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ANATOMY OF *ASPLENIUM TRICHOMANES* L.

RODICA BERCU

Abstract. The paper deals with the investigation on the anatomical structure of the vegetative organs of a common fern frequently growing in Romania mountain namely *Asplenium trichomanes* L. The main anatomical characteristics of the adventitious root, the rhizome and the leaf (including the pinnae), with special references to the variations in the vascular system organization, were observed and discussed. The rhizome, petiole and rachis anatomy were performed on serial cross sections, distributed from the base to the tip, illustrations included.

Key words: anatomy, root, stem, pinnae, *Asplenium trichomanes*

АНАТОМСКА ГРАЂА ПАПРАТИ *ASPLENIUM TRICHOMANES* L.

RODICA BERCU

Извод. У раду су дати резултати истраживања анатомске грађе вегетативних органа папрати *Asplenium trichomanes* L., која је честа на румунским планинама Обрађене су главне анатомске карактеристике адвентивног корена, ризома и листа (укључујући пине), са посебним осврtом на различиту организацију васкуларног система. Анатомска грађа ризома, лисне петељке и цветне дршке анализирана је на серији попречних пресека, од основе ка врху, а дате су и илустрације.

Кључне речи: анатомска грађа, корен, стабло, пине, *Asplenium trichomanes* L.

1. INTRODUCTION

Asplenium trichomanes L. (syn. *Asplenium melanocaulon* Willd) (fam. Aspleniaceae), known as maidenhair spleenwort is quite a small fern with glabrous evergreen fronds. The spreading fronds, 7-35 cm long, grow in neat rosettes. Pinnately divided into numerous pairs of oblong to oval pinnae that are reduced in size toward the tip. The pinnae are about 5 mm wide and entire-margined below, but shallowly lobed toward the tip. Fertile and sterile fronds are alike. The rachis is shiny, reddish-brown or blackish brown throughout, lustrous and tends to persist after the pinnae have fallen. Pinnae in 15-35 pairs are oblong to oval; edges shallowly toothed to more or less smooth. The tip is obtuse. Pinnules absent. Spores (2-4 pairs per pinna) are borne in 1-4 clusters arranged along the veins on the underside of the pinnae, and are partially covered by the flap-like indusium. The short-creeping rhizome is often branched, possessing lanceolate black scales throughout or with brown borders, The roots is not proliferous. The knowledge of the fearns variations in the vascular system organization of the vegetative organs is quite limited, and those of *Asplenium trichomanes* L., almost lack.

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2. MATERIAL AND METHODS

Cross sections of root, rhizome and leaf were performed using the manual technique. The samples were stained with alum-carmine and iodine green and embedded in glicerine-gelatine. The observations were performed with a BIOROM-T bright field microscope, equipped with a TOPICA-1006A video camera. The microphotographs were obtained taking over the samples, directly from the microscope (by the help of video camera) and sending them to the computer.

3. RESULTS AND DISCUSSION

Cross section of the adventitious root reveals a cortex and a stele. However, the cortex replaces the outermost layers of the root that are exodermis and rhizodermis. The cortex consists of a number of layers of simple large parenchymatous cells cells. The inner layers of the cortex are highly modified. This cells have thick-waled cells. Kroemer (1903) suggested that, this thickness is the result of the cutinized blades superpositions.

A long time ago some authors noticed the presence of such "curious cells" around the stele and suggested that this tissue belong to the stele and named them "sclerenchymatous mass" (Russow, 1872; Bierhorst, 1971) or "stereomic sheath" (de Bary, 1877; Ogura, 1938, Bercu, 1998, 2000). Other authors named it endodermis () (Figure 1A, B).

The stele consists of xylem and phloem, surrounded by pericycle. The centrally located xylem bundles join by their metaxylem vessels (2 metaxylem elements per each bundle), whereas the protoxylem elements (3 for each bundle) are in an exarch position, facing the pericycle. The sieve cells (2 phloem bundles), lack companion cells are located on either side of the xylem strings (Figure 1B).

