

ANATOMY OF *AUSTROCYLINDROPUNTIA SUBULATA* (MUEHL.) BACKEB. (CACTACEAE)

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Abstract: Anatomy of *Austrocyllindropuntia subulata* (Muehl.) Backeb. (Cactaceae). *Austrocyllindropuntia subulata* (Muehl.) Backeb. is member of the Cactaceae family, very common in house plants collections. This paper deals with some anatomical aspects of the root, stem and its subulate leaves. The results revealed that the anatomical structure of this plant justify its succulent nature, especially the water storage parenchyma is well developed, forming the largest portion of the stem and mesophyll. The root of this cactus species is well developed, its secondary structure gives special strength to it. The mechanical tissue is absent in the stem. The vascular system of the stele is poorly developed, represented by a number of closed collateral vascular bundles in rhomboidal arrangement. The mesophyll of the subulate leaves is differentiated into palisade tissue and storage parenchyma. The vascular tissue of the leaves is represented by three closed collateral bundles. Remarkable is the presence of some large, isolated, circular lacuna in the stem cortex and in the mesophyll of the subulate leaves.

Introduction

The cactaceous family, morphologically heterogeneous group of succulent plants, comprising about 100 genera and 1500 species. Succulent plants are usually not considered xerophytes because they retain considerable amount of water in their body as adaptation that allows them to live in dry areas. They collect water efficiently, store it for long periods of time and conserve it (minimizing water loss caused by evaporation) [1]. Therefore, they can survive long periods of drought (lack of water). With the exception of one genus, all members of this family are native of America [6, 7]. There are recognized three subfamilies: Opuntioideae, Cactoideae and Pereskioideae [4].

Austrocyllindropuntia subulata (Muehl.) Backeb. [syn. *A. exaltata* (Berg.) Backeb., *A. subulata* (Engelm.) Backeb., *Opuntia exaltata* Berg.], subfamily Opuntioideae, known as Eve's Needle, native to Ecuador and Peru, is a tree-like cactus, up to 4 m tall and 3 m in diameter. Its stem is up to 50 cm in length and has awl like leaves, up to 12 cm and 1 to 4 spines, up to 8 cm long. *Austrocyllindropuntia subulata* has large red flowers, 6 cm in length [3, 5, 8, 9].

Material and Methods

Cross sections of the root, stem and leaf were performed, using a rotary microtome using manual techniques, clarified with chloral hydrate and stained with alum-carmin and iodine green. The samples were embedded in glycerin gelatin. The observations and microphotographs were performed with a BIOROM-T bright field microscope, equipped with a TOPICA-6001A video camera. Digital micrographs were obtained using the video camera helped by computer.

Results and Discussions

Cross sections of the root of *Austrocyllindropuntia subulata* exhibit the cork, secondary cortex and stele (Fig. 1a). The outermost layers of flattened cells correspond to the cork, followed by the phellogen and 3-4 layers of parenchyma cells belonging to the secondary cortex. The central cylinder is well developed and consists of a number of cambium produced vascular bundles. The vascular tissues are compactly arranged being separated by large medullar rays.

Each vascular bundle consists of secondary phloem (a few sieve cells, companion cells and phloem parenchyma) and secondary xylem (a few xylem vessels embedded in sclerenchymatous parenchyma (Fig. 1b). Few primary xylem vessels, located towards the pith zone, are present too. The centrally located pith, consists of large parenchymatous cell, with deposited reserve substances (Fig. 1a).

