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ON THE ANATOMY OF THE ENDANGERED PLANT SPECIES *ASPLENIUM LEPIDUM* (ASPLENIACEAE)

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Studies of the endangered fern species *Asplenium lepidum* revealed new data and features on the anatomical structure of the adventitious root, the rhizome and the leaf (petiole, rachis and pinnulae). The structures of the petiole and rachis were analysed on serial cross sections, beginning from the base up to the rachis tip, with special attention to the changes and organisation in the vascular system. With six figures.

Key words: adventitious root, anatomy, *Asplenium lepidum*, petiole, rachis

INTRODUCTION

Asplenium lepidum C. Presl, known as spleenwort, is a small fern with tufted leaves 5 to 10 cm in length. It has a long green petiole, brown at the very base and the blade possesses many glandular hairs, broadest at base. The pinnulae cutting is deep but variable. This little fern, in natural habitats, used to grow on limestone overhangs and cliffs and in the side of the caves, often in dry situations, even below 1,000 m in altitude. The spleenworts develop in spring and fructify in summer, the leaves drying in winter.

Asplenium lepidum is a rare and endangered fern species in the native flora of Transylvania (Romania). It occurs in the region of Cris – Cheile Turzii at the broad alcove, and in the Ford Cave – Crisului Ford nature reserve. Previously it was also found at Suncuius (Beius), Banat (Baile Herculane zone) – Columbaci Cave and Gorj region (Polovraci) in the Oltetului Gorges (SAVULESCU 1952).

Generally, fern structures, especially those concerning the changes and variation in the vascular system and organisation of the vegetative organs, are little known, especially in the case of *Asplenium lepidum* C. Presl.

MATERIALS AND METHODS

Cross sections of the root, rhizome and leaf (petiole and bade) of specimens, preserved in the Herbarium and Botanical Garden "Alexandru Borza" in Cluj-Napoca (Kolozsvár/Clausenburg), were prepared using a rotary microtome. The samples were stained with alum-carmine and iodine green and were embedded in Canada balsam. Observations were made with a BIOROM-T bright field microscope, equipped with a TOPICA-6001A video camera. The microphotographs were obtained from the video camera through a computer.

RESULTS AND DISCUSSION

The adventitious root, in cross sections, revealed that the cortex consists of few layers of compactly arranged parenchyma cells. The inner layers of cortex cells are modified and have thick walls. KROEMER (1903) has suggested that this wall thickening is the result of cutinised blade superpositions. Noticed by early authors, the presence of such "curious cells" around the stele have led to the recognition of this tissue belonging to the stele and naming it "sclerenchymatous mass" (RUSSOW 1872, BIERHORST 1971) or a "stereomic sheath" (DE BARY 1877, OGURA 1938, BERCU 2004, 2005, 2006) (Fig. 1A, B). This configuration has led SCHNEIDER (1996) to include this type of root to that of *Asplenium* (Fig. 1A, B).

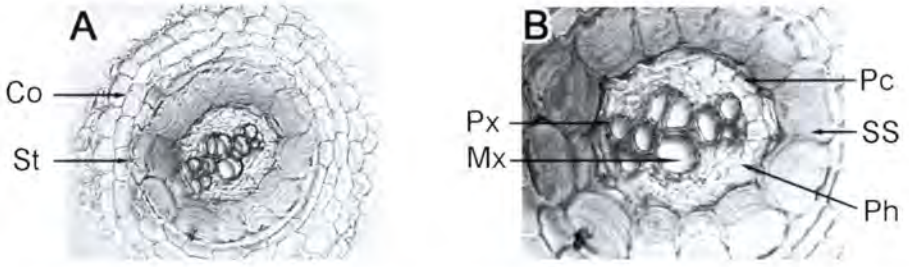


Fig. 1. Cross section of the adventitious root. A: general view of the root (×150); B: detail of the stele (×240). (Co = cortex, Mx = metaxylem, Pc = pericycle, Ph = phloem, Px = protoxylem, St = stele, SS = stereomic sheath (orig.)).

