ANATOMY OF *BUTOMUS UMBELLATUS* L. (BUTOMACEAE)

Rodica Bercu

DEPARTMENT OF BOTANY, FACULTY OF NATURAL AND AGRICULTURAL SCIENCES,"OVIDIUS" UNIVERSITY, CONSTANTZA

Summary

The paper deals with anatomical investigation of the vegetative organs of a marginal aquatic perennial plant, living on the Danube Delta channels (Romania), namely *Butomus umbellatus* L. The anatomical investigation of the root, rhizome, the floral axis and leaf discloses both monocot and aquatic features, the latter in accordance with it semi-aquatic nature. The results reveal that the root has a primary structure. The cortex is differentiated into two zones. Remarkable is the external cortex with large air chambers separated by trabeculae., The rhizome has a characteristic structure. Bellow the epidermis is the region of the ground tissue, characterized by the presence of the large air chambers separated from one another by thin-wall done-seriate partitions. The inner cortex is a parenchyma tissue abounding of starch grains. The vascular system consists of a number of smaller and large poorly developed vascular bundles, irregularly scattered in the ground tissue, shielded by the abundance of the starch grains. Anatomical blade analyses allowed us to conclude, that the leaf has a characteristic triangle-shaped, protected to the exterior by a single-layered epidermal cells. The mesophyll, without adaxial palisade, is differentiated into a chlorenchyma, possessing large round-shaped parenchyma cells and an aerenchyma tissue with air cavities. Close collateral vascular bundles of the chlorenchyma tissue possess small sclerenchymatous caps, with mechanical role. In between the air cavities, second-order vascular bundles are present. Externally, a parenchyma sheath protects the small vascular bundles.

Key words: anatomy, aerenchyma, root, rhizome, leaf, floral axis, stoma

rodicabercu@yahoo.com

Introduction

Butomus umbellatus L. (fam Butomaceae), the flowering rush, is an emergent hydrophytic to helophytic herbaceous perennial plant, It typically grows 40-150 cm tall. The rhizomes consist a large quantity of starch and it is used as nutrient in alimentation (Crow & Hellquist, 1982; Mabey, 1984). The leaves have sharp edges and will grow 2 m tall. The floral peduncles arrive between 5 to 20 cm (Cook, 1985). The pink flowers are borne in round open clusters (polichasiu), carried above the leaves. Red anthers contrast with the pink tepals (Tarnavschi, 1974; Strasburger, 1991). Propagation: seed or by division done in the spring. It can be planted at the margins of ponds or it can grow in shallow water up to a foot deep (Mulberg, 1982, Stukey *et al*., 1990). The submersed forms, can grow in water up to 3 m deep and tends to have very narrow, long thin leaves and does not flower (Gauthier, 1972). In literature are mentioned the morphological (Jones, 1974; Nyárády, 1966; Bavaru & Bercu, 2002) aspects of the plant, the leaf and flower anatomy (Singh, 1966, Bercu, 2004) but a study on the root, floral axis and leaf (in paradermal sections) anatomy of this species, almost lack.

Material and Methods

The plant was collected from the Cardon channel of the Danube Delta. Small pieces of root, stem and leaf were fixed in F.A.A. (formalin-aceto-alcohol), clarified with chloral hydrate and stained with alum-carmine and iodine green. The samples were embedded in glycerin-gelatin (Bercu & Jianu, 2003). The Histoanatomical 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 root exhibits a rhizodermis, a cortex and a stele. Rhizodermis consists of a single layer of slightly elongated cells, without hairs. Bellow the rhizodermis is a one-layered exodermis composed of radial compactly arranged slightly suberized cells, protecting the inner cortex (Fig. 1, A, B).

