

STRUCTURAL ASPECTS OF *ALISMA PLANTAGO - AQUATICA* L. (ALISMATACEAE)

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ABSTRACT

*The paper presents anatomical aspects of some vegetative organs (adventitious root, stem and leaf) of a perennial aquatic plant *Alisma plantago-aquatica* L. belonging to Alismataceae family. In our country the plant can be found in banks of rue, lakes, ponds, ditches and marshes and in Danube delta as well. The material fixation and processing was done according to the usual protocol of the vegetal morphology and anatomy Laboratory belonging to the Natural Sciences Department of the our faculty. The adventitious root has a primary monocot structure with a developed aerenchyma. The stem cortex is well-developed with epidermis, hypodermis and an aerenchyma tissue with a number of air chambers. The endodermis is one-layered. The vascular system is poor developed. The leaf mesophyll is almost heterogonous, represented by an assimilation and a spongy tissue. In the mesophyll are embedded few poor developed vascular bundles.*

KEY WORDS: *anatomy, adventitious root, stem, leaf, *Alisma plantago-aquatica**

INTRODUCTION

**Alisma plantago-aquatica* L. (Alismataceae), known as water-plantain, is an aquatic perennial plant growing in shallow waters, originating from the northern hemisphere, in Europe, northern Asia and North America. It is included in The IUCN Red List of Threatened Species (Lansdown & Beentje, 2017). In Romania it can be seen on the banks of rue, lakes, ponds, ditches and marshes and as well in the Danube delta as well (Săvulescu & Nyáráy, 1966; Ianovici, 2015a).*

The plant has a thick long rhizome with fibrous adventitious roots and several broad, ovate basal leaves, with a corded base, placed in the bouquet, 15-30 cm long and with round tip. The submerged leaves are shorter (8-10 cm long) and 5 cm wide (Ciocârlan, 2000; Ze Xie, 2009).

*The petiolate leaves have an oval-elliptical-shaped form, with an undulate entire margin and a smooth texture up to 10 cm wide, with pronounced slightly arched reticulate veins. From the middle of the leaves begins the trimmed, long, nettle stem, which can reach up to 1 m which branches to the top in floral stems that start from the same node (Ciocârlan, 2000; Erhardt *et al.*, 2008; Ze Xie, 2009).*

The flowers are grouped into a pyramidal inflorescence with the branched branches, each are branching out again in umbel form inflorescences. Flowers are hermaphrodite, with round or slightly toothed petals of white or slightly pink, with 6 stamens. The flowers open

early in the morning (around 7 o'clock) and close at midday at 13-15. No flower opens the second time. Fruits are disciform achene. It is multiplied by underground branches (Brickell, 2003; Watson & Dallwitz, 1992; Ze Xie, 2009) (Fig. 1).

In literature are generally little information on this aquatic plant anatomy (Kordyum *et al.*, 2012), many articles and papers dealing with them in terms of morphologic and taxonomic of Alismataceae, including this species belonging to Fassett (1955); Haynes & Holm-Nielsen (1986/1994); and Somogyi (2006). Studies on the development of gynoecia with septal nectarines belong to W.A. van Heel (1988). More recent studies on seed embryo formation belong to Świerczyńska & Bohdanowic (2014).

In our country, succinct references on the structure of the vegetative organs of some aquatic species are found in some general studies concerning the angiosperms anatomy (e.g. Ianovici, 2010; Şerbănescu-Jitariu & Toma, 1980; Tarnavschi *et al.*, 1974 etc.). Extensive studies of aquatic spontaneous plants were held by Sârbu *et al.* (2005), Săndulescu *et al.*, 2017, Bercu (2007/2009/2015) the latter having studies on the anatomy of some aquarium plants.



FIG. 1. Natural view of *Alisma plantao-aquatica* L. (original).