The stele consists of xylem and phloem and is surrounded by a one-layered pericycle. The protoxylem vessels (5 for each bundle) are in an exarch position and face the pericycle. The phloem sieve cells, lack companion cells, are located on either side of the xylem string (Fig. 1B). The xylem elements (2 for each bundle) are joined together toward the centre by their metaxylem vessels (2 for each bundle). This attributes to the root a diarch structure (Fig. 1A, B).

Cross sections of the petiole base up to 2 cm reveal that the epidermis consists of a single layer of thick-walled cells (Fig. 2A). Below the epidermis is the cortex consisting of 3–4 layers of large parenchyma cells, followed by a single layer of regularly arranged cells that is endodermis (Fig. 2A). Remarkable is the presence of a large sclerenchyma mass placed in the adaxial portion of the stele with mechanical role, which towards the rachis tip is absent (Fig. 2B). Characteristic to the Aspleniaceae petiole structure the stele is monofascicular (OGURA 1972, BIR 1957, BERCU 1998, 2006), composed of two centrally located xylem strings, surrounded by phloem. That attributes to the vascular bundle a hadrocentric structure. The two xylem curved strings configuration reveals that initially two rhizome vascular bundles, called by OGURA (1938) meristeles, join together to form a foliar trace (Fig. 2B). The stele is surrounded by pericycle composed of a single layer of cells, locally in two or even three rows, sometimes called "special pericycle" (ANDREI 1978).

Transversal sections of the petiole and rachis, cut from the base (2 cm) up to 4 cm exhibit almost the same structure, but the monostele xylem strings appear in an X-shaped arrangement, characteristic to the Aspleniaceae species (OGURA 1972, BIR 1957, BERCU 1998, 2006). The phloem surrounds the xylem elements (Fig. 3A, B).

Cross sections of the rachis from 4 cm up to 6 cm, exhibit the same succession of tissues, but the xylem vessels form a T-shape arrangement (Fig. 4A, B), surrounded by phloem and endodermis, the latter with parenchymatous sheath value (Fig. 4B) (BERCU 2004, 2005). The small vascular bundle, derived by marginal breaking up, from the rachis stele, to form the pinnulae main vein. Remarkable is the reduced number of the cortex layers of cells and vascular elements. A typical sclerenchymatous hypodermis is present. Transversal sections of the rachis tip (6.5 cm from the petiole base) show a blade structural organisation with the same conformation of the stele vascular elements.

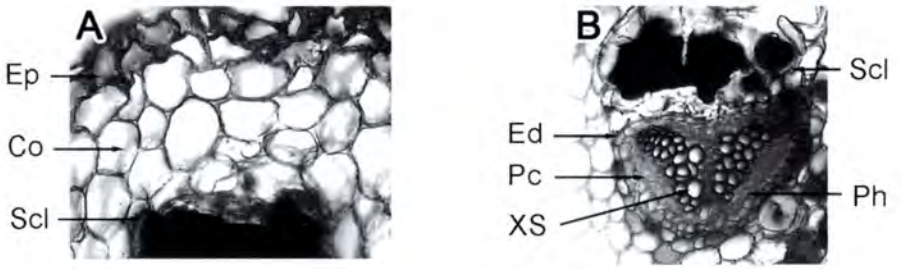


Fig. 2. Cross section of the petiole base. A: portion with epidermis and cortex (×150); B: the stele (×115). (Co = cortex, Ep = epidermis, Ed = endodermis, Pc = pericycle, Ph = phloem, Scl = sclerenchyma, XS = xylem string (orig.))