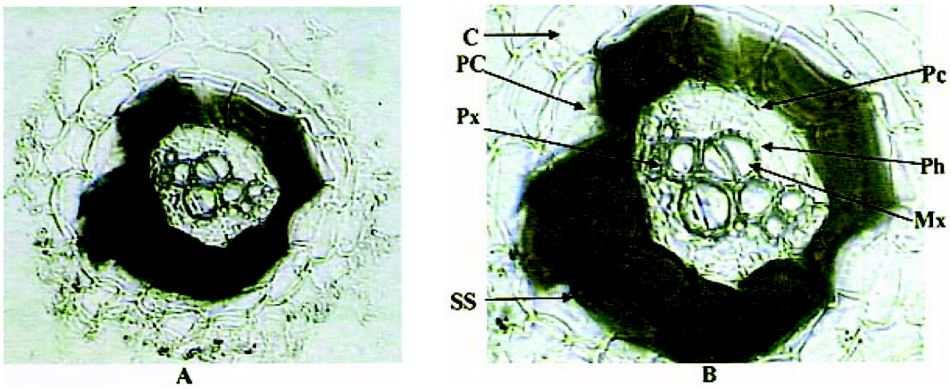

Figure 1 - Cross section of the root. General view. X 207. Detail of the stele-. X 333: C- cortex; mx- metaxylem; Pc- pericycle; Ph- pfloem; PC- passing cell; Px- protoxylem; SS- sclerenchyma sheath; St- stele. Orig.

Слика 1 - Попречни пресек корена. Општи изглед. X 207. Деталь стеле-. X 333: С- кортекс; тх- метаксилем; Рс- перицикл; Ph- флоем; РС- пропусна ћелија; Рх- протоксилем; SS- склеренхимски омотач; St- стела. Ориг.

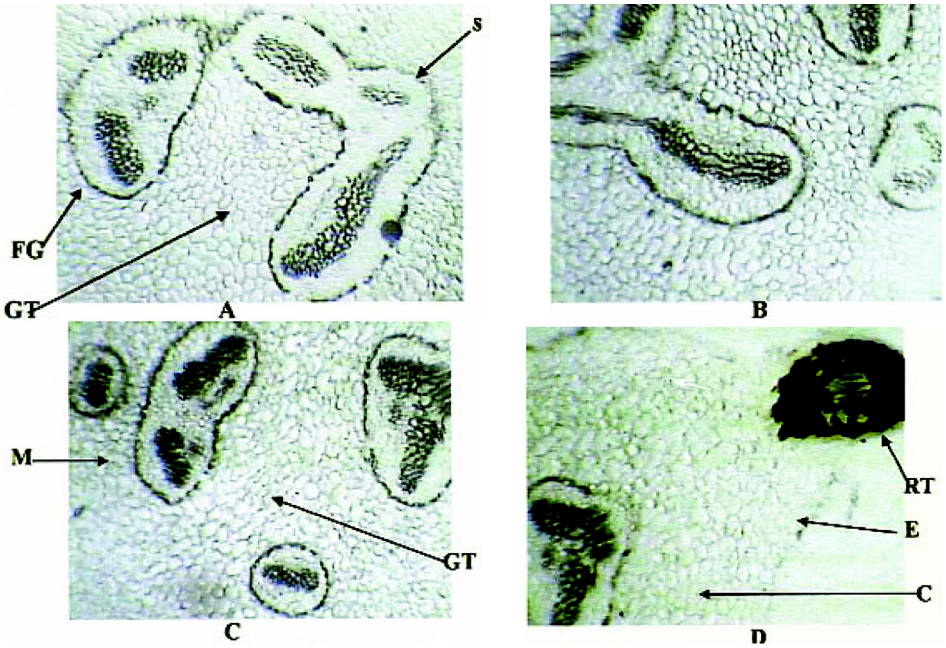

Figure 2 - Cross sections of the rhizome. Portion of the stele with 2 meristeles (A). X 38. Portion of the stele with 3 meristeles (B). Portion of the stele with 4 meristeles (C). X 38. Portion of the rhizome with a root trace (D). X 49: C- cortex; Ed- endodermis; FT- leaf trace; GT- ground tissue; M- meristeles; Mx- metaxylem; Pc- pericycle; Ph- phloem; Px- protoxylem; RT- root trace. Orig.
Слика 2 - Попречни пресек ризома. Део стеле са 2 меристеле (А). Х 38. Део стеле са 3 меристеле (В). Део стеле са 4 меристеле (С). Ц 38. Део ризома са трагом корена (D). Х 49: С- кортекс; Ed- ендодермис; FT- траг листа; GT- покровно ткиво; М- меристеле; Мх- метаксилем; Рс- перицикл; Ph- флоем; Рх- протоксилем; RT- траг корена. Ориг.