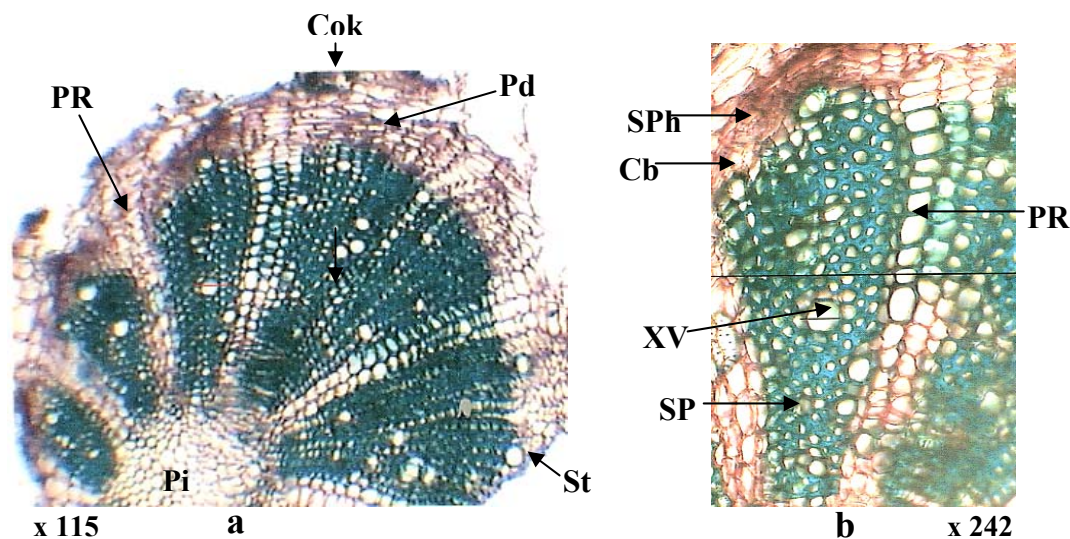


Fig. 1: a – Portion of root cross section (a). b – Detail of stele. Cb- cambium, Cok - Cork, Pd- phelloderm, Pi - pith, PR - pith ray, Sb - suber, St - stele, SP - sclerenchymatous parenchyma, SPh - secondary phloem, XV - xylem vessel. Original.

Cross sections of the stem reveal the epidermis, cortex and stele. Epidermis consists of a layer of slightly flattened cells covered by cuticle, coated by wax. Its continuity is interrupted by the presence of stoma and areolar cavities (Fig. 2b, c), generating subulate leaves and two groups of stone spines [2]. Some of them possess thick base, stone body and sharp tip, whereas others are thinner with sharp and curved tip. Just around them, small, soft, white hairs occur. The surface of spines is covered by cuticle plates impregnated with silicon dioxide (Fig. 4a, b). Bellow the epidermis there is a hypodermis followed by cortex.

The first 3-4 layers of cortical cells contain chloroplasts. Bellow the assimilatory zone, there is the water storing parenchyma (aquiferous tissue). The stele consists of a number of closed collateral vascular bundles occurring in different developmental stages, placed in rhomboidal arrangement (Fig. 3a). Each vascular bundle consists of few xylem and phloem elements. The centrally located pith consists of large parenchyma cells depositing starch grains, water and druses the later mostly in the basal region (Fig. 3b).

It should be noticed, as for other cacti [3], the presence of large (circular in optical cross section), seemingly empty spaces (lacuna) in the cortex and the ground-work tissue of the stem (Fig. 5a).

Cross section of the subulate leaf exhibits an epidermis and the mesophyll, the later differentiated into palisadic region, its cells containing chloroplasts and parenchymatous tissue storing the water – aquiferous tissue. The continuity of the epidermis is broken by the presence of a deep gap with a tuft of soft hairs, marking the clamping place of the leaf, and an areolar cavity with spine.

The vascular system of the mesophyll consists of one large and two small, closed collateral vascular bundles. A number of collenchymatous cells are present in their abaxial region. Large druses of calcium oxalate occur mostly around the vascular bundles.