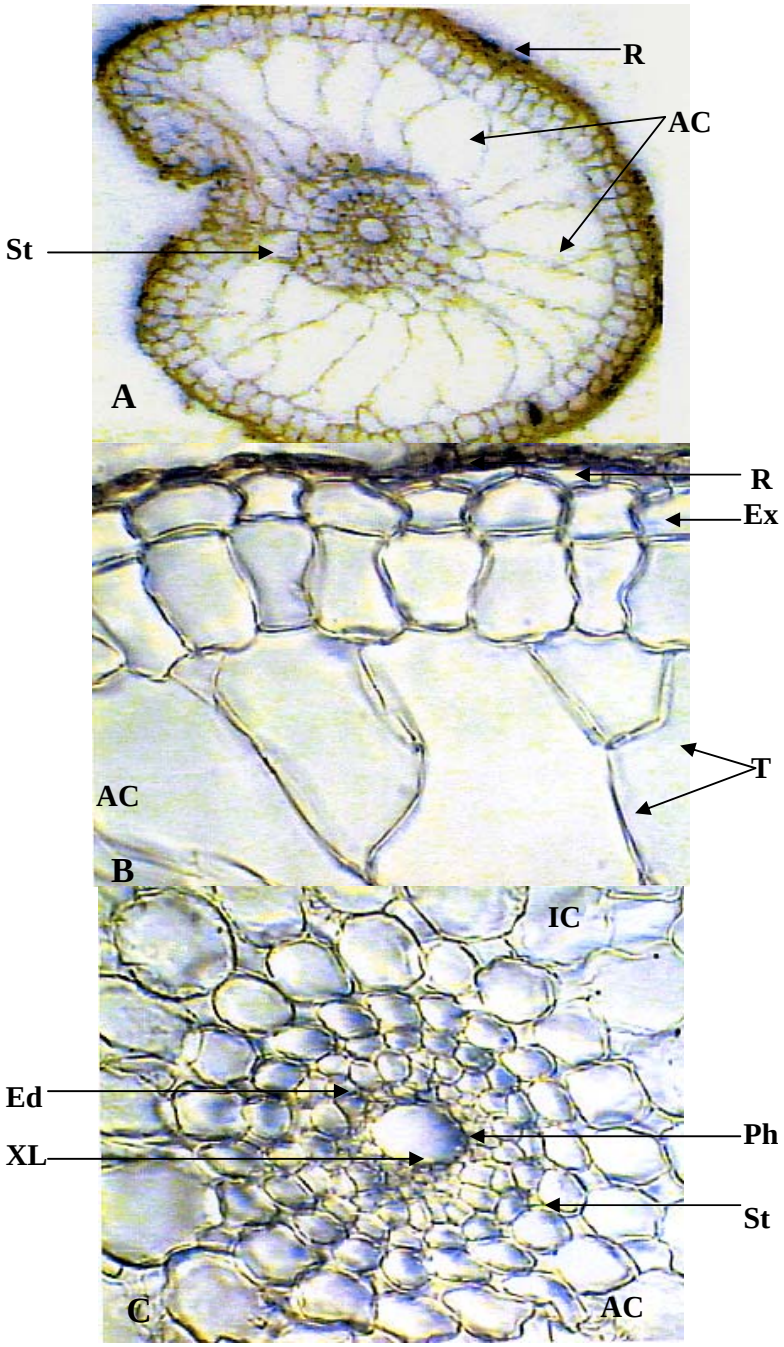

Fig. 1. Cross sections of the root. General view (A). X 79. Portion of the cortex (B). The stele (C). X 370: AC- air chambers; Ed- endodermis; Ex- exodermis; IC- inner cortex; Ph- phloem; R- rhizodermis; St- stele; T- trabeculae; XL- xylem lacuna.