Serial cross sections of the rhizome exhibit the usual structure that is an epidermis, a cortex and a stele. The epidermis consists of a single layer of simple cells. The cuticle is absent. The cortex is represented by a number of layers of parenchyma cells with slightly thick-waled cells, containing abundant starch starch grains. Such as the rhizomes of other Polypoditae species (*Asplenium viride*, A. *septentrionale*, Bercu 1997/98, 1998, 2000) the stele is a dictyostele, composed of 2-4 meristeles in response with the cutting level and the number of foliar gaps (Figure 2A, B, C), and roots traces (Figure 2D) embedded in a ground tissue. Each meristeles is surrounded by pericycle and endodermis. The endodermal cells consist starch grains (starch sheath). The pericycle bears simple slightly elongated cells, arranged in one, two even three layers. The vascular system consists of xylem and phloem elements. Xylem is in a central position, whereas protoxylem vessels have an exarch arrangement, facing the pericycle. In the center of the rhizome, the pith is present (Figure 3).

Transections of the rachis analyzed from the base to the tip, reveal almost the same succession of tissues that is a monolayed epidermis, consisting of regularly

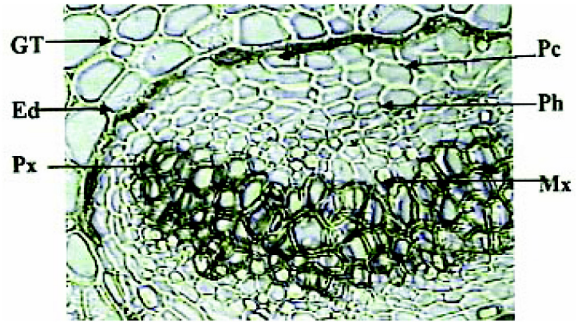

Figure 3 - Portion of a rhizome meristele. X 181: Ed- endodermis; GT- ground tissue; Mx- metaxylem; Pc- pericycle; Ph- phloem; Px- protoxylem. Orig.
Слика 3 - Део мерисшеле ризома. X 181: Ед- ендодермис; GT- йокровно шкиво; Мх- мешаксилем; Рс- йерицикл; Ph- флоем; Рх- йрошоксилем. Ориī.

arranged simple thick-walled cells, the cortex and the stele, the latter centrally located. The cortex is distinguished into an external region and an internal one. The external region is hypodermis consisting of 4 layers of sclerenchymatous cells, but the walls are thickened with a brown substance of an unknown composition (Figure 4A, 5A). The inner zone consists of several layers of compactly arranged parenchyma slightly thick-walled cells, deposing starch grains. The number of layers cortex are gradually reduced toward the tip from three (1,5 cm from the base of the rachis) to one (14 cm from the rachis base) (Figure 5A, 6A). In the tip hypodermal cell disappear. The inner cortex shows the same reduction of the layers cortex toward the tip of the rachis (2 layers) (Figure 7)