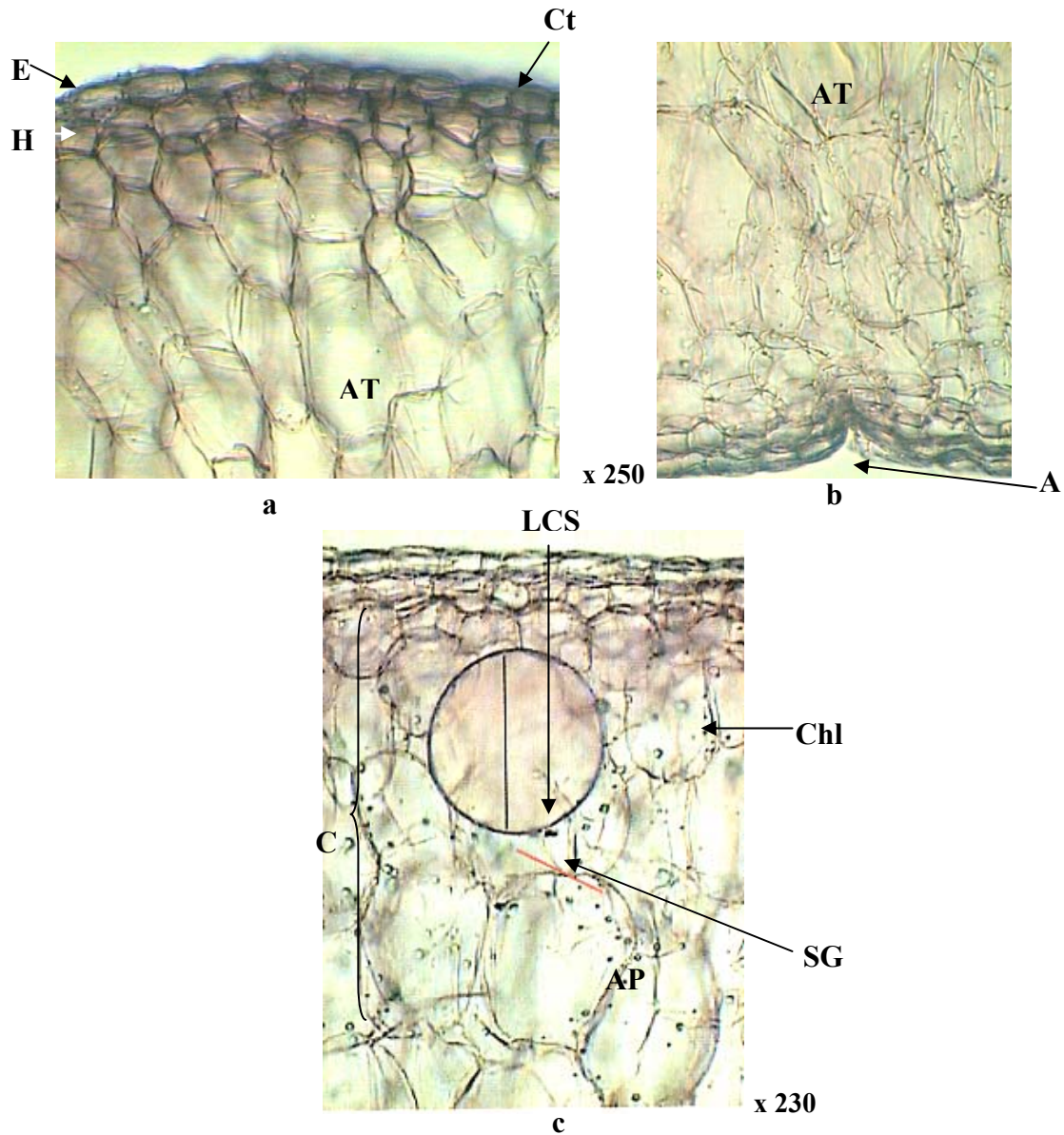


Fig. 2: Cross sections through the stem. a - Portion of epidermis and cortex. b, c - Abaxial portion with areole. A - areole, AT - aquatic tissue, C - cortex, Chl - chloroplasts, Ct - cuticle, E - epidermis, H - hypodermis, LCS - lacuna (circular space), SG - starch grains. Original.