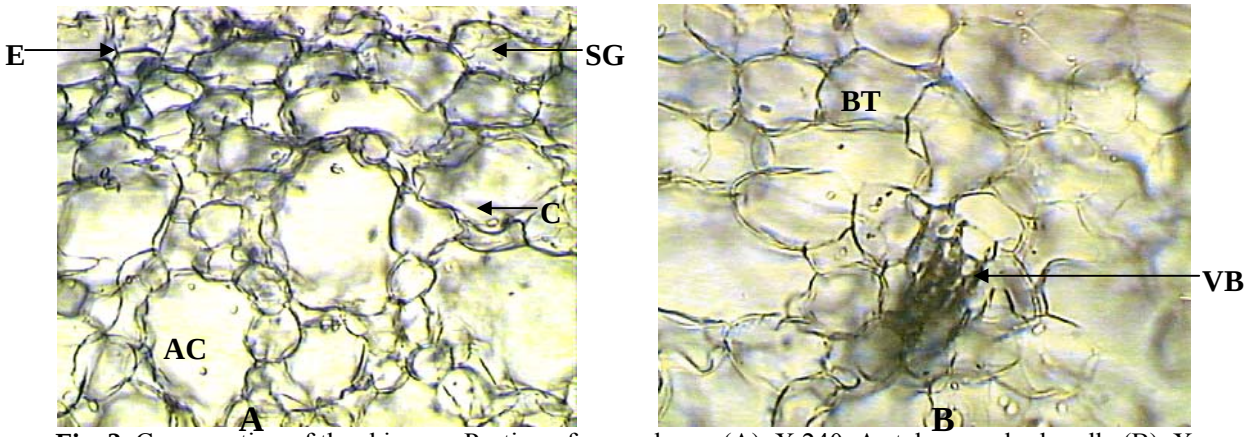

Fig. 2. Cross section of the rhizome. Portion of aerenchyma (A). X 240. A stele vascular bundle (B). X 450: AC- air chamber; BT- basic tissue; E- epidermis; SG- starch grains; VB- vascular bundle.