MATERIALS AND METHODS

The plant was collected from the Danube delta in August 28, 2016. Small pieces of adventitious roots, aerial stem and leaf (petiole and blade) were fixed in FAA (formalin: glacial acetic acid: alcohol 5:5:90). Cross sections of the leaf were performed by free hand made technique (Bercu & Jianu, 2003; Ianovici, 2015b). The samples were stained with alumarmin and iodine green and mounted in glycerinated gelatin. Anatomical observations and micrographs were performed with a Biorom-T bright field microscope, equipped with a TOPICA 6001A video camera.

RESULTS AND DISCUSSIONS

Cross section of the adventitious root discloses an epidermis - a single layer of isodiametrical cells - and the cortex. Our findings exhibits that cortex is made of 2 zones: one

region is represented by three layers of slightly suberized cells, such as reported Kordyum et al. 2012 for *A. plantago-aquatica*.

Bellow the cortex an aerenchyma tissue with a number of large air chambers is present. The air chambers have a radial arrangement separated by trabeculae (Batanouny, 1992). Aerenchyma is followed by an endoderm on the inner side. The endoderm is formed by a single layer of U-shaped cells with radial and inner lignified walls. In front of the xylem vessels passing cells are present (Fig. 2, A).

The vascular system is made of pericyclic - small parenchyma cells arranged on a single row – and the conductive tissue: The vascular bundles are radially and alternately arranged. The xylem bundles are more developed comparatively with phloem bundles (Fig. 2, B).

The aerial stem. The external region is made of a unistartous epidermis with small almost rounded in shape cells. It is followed by a hypodermis (one-two layers of parenchyma cells). Bellow the hypodermis is an aerenchyma tissue made up of a number of small air chambers arranged around the stele. The stele consists of a number of close collateral vascular bundles, the peripheral ones are smaller than those of the center (Fig. 3, A).

Due to Watson & Dallwitz (1992) și Kordyum *et al.* (2012) findings, some secretoty cavities may be found. In our findings no secretory cavities where found. The vascular bundles are slightly poor developed consisting of few xylem vessels (6-7 metaxylem vessels) and a protoxylem lacuna. The phloem is normally developed composed of phloem vessels, companion cells and and phloem parenchyma (Fig. 3, B).

The leaf. The petiole, in cross section, appears almost triangle-shaped and slightly arched in adaxial portion. Bellow the one-layered epidermis, covered by a thin cuticle, is the hypodermis composed of a parenchyma tissue (Fig. 4, A). It is followed by a well developed aerenchyma with a large number of cortical and meduar air chambers with variable size, formed by schizogenesis (Fig. 4, A). Some air chambers still retain diaphragmatic tissue remains (Săndulescu *et al.*, 2017). The petiole stele is represented by close collateral bundles.

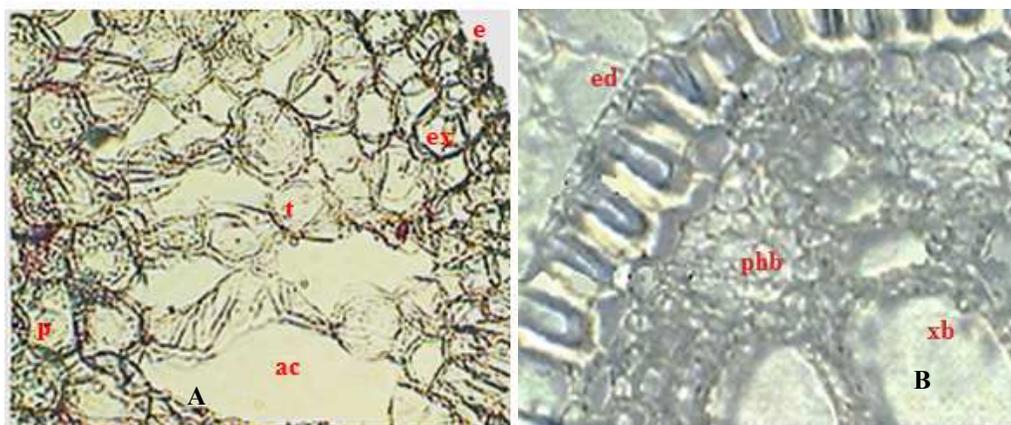


FIG. 2. Cross section of the adventive root. Portion with epidermis, cortex and aerenchym (A, x 180) and portion of stele (B, x-290): ac- air chamber, e- epidermis, ed- endoderm, ex- exodermis, p- parenchyma cortex, phb- phloem bundle, t- trabeculae, xb- xylem bundle.