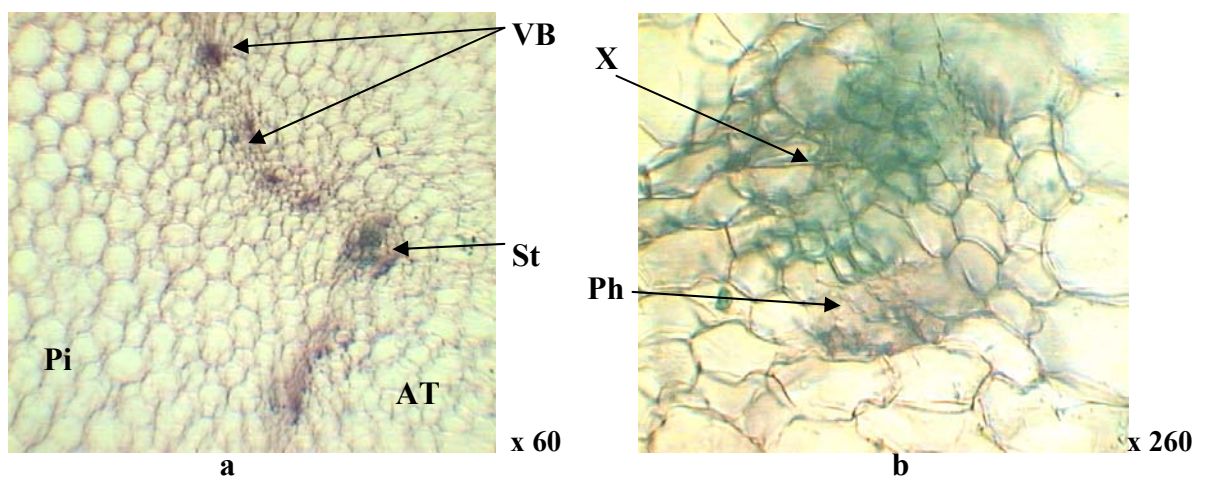


Fig. 3: a - Portion of the stem with cortex and stele. b - Detail of a vascular bundle. C - cortex, Pi - pith, AP - aquiferous tissue, St - stele, VB - vascular bundle, X - xylem. Original.

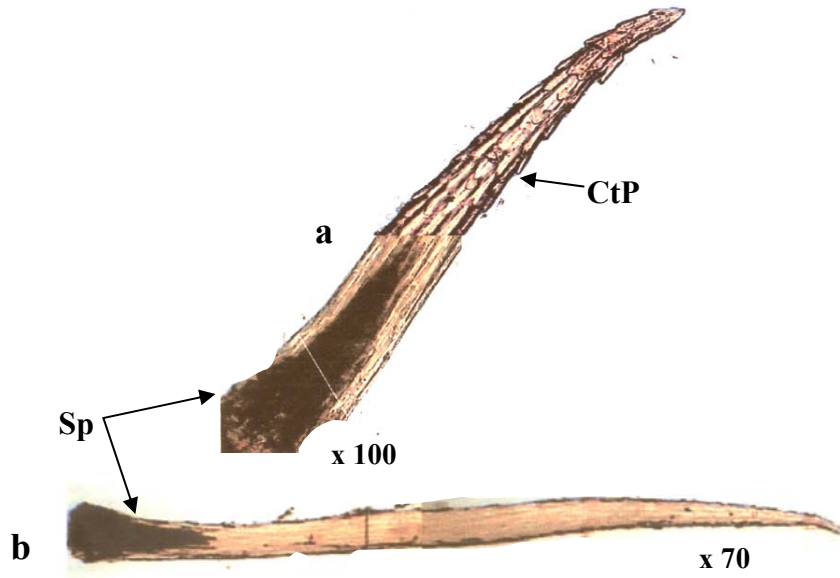


Fig. 4: Caulinar spines (a, b). CtP - cuticle plates, Sp - spines. Original.