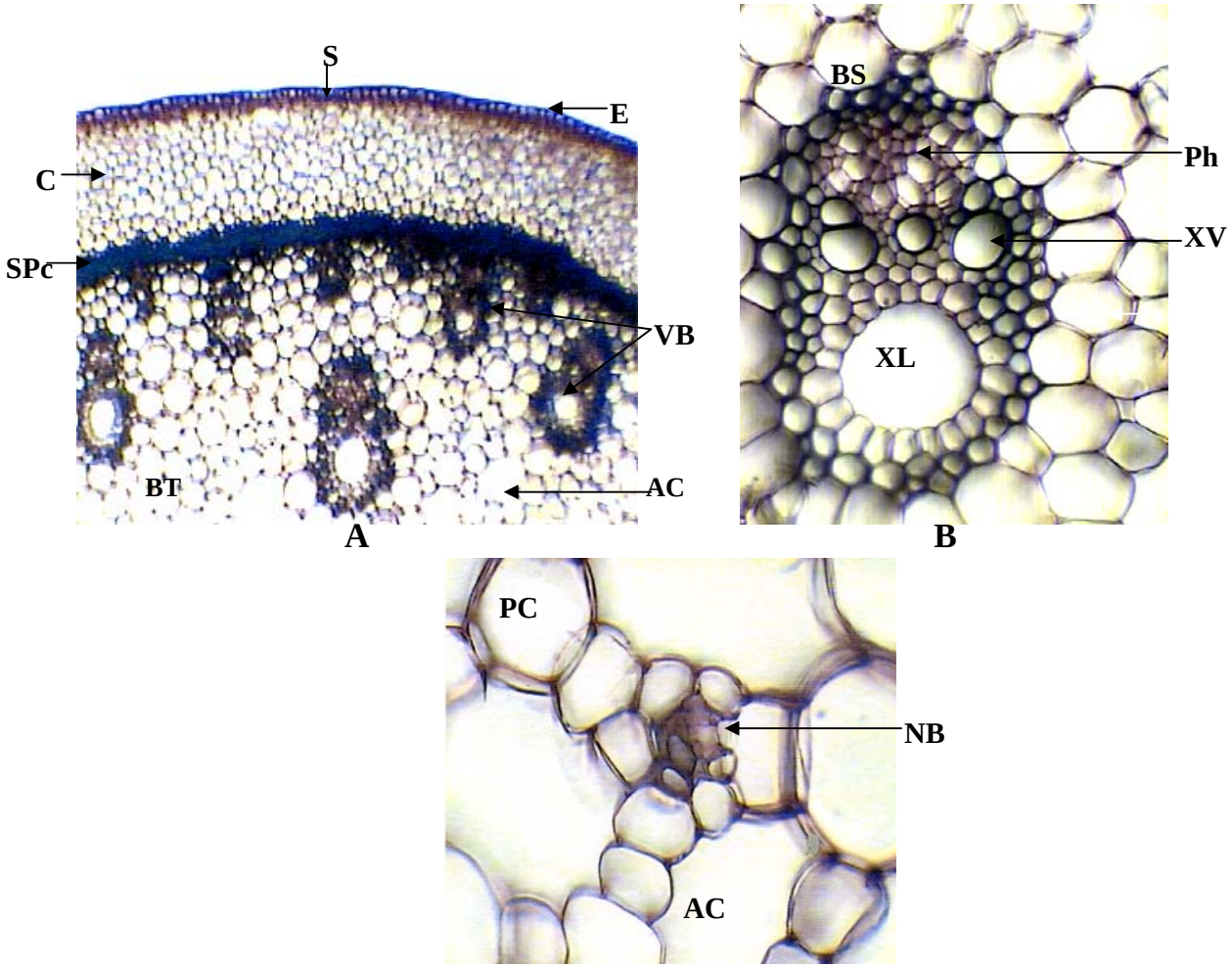

Fig. 3. Cross sections of the floral axis. Portions with epidermis, cortex and stele (a, b). X 64, 205. A vascular bundle of aerenchyma (c). X 205. Nodal vascular bundle (d). X 327: AC- air chamber; BS- bundle sheath; BT- basic tissue; C- cortex; E- epidermis; NB- nodal bundle; Ph- phloem; PC- parenchyma cell; S- stoma; SPc- sclerenchymatous pericycle; VB- vascular bundles; XL- xylem lacuna; XV- xylem vessel.