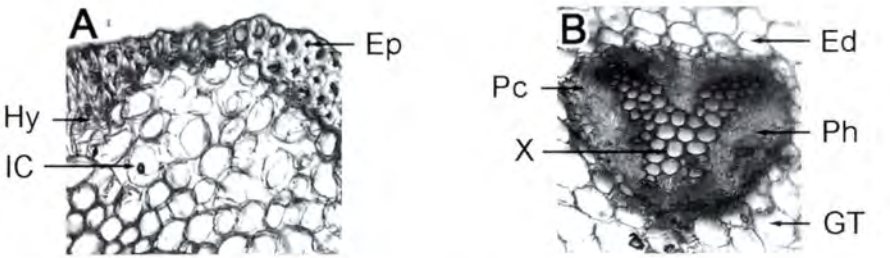


Fig. 3. Cross section of the petiole (2 cm from the base). A: portion with epidermis and cortex (×330); B: the stele (×330). (Ep = epidermis, Ed = endodermis, GT = ground tissue, Hy = hypodermis, IC = inner cortex, PC = pericycle, Ph = phloem, X = xylem (orig.)).

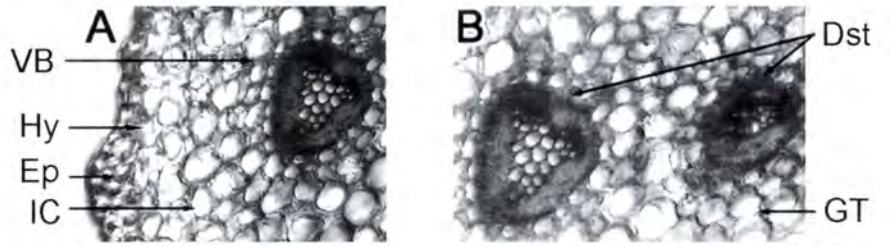


Fig. 4. Cross section of the leaf rachis (4 cm from the petiole base). A: portion with epidermis and cortex (×235); B: the distele vascular bundles (×235). (Dst = distele, Ep = epidermis, GT = ground tissue, Hy = hypodermis, IC = inner cortex, VB = vascular bundle (orig.)).

Remarkable are the loosely arranged mesophyllous cells, the epidermis interrupted by the presence of stomata, and the endodermis cells with parenchymatous sheath value (Fig. 5A, B).

The pinnulae appear, in cross section, to consist a single layer of regularly arranged epidermal glandular cells, covered by a thin cuticle (Fig. 6). The continuity of the lower epidermis smaller cells is broken by the presence of stomata. The mesophyll is undifferentiated into palisade and spongy tissue. Noticed by early authors for Aspleniaceae species (POIRAULT 1893, OGURA 1938), the mesophyll consists of a number of branched and lobed cells, arranged into a number of rows, forming a system of intercellular spaces. The poorly developed vascular system of the midrib is represented by a hadrocentric vascular bundle. The vascular bundle is surrounded by a bundle sheath (Fig. 6).

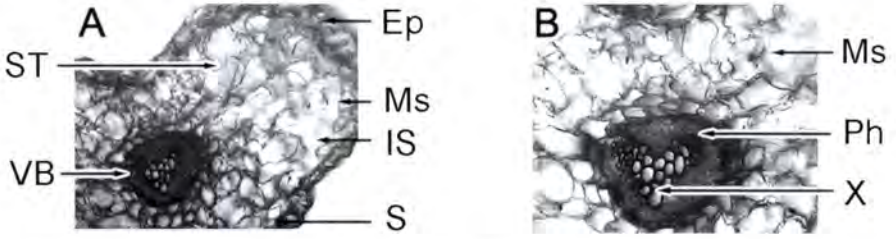


Fig. 5. Cross section of the subterminal rachis (6.5 cm from the petiole base). A: portion with spongy tissue (200); B: the vascular bundle (×290). (Ep = epidermis, IS = intercellular space, Ms = mesophyll, Ph = phloem, S = stoma, ST = spongy tissue, VB = vascular bundle, X = xylem (orig.)).

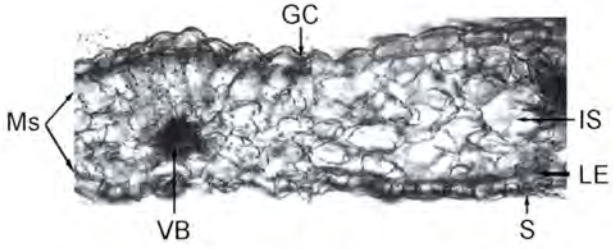


Fig. 6. Cross section of pinnulae (×200). (GC = glandular cells, IS = intercellular space, LE = lower epidermis, Ms = mesophyll, S = stoma, VB = vascular bundle (orig.)).