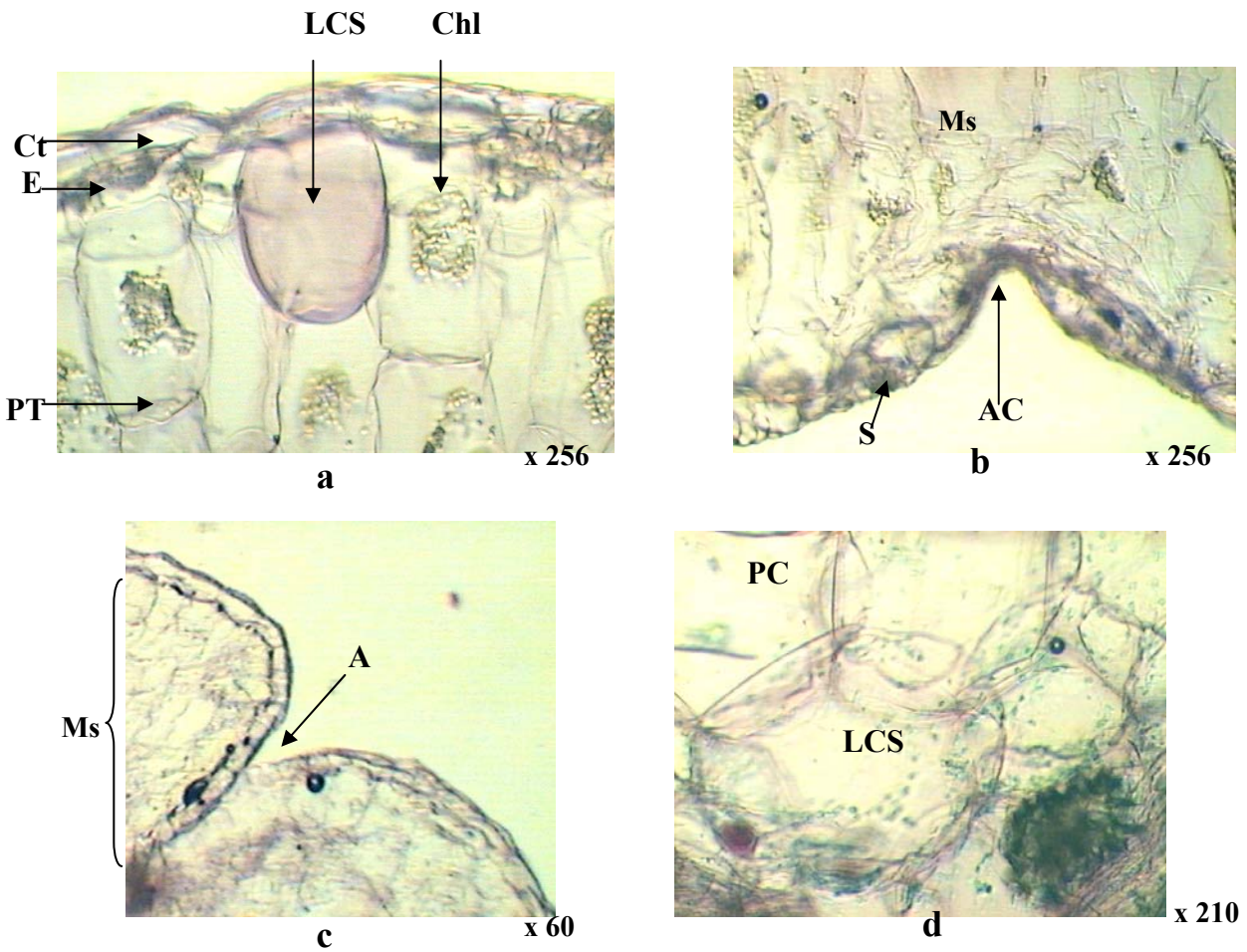


Fig. 5: a-d – Cross sections of the leaf. A - areole, Chl - chloroplasts, Clo - chlorenchyma, Ct - cuticle, PC - parenchymatous cell, E - epidermis, Ms - mesophyll, LCS- lacuna, PT - palisadic tissue, S – stoma. Original.