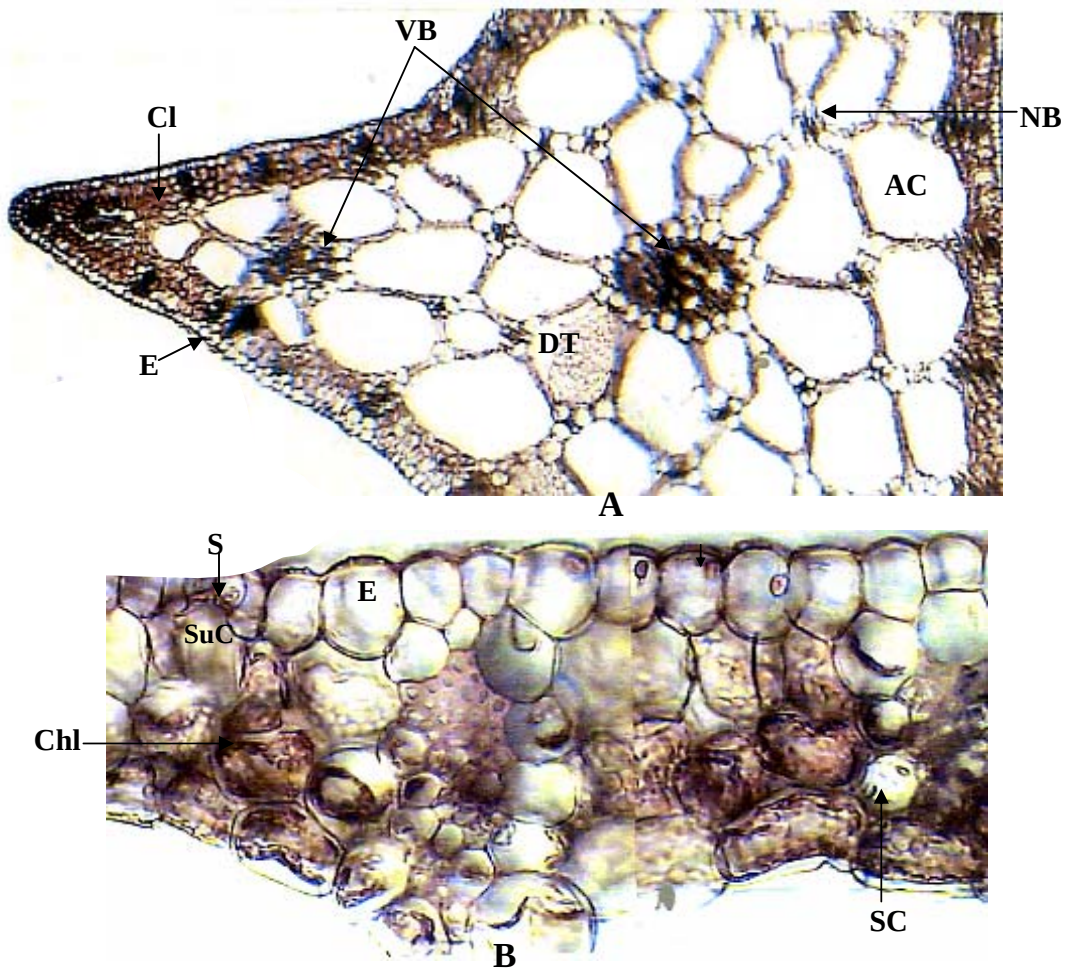

Fig. 4. Cross sections of the leaf. General view of the lamina (A). X 60. Portion of chlorenchyma tissue (B). X 230: AC- aerenchyma tissue; Chl- chloroplasts; Cl- chlorenchyma; DT- diaphragmatic tissue; E- epidermis; NB- nodal bundle; S- stoma; SC- secretive cavity; SuC- substomatal cavity; VB- vascular bundle.

Internally, the cortex is differentiated into two regions. The external region covers the major portion of the root. It consists of a of large number of conspicuous air chambers, which are separated, from each other, by uniseriate cells, named trabeculae (Batanouny, 1992). Occasionally, the branched trabeculae form an anastomosing system, especially to the peripheral zones (Fig. 1, A, B). The inner zone of the cortex consists of two or three layers of simple parenchymatous cells. The endodermal cells enclose the centrally located stele. It consists of a one-layered pericycle and the vascular tissue. The pericycle's cells are smaller than those of the endodermal ones. Bellow the pericycle is the vascular system. It is poorly developed, consisting of few phloem vessels, lack companion cells, and phloem parenchyma. Watson, & Dallwitz (1991/94) mentioned that the root's xylem vessels are mainly simple or scalariform, but here xylem is represented by a single large lacuna (Fig. 1, C).