CONCLUSIONS

The root of *Asplenium lepidum* has a diarch structure, with modified layers of cortex around the stele and a one-layered pericycle. The rhizome (analysed by serial transversal sections) consists of an epidermis, a parenchymatous cortex and a centrally located dictyostele containing a variable number of meristeles. The leaf petiole and rachis exhibit a differential cortex (a sclerenchymatous hypodermis and an inner parenchyma). Close to the rachis tip the sclerenchymatous hypodermis disappears. Remarkable is the variation in the organisation of the vascular system. At the base of the leaf petiole, the vascular system is distelic (bifascicular) while up to the subterminal rachis the monofascicular stele is X-shaped and T-shaped. The pinnulae have a homogenous mesophyll composed of branched and lobed cells. Remarkable are the glandular papillae (cells) of the upper epidermis. The midrib is collateral possessing a hadrocentric structure. The lower epidermis cells are smaller and possess a number of stomata.

REFERENCES

ANDREI, M. (1978): *Anatomy of plants.* – Ed. Didact. Pedagog., Bucuresti, pp. 227–229.

BERCU, R. (1998): Anatomical modifications of the corm stele in fern Asplenium septentrionale (L.) Hoffm. – *Forestry, Šumarstvo*, Belgrade, **1**: 35–40.

BERCU, R. (2004): Anatomical aspects of Asplenium adiantum-nigrum L. – *J. Biol. Res.* **2**: 57–61.

BERCU, R. (2005): Contributions to the anatomy of Asplenium ruta-muraria. – *Studia bot hung.* **36**: 13–20.

BERCU, R. (2006): *Histoanatomy of the vegetative organs of some species belonging to Polypodiales order.* – Ex Ponto, Constanţa, 232 pp. (in Romanian).

BIERHORST, D. W. (1971): *Morphology of vascular plants.* – Collier and Macmillan Ltd., London, New York, pp. 296–298, pp. 300–304.

BIR, S. S. (1957): Stelar anatomy of Indian Aspleniaceae. – *Proceeds Ind. Sci. Congr. Association* **44**: 232.

DE BARY, A. (1877): *Vergleichende Anatomie der Vegetationsorgane der Phanerogamen und Farne.* – W. Engelmann, Leipzig, 664 pp.

KROEMER, K. (1903): Wurzelhaut, Hypodermis und Endodermis der Angiospermenwurzel. – *Biblioth. Bot.* **12**: 151.

OGURA, Y. (1938): *Anatomie der Vegetationsorgane der Pteridophyten.* – In: Handbuch der Pflanzenanatomie, Gebrüder Borntraeger, Berlin, pp. 128–140.

OGURA, Y. (1972): *Comparative anatomy of vegetative organs of Pteridophytes.* 2nd ed. – Gebrüder Borntraeger, Berlin, Stuttgart, pp. 325–395.

POIRAULT, G. (1893): Recherches anatomiques sur les cryptogames vasculaires. – *Ann. Sci. Nat. Bot.*, Paris, Sér. VII, **18**: 113–256.

RUSSOW, E. (1872): Vergleichende Untersuchungen betreffend die Histologie der vegetativen und sporenbildenden Organe und die Entwicklung der Sporen der Leitbündel-Kryptogamen. – *Mém. Acad. Imp. Sc.*, St. Petersburg, 7(19): 1–207.

SAVULESCU, T. (ed.) (1952): *Flora României.* Vol. I. – Ed. Acad. Române, Bucureşti, pp. 133–135.

SCHNEIDER, H. (1996): *The root anatomy of ferns: a comparative study. Pteridology in perspective.* – Royal Botanical Garden, Kew, Litho Ltd., Whitstable, Kent, pp. 271–283.

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