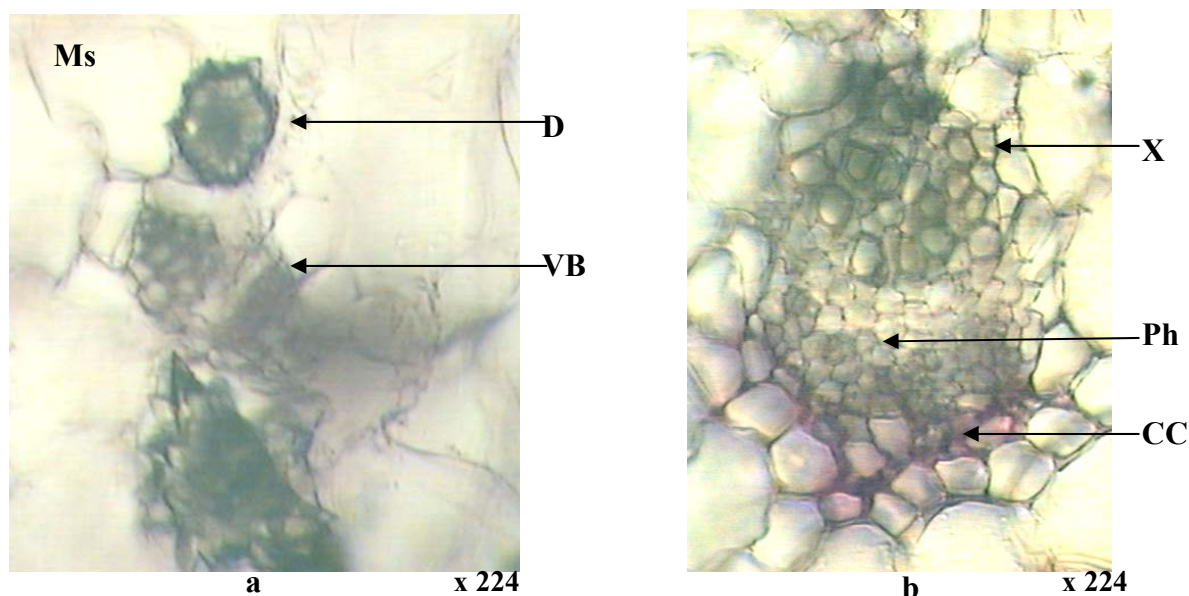


Fig. 6: a-b – Cross sections through the vascular bundles of the veins. CC - collenchymatous cells, D - druses, Ms - mesophyll, Ph - phloem, VB - vascular bundle, X – xylem. Original.

Conclusions

The present findings indicate that the root is strong, having a well developed secondary structure. The epidermal cells of the stem are closely arranged and thick-walled. The thick-walled cutinized cells get waxy deposit on their outer surface. Presumably, the thickness of deposition is directly proportional to xeric condition. Two kinds of spines are present in the areoles to ensure the protection of plant. The multilayered cortex of the stem consists of parenchyma cells. Just below the epidermis two or three cell layers possess chloroplasts, the rest of the cortex consists of large parenchymatous cells with mucilaginous content, allowing the storage of water and of starch grains. The vascular tissue is poorly developed consisting of a reduced number of closed collateral bundles in rhomboidal arrangement. Mechanical tissues are absent. The mesophyll of subulate leaves is differentiated into palisadic tissue and storage parenchyma tissue. The vascular tissue of the leaves is represented by three, closed collateral bundles. Remarkable is the presence of some large, isolated, seemingly empty spaces (lacunas) in the stem cortex and subulate leaf mesophyll. The vegetative organs of *Austrocylandropuntia subulata* possess features of anatomical interest, in accordance with their succulent and fleshy nature.