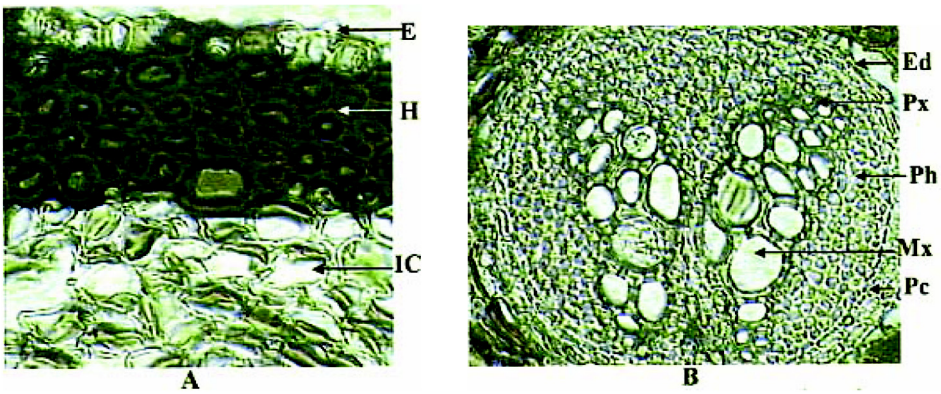

Figure 4 - Cross section of the rachis (1,5 cm from the base). Portion with epidermis and cortex (A). Detail of the stele (B). X 200: E- epidermã; ed- endoderm; H- hypodermis; IC- inner cortex; Ph- phloem; Mx- metaxilem; Pc- periciclu; Px- protoxilem. Orig.
Слика 4 - Йойречни йресек цвешне дршке (1,5 ст од основе). Део са еūидермисом и коршексом (А). Дешаль сшеле (В). X 200: Е- еūидермис; ed- ендодермис; Н- хūодермис; IC- унушрашњи коршекс; Ph- флоем; Мх- мешаксилем; Рс- йерицикл; Рх- йрошоксилем. Ориī.

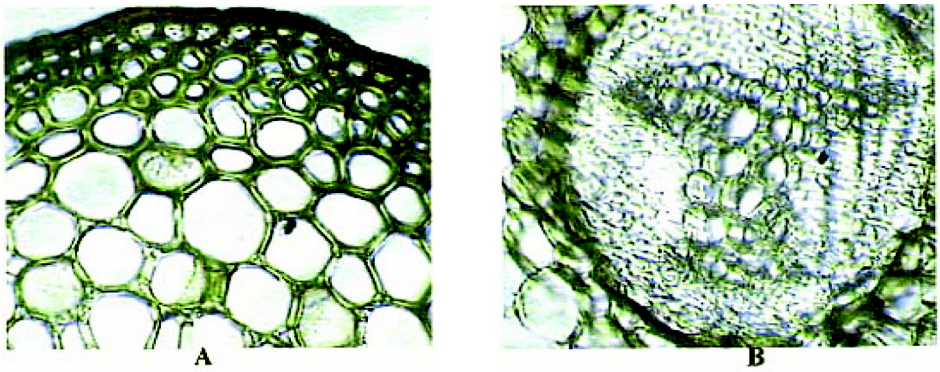

Figure 5 - Cross section of the rachis (6-12 cm from the base). Portion with epidermis and cortex (A). Detail of the stele. X 266. Orig.
Слика 5 - Попречни пресек цветне дршке (6-12 ст од основе). Део са епидермисом и кортексом (А). Детаљ стеле. X 266. Ориг.

Cross section performed closely to the rachis base (1,5 cm) discloses a monostelic structure of the central cylinder. This monofascicular structure persists towards the tip. The stele is composed of xylem and phloem. The small distance between the xylem vessels strings (2 curved xylem strings) indicate that, initially, meristeles leaved the rhizome under foliar traces, forming the leaf petioles. The major portion of the stele is covered by phloem (sieve cells, lack companion cells and phloem parenchyma). The stele is protected by a monolyered endodermis (an amylipherous sheath) and a special pericycle (arranged on one, two layers of cella) (Andrei, 1978). Endodermis and pericycle configuration remain the same toward the tip. That attributes to the vascular bundle a hadrocentric structure (Figure 4B).

Xylem strings (6-12cm from the rachis base), gradually, remove one to another by their metaxylem vessels, toward the center, and join one to another in, a more or less, X- shaped connection, characteristically to Aspleniaceae species (Bercu 1998, 2000; Bir, 1957; Ogura, 1938) (Figure 5B).

Cross sections of the under rachis portion show the xylem strings in a T-shaped connection (Figure 6A, B). Remarkable are the thickness of the epidermal cells walls, replacing the hypodermis role, and the reduced number of the cortical cells. However, toward the pinnae tip, the vessels elements are reduced, in accordance with the lateral pinnae veins formation (Figure 6A, B).

