only variation found. Attempts to trace the developmental stages of the stomata had to be given up for want of suitable material.

The venation (Fig. 33) is pinnate; from the secondary veins branches arise forming meshes of areoles. The costal areoles are longer than broad and are much bigger than the marginal areoles. Included veinlets are not seen.

**SORUS**

The sorus is abaxial, superficial and indusiate, the indusium being umbrella-shaped and paleate. The sori are present on the secondary veins often terminating them, sometimes the vein continues beyond the sorus (Fig. 34). The ripe sporangium (Fig. 35 and Photo 4) is pear-shaped having a vertical incomplete annulus of 14–18 cells. The stalk is long and is made up of two rows of cells, a third row is present and extends only from the base of the sporangium to a certain distance of the stalk. The slit is oblique.

There are 64 spores in a sporangium. The ripe spores (Fig. 36 and Photo 5) are light brown in colour, homosporous, monolete, bilateral, slightly
planoconvex, ovate and measure from $31.5 \mu \times 53.5 \mu \times 34.2 \mu$ in size (range $24 \mu \times 36 \mu \times 36 \mu$ to $39 \mu \times 60 \mu \times 33 \mu$). The leisure is $30 \mu$ long and narrow (3 \mu). In equatorial view the spores are ovate and very slightly planoconvex (Fig. 37) with thin transparent perine which is spinulate and is thrown into irregular folds (Fig. 36). The folds are $6 \mu$ broad. The exine (Fig. 38) is spinulate and $2.8 \mu$ thick. The endoexine has two layers, a dark-coloured thick layer and below it is present a thin layer. The ectoexine is $1.4 \mu$ broad, colourless, with very small spinules. The transparent perine is $6 \mu$ broad and envelops the whole spore. It bears spinules all over the surface. In general, the ornamentation is spinulate. Acetolysed spores are slightly bigger in size than the unacetolyzed ones.

**DISCUSSION**

The genus *Tectaria* Cav. occupies a controversial systematic position. Copeland (1947-49) places it under the family Aspidiaceae. But Holttum (1947-49) treats it as a member of the subfamily Tectarioideae of the family Dennstaedtiaceae. The genus is represented by 212 species (according to Copeland) in the moist tropical regions of the world. The present paper deals with the description of the sporophytic generation of the second species *T. cicutaria* available here. It resembles the previously described species *T. amplifolia* (Rao and Khare, 1964) in having the dictyostelic rhizome, dorsal sori and constant occurrence of perispore in the spores.

*Tectaria cicutaria* shares with the allied genera *Peranema* and *Diacalpe* (Davie, 1912) the following characters: a polystelic erect rhizome covered with branched fibrous roots, polystelic long stipe with parenchymatous ground tissue and articulate scale-like dermal appendages, superficial dorsal sori with stalked sporangia and large monolet spores with folded perine.

In the presence of persistent unicellular hairs *Tectaria cicutaria* resembles *Cystopteris* (Palser and Beric, *loc. cit.*). The open dichotomous venation of *T. cicutaria* is met with in *Acrophorus* (Thomson Betty, 1943).

*T. cicutaria* also resembles *Metteuecia* (Nayar, 1961; Nayar and Kazmi, 1963) in having a dictyostelic rhizome covered with persistent leafbases, paleae and roots, undifferentiated mesophyll and spor characters like the monolet, planoconvex shape, and the presence-of a perine. Spores of *T. cicutaria* resemble the spores of *Didymochena* (Stoky and Atkinson, 1954) and *Quercifilix* (Nayar, 1960) all members of Aspidiaceae, *T. cicutaria* resembles *T. amplifolia* in all essential characters except in having the spinulate exine and perine.
In view of the above-mentioned characters the reference of this species of *Tectaria* also to the subfamily Tectarioideae of Holttum and its inclusion in Aspidiaceae seems to be justified.