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**ANATOMIA SPECIEI *AUSTROCYLINDROPUNTIA SUBULATA*
(MUEHL.) BACKEB. (CACTACEAE)**

(Rezumat)

Lucrarea prezintă structura anatomică a organelor vegetative a speciei *Austrocyllindropuntia subulata* (Muehl.) Backeb., plantă ornamentală, membră a familiei Cactaceae, aducând contribuții la cunoașterea acestui grup de plante. *Austrocyllindropuntia subulata* (Muehl.) Backeb., ca majoritatea cactaceelor [6, 7], este originară din America, mai precis Ecuador și Peru, cu aspect arborescent ce poate ajunge până la 4 m înălțime și 3 m în diametru. Ramurile sale pot depăși 50 cm lungime. Frunzele sale (12 cm lungime) sunt subulate prevăzute cu 1-4 spini. Florile plantei sunt roșii atingând 6 cm lungime [5, 8, 9].

Pe secțiuni transversală rădăcina prezintă o structură tipic secundară (Fig. 1a, b), cu rol și în consolidarea rădăcinii.

Secțiunile transversale prin tulpină înfățișează, la exterior, epiderma unistratificată, întreruptă în dreptul areolei, urmată de hipodermă (Fig. 2b). Cortexul este pluristratificat, cu celule mari parenchimatice ce formează un țesut acvifer (Fig. 2a, c). În hipodermă, cortex și în măduvă, din loc în loc, se găsesc spații lacunare mari, circulare goale (Fig. 2c). Stelul este așezat central și are un contur romboidal. Acesta este alcătuit din numeroase fascicule vasculare, aflate în diferite faze de dezvoltare (Fig. 3a). Fasciculele vasculare sunt de tip colateral închis, reprezentat prin puține elemente de xilem și de floem (Fig. 3b). În centrul stelului se observă măduva de natură parenchimatică (Fig. 3a). Frunza, pe secțiune transversală, prezintă următoarele succesiuni de țesuturi: epiderma este unistratificată, cu celule ușor alungite tangențial. Continuitatea sa e întreruptă de prezența stomatelor și de prezența areolelor fie sub forma unei fante atenuate fie mai adânci, cu smocuri de peri fini, reprezentând locul de prindere a spinilor pe tulpină (Fig. 5b, c) [2]. Sub epidermă se observă 2-3 straturi de celule în palisă cu multe cloroplaste, dispuse parietal sau central (Fig. 5a). Sub acest țesut se găsește un țesut omogen, format din celule mari parenchimatice, poligonale acvifere ce conțin substanțe mucilagigene pentru reținerea apei (Fig 5d). În țesutul fundamental se găsesc nervurile, reprezentate prin două fascicule vasculare mici și unul mai mare. Fasciculele vasculare sunt de tip colateral închis, cele mici fiind sărace în elemente vasculare lemnoase și liberiene. În jurul fasciculelor vasculare se observă druze de oxalat de calciu (Fig 6a, b).

Caracterele anatomice ale acestei specii justifică natura sa de plantă suculentă, în special, prin prezența țesutului acvifer (care ocupă cea mai mare parte din structura tulpinii și frunzei), cu rol de depozitare a apei., ca rezultat al adaptării sale la mediul în care habitează. Pentru acesta plantele suculente nu pot fi considerate xerofite [1]. Se remarcă lipsa țesutului mecanic din structura tulpinii. Iar în frunză el este reprezentat numai prin câteva celule colenchimatizate. Specific frunzei subulate, la specia *Austrocyllindropuntia subulata*, ca și a frunzei altor cactacee [3], este prezența în număr mai mare ca în tulpină a spațiilor rotunde, izolate, goale și a spinilor, caracteristici.