Cross section of the tip exhibits a structure with a plane and convex surfaces. Remarkable are the thick walled epidermal cells and the reduced number of the cells cortex (2 layers of cells). The vascular system of the stele consists of few xylem cells in an excentryc position and phloem elements, surrounded by endodermis and pericycle. However the vascular bundle is close collateral such as the pinnae vein one (Fig 7).

Cross section of the pinnae reveals that the upper epidermis such us the lower one consists of a single layer of simple cells, covered by a thin cuticle. Bellow the upper epidermis is the homogenous mesophyll of spongy tissue (Ogura, 1972), such as most of the Polypoditae species, due to the graduate reduction of the inter-

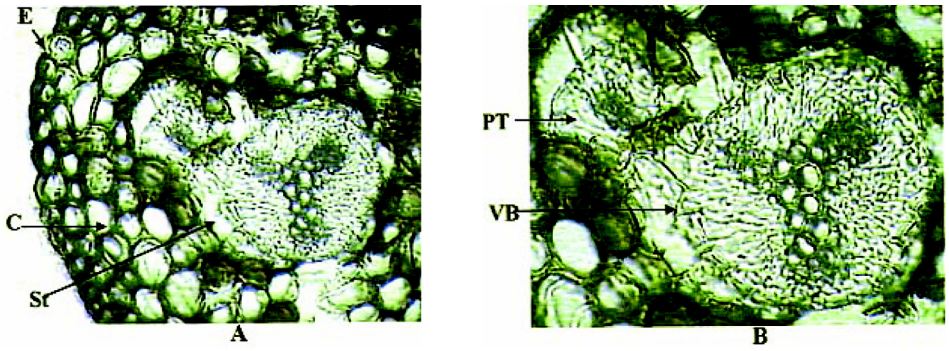

Figure 6 - Cross section of the rachis (14 cm de la bază). Portion with epidermis and cortex (A). X 115. Stele with a pinnae trace (B). X 200: C- cortex; E- epidermis; PT- pinnae trace; St- stele; VB- vascular bundle. Orig.
Слика 6 - Попречни пресек цветне дршке (14 cm од основе). Део са епидермисом и кортексом (A). X 115. Стела са трагом пина (B). X 200: C- кортекс; E- епидермис; PT- траг пине; St- стела; VB- спроводни снопић. Ориг.

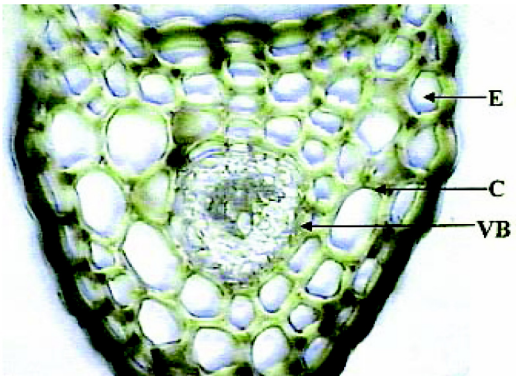

Figure 7 - Cross section of the rachis tip. X 360. E- epidermis; c- cortex; VB – Vascular bundle. Orig.
Слика 7 - Попречни пресек врха цветне дршке. X 360. E- епидермис; c- кортекс; VB – Спроводни снопић. Ориг.

cellular species from the upper to the lower surface parallel with the reorientation of the superior cells (Poirault, 1893) (Figure 8A) It consists of parenchyma rounded and branched cells with intercellular spaces, consisting numerous chloroplasts.

The lower epidermis continuity is interrupted by the presence of polocytic and few anomocytic stomata (van Cotthem, 1970; Dilcher, 1974). A number of chloroplasts, in the epidermal cells, are present (Figure 8B).