The blade, in cross section, exhibits the two unistratous epidermis (upper and lower). The mesophyll is heterogeneous (assimilation and spongy tissue) (Fig. 5, A). The two epidermes continuity is broken by the presence of stomata.

The mesophyll is well developed in the mid rib area, narrowing slowly towards the margins. Large intercellular spaces, equivalent to air chamber, appear around the mid rib zone. In the mid rib zone two vascular bundles are present. Such as Săndulescu et al, 2017 described for *Alisma plantago aquatica* leaf, our findings reveal the same double mixed vascular bundle, consists of xylem and phloem elements. The vascular bundles are protected by a parenchymatous sheath. Between the lower epidermis and the mid rib vein some collenchyma cells are present (Fig. 5, B).

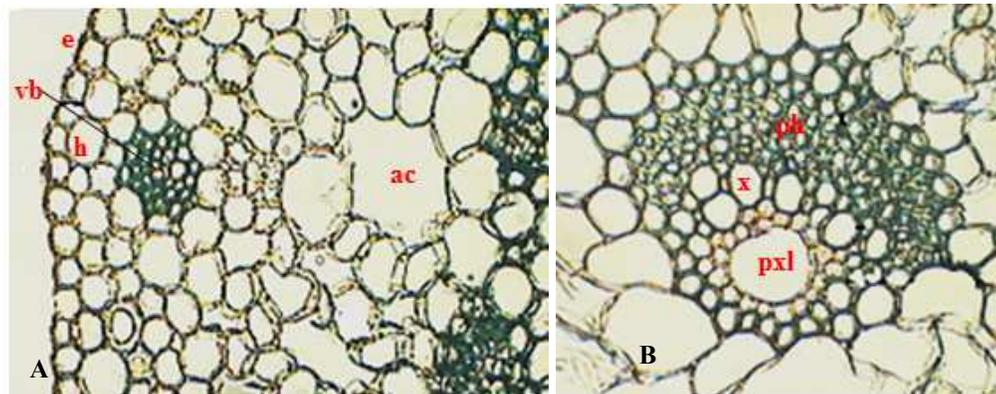


FIG. 3. The aerial stem. Portion with epidermis and cortex (A). Detail of a vascular bundle (B) (A, B, x 130): ac- air chamber, e- epidermis, h- hypodermis, ph- phloem, pxl- protoxylem lacuna, vb - vascular bundle. x- xylem.

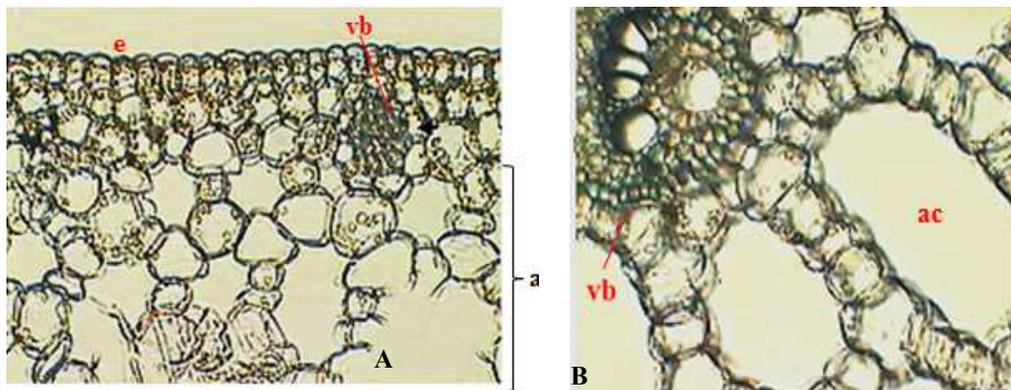


FIG. 4. Cross section of the petiole. Portion with epidermis and cortex (A, x 180). Portion with a vascular bundle and air chambers (B, x 195): ac - air chambers, e- epidermis, vb- vascular bundle.