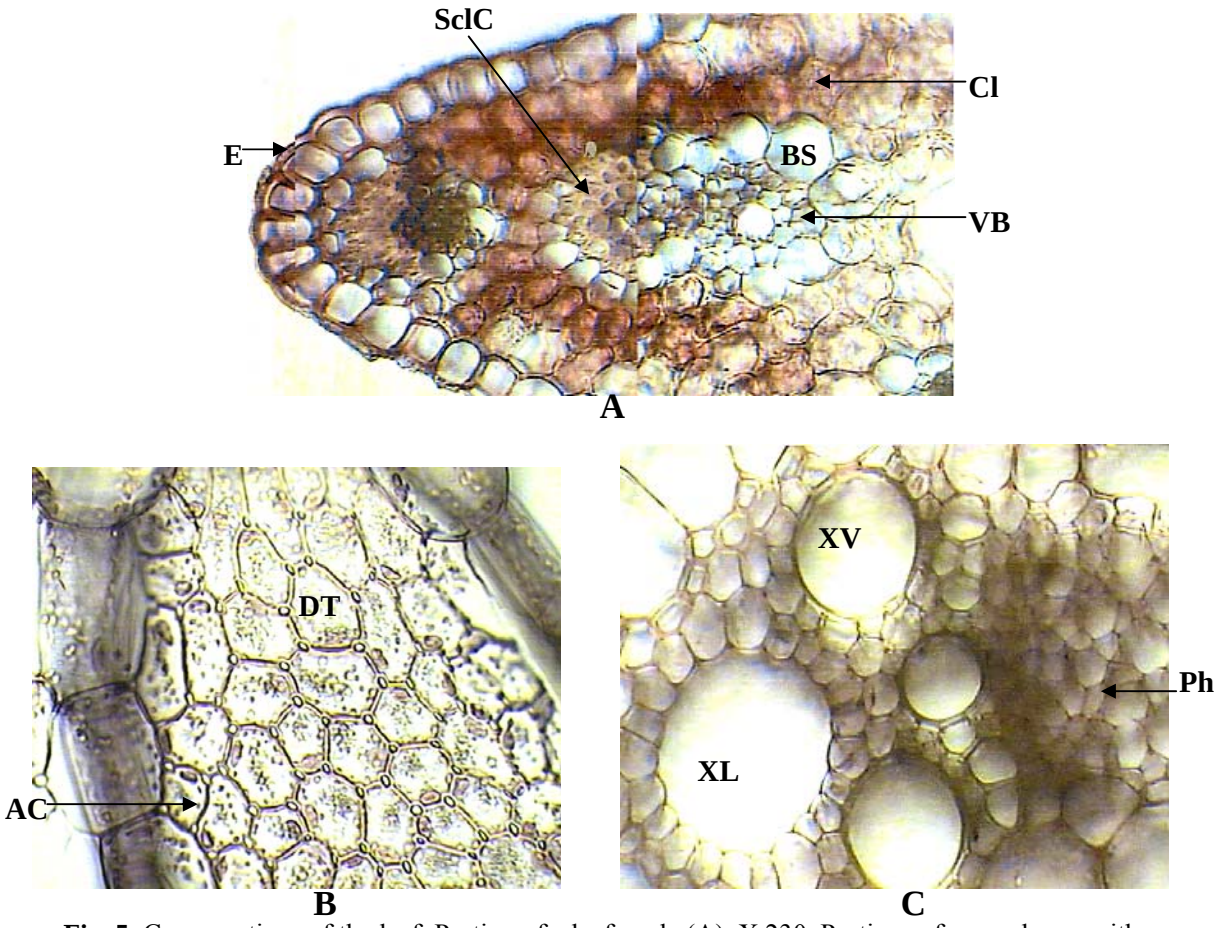

Fig. 5. Cross sections of the leaf. Portion of a leaf angle (A). X 230. Portions of aerenchyma with diaphragmatic tissue (B) and an air chamber with nodal bundle (C). A vascular bundle of the lamina (D). X 210: AC- air chamber; BS- bundle sheath; Cl- chlorenchyma; DT- diaphragmatic tissue; E- epidermis; Ph- phloem; SclC- sclerenchyma cap; VB- vascular bundle; XL- xylem lacuna; XV- xylem vessel.

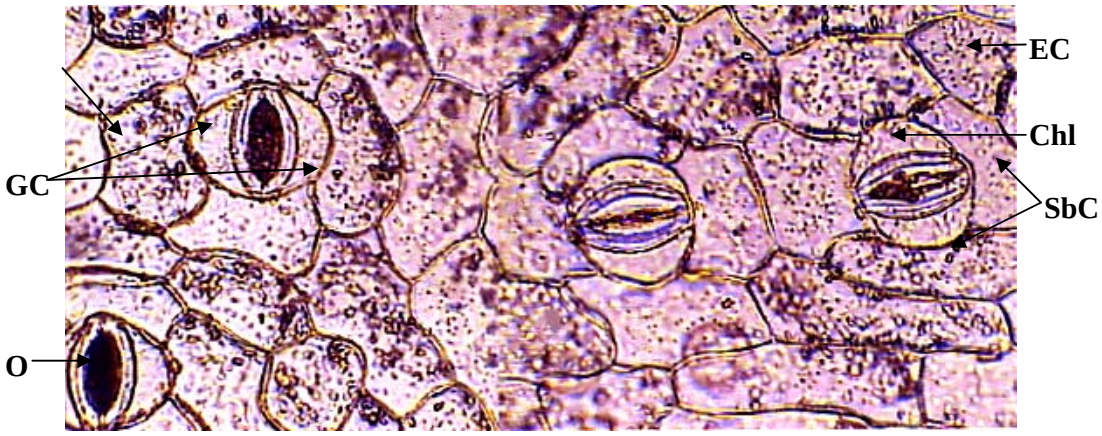

Fig. 6. Portion of epidermis (tangent section). X 436: Chl- chloroplasts; EC- epidermal cell; GC- stoma cells; O- ostiole; SbC- subsidiary cells.

The outermost layer of the rhizome, in cross sections, is epidermis, composed of a single layer of small cells, covered by a thin cuticle. The cortex consists of two distinct regions. An external zone, characterized by, more or less, large air spaces (air chambers), separated from one another, by thin-walled many-serial

parenchyma cells and an internal one of ground tissue (Fig. 3, A). As Stant (1967) and Watson & Dallwitz (1991/94) reported the inner cortex consists of many-layered large parenchyma cells, with numerous starch grains (Fig. 1, A). However, two types of vascular bundles may be found. The small vascular bundles are placed towards the external region and the large vascular bundles, commonly, are found towards the central region, the latter being shielded by the presence of the starch grains. Each vascular bundle consists of few xylem and phloem elements (Fig. 2, B).