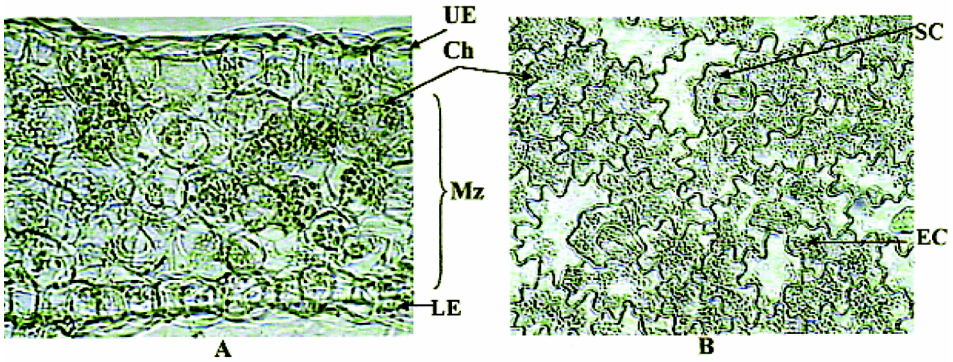

Figure 8 - Cross section of thr blade with mesophyll (A). X 333.Tangent section of the blade (B). X 181. Ch- chloroplasts; EC- epidermal cell; LE- lower epidermis; Mz- mesophyll; UE- upper epidermis; SC- subsidiary cell. Orig.

Слика 8 - Попречни пресек лиске са мезофилом (А). Х 333. Тангенцијални пресек лиске (В). Х 181. Ch- хлоропласти; ЕС- ћелија епидермиса; LE- доњи епидермис; Mz- мезофил; UE- горњи епидермис; SC- ћелија пратилица. Ориг.

4. CONCLUSION

The result indicates that the root of *Asplenium trichomanes* L. have a primary structure. The endodermis is highly modified forming a streomic sheath around the stele. The pericycle has only a single layer of cells. The root is of diarch type. The rhizome (analysed on serial transactions) discloses a primary structure of dyctiostelic type with variable number of meristeles in accordance to the number of foliar and roots traces living the rhizome. Each meristele is a hadrocentic vascular bundle, surrounded by endodermis and pericycle. The leaf rachis (analysed on cross sections from the base to the tip), exhibits a monolayered epidermis, possessing stomata, a sclerenchymatous hypodermis, a parenchymatous cortex and a stele. Closelly to the tip, the sclerenchymatous hypodermis disappears. Remarkable are the variations of the vascular system organization. However the base of the petiole (1,5 cm from the base) is distelic in structure. Between 6-12 cm the centrally located stele is monofascicular with xylem elements in an X- shaped form. The rest of the stele is occupied by phloem elements. From 6-12 cm xylem elements take a T-shaped form. To the tip of the rachis it have an excavated shape. Note the reduced number of the vascular elements to the tip, becose of the marginal fragmentations to form the vascular elements of the pinnae veins. The pinnae have, in transection, an upper epidermis, a homogenous mesophyll and the lower epidermis possessing polocytic and anomocytic stomata. The vain have a more or less collateral structure.

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АНАТОМСКА ГРАЂА ПАПРАТИ *ASPLENIUM TRICHOMANES* L.

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РЕЗИМЕ

На основу резултата, утврђено је да корен папрати *Asplenium trichomanes* L. има примарну грађу. Ендодерм је веома модификован и образује покривач око стеле. Перицикл има само један слој ћелија. Корен је диархног типа. Ризом (анализиран кроз серију пресека) има примарну грађу диктиостелног типа са различитим бројем меристела у складу са бројем лисних и коренских ожиљака. Свака меристела је хидроцентични спроводни снопић, окружен ендодермом и перициклом. Лист цветне дршке (анализиран на попречним пресецима од основе до врха) има једнослојни епидермис, стоме, склеренхимски хиподермис, паренхимски кортекс и стелу. При врху, склеренхимски хиподермис нестаје. Постоје велике разлике у организацији васкуларног система. Основа петељке листа (1,5 cm од основе) има дистелну грађу. Између 6-12 cm централно смештена стела је монофасцикуларна са ксилемским елементима у облику X. Остатак стеле садржи елементе флоема. Између 6-12 cm елементи ксилема имају облик T. Запажа се смањен број спроводних елемената на врху. Пине на пресеку имају горњи епидермис, хомоген мезофил и доњи епидермис са полоцитним и аномоцитним стомама. Нерватура има мање више колатералну грађу.