**SUMMARY**

The morphology and anatomy of *Tectaria cicutaria* (L.) Copel. has been studied in detail. It shows structural and developmental similarities with *Tectaria amplifolia* (Rao and Khare, 1964) already studied. Some resemblances are also recognisable with allied genera *Peranema* and *Diacalpe* (Davie, 1912). *Tectaria* was earlier placed under Polypodicaeae, but the morphological and anatomical features brought out from the present study of *T. cicutaria* show that like *T. amplifolia* also, it should be placed under Aspidiaceae, as has been rightly done by Copeland (1947).

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**REFERENCES**

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FIGS. 1-5
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**EXPLANATION OF TEXT-FIGURES**

Figs. 1-15. Fig. 1. Free hand sketch of the rhizome. Figs. 2-6. Development of the dermal hair, ×260. Figs. 7-8 and 9 A. Dermal appendages, ×35. Fig. 9 B. Tip of the Fig. 9 A, ×35. Figs. 10 and 11. Tips of the dermal appendages, ×190. Fig. 12. Topographic T.S. of rhizome, ×5. Fig. 13. Clear amount of the vascular supply of rhizome, ×5. Fig. 14. L.S. of rhizome passing through one of the vascular bundles, ×260. Fig. 15. Endodermis of the rhizome, ×260.

(a r, adventitious roots; c rh, casparian thickenings; d a, dermal appendage; end, endodermis; per, pericycle; pt b, petiole base; ph, phloem; phb, phlobaphane; pt s, petiole supply; rh, rhizome; rh s, rhizome supply; r s, root supply; r tr, root trace; scl b, sclerenchyma band; scl t, seleriform tracheids; sp t, spiral tracheids.)

Figs. 16-28. Fig. 16. A sector of the T.S. of rhizome, ×50. Fig. 17 A-D. Serial transverse sections of the rhizome showing the departure of a petiole trace (all magnified to 5 times). Fig. 18. T.S. of a mature root, ×75. Fig. 19. T.S. of a young root, ×75. Fig. 20. Topographic T.S. of petiole near the base, ×10. Fig. 21. A portion of the T.S. of petiole near the base, ×75. Fig. 22. A portion of the T.S. of petiole in the middle, ×75. Fig. 23. T.S. of the petiole at the tip, ×50. Figs. 24 and 25. Topographic T.S. of petiole showing the departure of a pinna trace, ×10. Figs. 26-28. Topographic T.S. of the terminal pinna, ×20.

(end, endodermis; ep, epidermis; h, hair; ic, inner cortex; lv b, lateral vascular bundle; mv b, main vascular bundle; mxy, metaxylem; oc, outer cortex; per, pericycle; ph, phloem; phb, phlobaphane; pt b, petiole base; pt r, pinna trace; pt tr, petiole trace; rh, rhizome; rhs, rhizome stele; v b p, vascular bundle of the pinna.)

Figs. 29-38. Fig. 29. T.S. of pinna, ×110. Fig. 30. Stele of the pinna, ×375. Figs. 31 and 32. Stomata with subsidiary cells, ×375. Fig. 33. Venation of the leaf, ×5. Fig. 34. Arrangement of the sorus, ×5. Fig. 35. Mature sporangium, ×260. Fig. 36. Polar view of the spore, ×375. Fig. 37. Equatorial view of the spore, ×375. Fig. 38. Exine structure with perine, ×850.

(an, annulus; a sp, air-space; c a, costal areole; ec ex, ectoeexine; en ex, endoexine; end, endodermis; ex, exine; g c, guard cells; h, hair; ind, indusium; l, leasure; l ep, lower epidermis; l v, lateral vein; m a, marginal areole; mes, mesophyll; mrb, midrib; mxy, metaxylem; ph, phloem; pr, perine; s, sorus; sc, subsidiary cells; so, stomatal opening; sp, spinules; u ep, upper epidermis.)

**EXPLANATION OF PLATE XXII**

**PHOTO 1.** Scale, ×35.6.

**PHOTO 2.** T.S. of petiole, ×40.

**PHOTO 3.** Vascular bundle of the petiole enlarged, ×80.

**PHOTO 4.** Mature sporangium, ×185.

**PHOTO 5.** Polar view of the spore, ×1,255.