Transversal sections of the floral axis exhibit an epidermis, a cortex and a stele. Externally, the epidermis is composed of one layer of isodiametric and cutinized cells. A distinct layer of cuticle is found on its surface. Its continuity is broken by stomata. Epidermal hairs are absent. Bellow the epidermis, several layers of compactly arranged parenchymatous cells are present, forming the cortex. Bellow the cortex is the endodermis, followed by a sclerenchymatous pericycle. Beneath the pericycle, the stele is present (Fig. 3, A, C).

The vascular system is represented by a number of close collateral bundles, irregularly embedded in the ground tissue. The ground tissue is represented by an aerenchyma, enclosing irregular large air chambers, separated one cell thick partitions. However, the vascular bundles consist of one large xylem lacuna and phloem elements (toward the epidermis). Characteristically to monocots stem (Batanouny, 1992), the vascular bundles are protected by a sclerenchyma sheath. Phloem consists of meta- and protophloem vessels, companion cells and few phloem parenchyma elements (Fig. 3, B). In between the air chambers small bundles occur, forming a nodal tissue (Fig. 2d).

Cross sections of the leaf reveal a triangle-shaped lamina. Epidermis is the outermost layer composed of isodiametric regularly arranged simple cells, covered by a thick cuticle. At places the epidermis is interrupted by the presence of stomata (Fig. 4B).

The mesophyll is well developed and differentiated into a chlorenchyma tissue and an aerenchyma tissue. The chlorenchyma region consists of three layers of large parenchyma cells, irregularly radiate around the vascular bundles. At places, conspicuous close collateral vascular bundles are present, mostly, in the corners of the triangle-shaped leaf; 7 to 9 mesophyll cells between contiguous vascular bundles. Small sclerenchyma caps are present in the margin of the lamina (Figs. 4, A; 5, A). Bellow the chlorenchyma tissue is the aerenchyma, represented by well-developed air cavities. A diaphragmatic tissue inside some of the air chambers is present (Fig. 4, A, 5, B, C). In between the air chambers, large midribs of first-order vascular bundles, structurally distinguishable from the lateral first-order vascular bundles, solitary, associated with parenchyma air chambers, occur. Parenchyma sheath cells, inflated with thin walls (with 16 to 22 parenchyma cells), completely surround the large vascular bundles. The first–order vascular bundles consists of one large xylem lacuna and three protoxylem vessels. The abaxial phloem, present in the first-order bundles, shows normal development, consisting of sieve cells, companion cells and phloem parenchyma (Fig. 5, C). Small second-order bundles consist of few vascular elements, surrounded by parenchyma sheath with 4 to 6 small parenchyma cells (Figs. 4, A; 5, A) (Bercu, 2004).

Lamina, in paradermal section, discloses four to six-walled, elongated epidermal cells. The epidermal cells continuity is interrupted by stomata (2 stomata to 1-2 epidermal cells). Between the cells small intercellular spaces are present. Watson and Dallwitz (1991/94), concluded that the stoma apparatus in *Butomus umbellatum* leaf is of paracytic type, but our micrograph shows a tetracytic type one (four subsidiary cells enclosing the guard cells). Beneath the guard cells, a

large ostiole occurs (Dilcher, 1974; Paliwal, 1972). The guard cells contain few chloroplasts (Fig. 6).

Conclusions

The results reveal that the root has a primary monocot structure. Remarkable is the external cortex with large air chambers separated by trabeculae.

The stem has a characteristic aquatic plant rhizome structure with a number of smaller and larger poorly developed vascular bundles, irregularly scattered in the ground tissue, shielded by the abundance of the starch grains.

The foliar analyses of this species allowed us to conclude, that the triangle-shaped blade has a differentiated mesophyll (a chlorenchyma tissue and an aerenchyma) and a poor developed veins vascular bundles. Characteristically, in between the air cavities, second-order vascular bundles are present.

Characteristically for monocots, the floral axis has a typical primary structure with a sclerenchymatous pericycle and poor developed vascular bundles.

Note the developed nodal system in the blade and the floral axis.

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