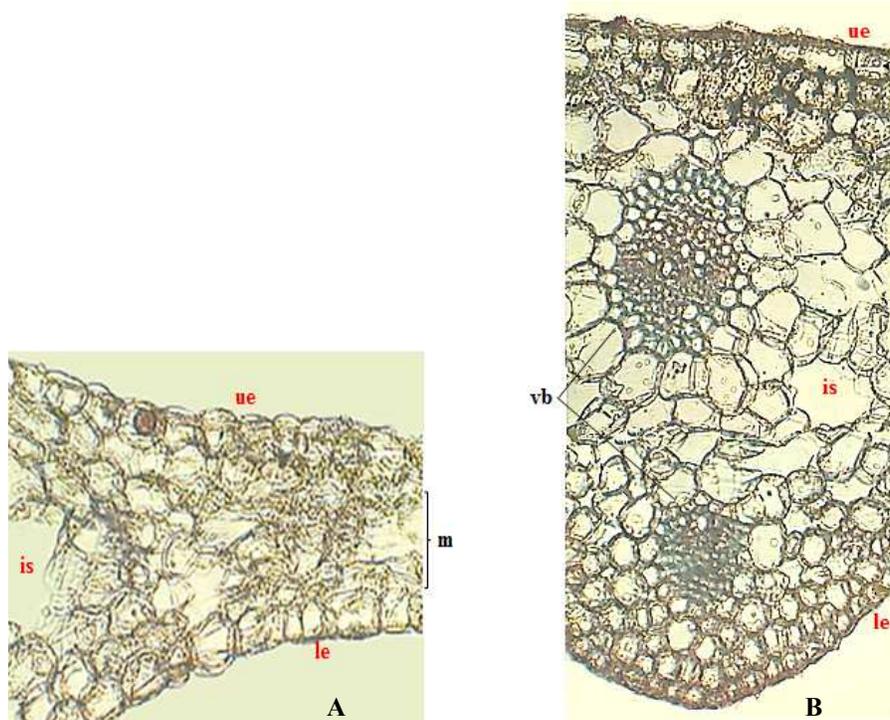


FIG. 5. Cross section of the blade. Portion with epidermes and mesophyll (A, x 170). Portion of the blade in the mid rib zone (B, x 180): is- intercellular space, le- lower epidermis, m- mesophyll, ue- upper epidermis, vb- vascular bundles.

CONCLUSIONS

The adventitious root has a characteristic monocot primary structure, with a well-developed aerenchyma tissue around the stele. The part of the aerial stem possesses epidermis, followed by a hypodermis. Below the hypodermis is an aerenchym tissue with a number of small air chambers. The stele consists of a number of close collateral vascular bundles.

The leaf petiole epidermis has thin-walled cells, covered by a thin cuticle. The cortex possesses air chambers and a number of poor collateral vascular bundles, embedded in the parenchyma tissue. Xylem is more developed than the phloem. The leaf blade mesophyll is heterogeneous, possessing air chambers mostly near by the mid rib vein and poor developed vascular bundles to the margins. The mechanical tissues almost lack, only the petiole and blade has collenchyma cells below epidermis.

This species has revealed some specific aquatic characters such as the presence of the air chambers, the diaphragm tissue, the lack of proper roots but the presence of adventitious roots at the rhizome nodes and the presence of stomata for the aerial stem and leaf.

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