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— SHORT COMMUNICATION —

Contribution to the anatomy of *Sagittaria sagittifolia* L. (Alismataceae)

RODICA BERCU

Department of Botany, Faculty of Natural and Agriculture Sciences, "Ovidius" University, Mamaia 124, 900590, Constantza, Romania

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Anatomically, *Sagittaria sagittifolia* L. (arrowhead) exhibits characteristics of monocots with hydrophytic features in accordance to its aquatic habit. The root has a primary structure with a conductive stele and a cortical aerenchyma. The stele is well developed. The stem cortex is also aerenchymatic and is covered by an epidermis. The stele consists of a number of collateral bundles, each bearing of a few xylem and phloem elements. The leaf has a chlorenchymatic mesophyll with large air cavities. The upper and lower epidermises possess paracytic stomata. The leaf petiole cortex is aerenchymatic.

Key words: anatomy, root, stem, leaf, *Sagittaria sagittifolia*.

Abbreviations used in figures: AC = air chamber, C = cortex, CH = chloroplast, Ct = cuticle, Ed = endodermis, EC = epidermal cells, GC = guard cells, LE = lower epidermis, Mx = metaxylem, O = ostiole, Pc = pericycle, Ph = phloem, Pi = pith, Px = protoxylem, PC = parenchyma cell, PS = parenchymatous sheath, PxL = protoxylem lacuna, R = rhizodermis, S = stoma, SC = subsidiary cell, VB = vascular bundle, XP = xylem parenchyma.

INTRODUCTION

Sagittaria sagittifolia L. (Alismataceae), known as "arrowhead", is a stoloniferous aquatic perennial plant with two sorts of leaves: submerged ribbon-like leaves and leaves above the water surface which develop the characteristic arrowhead shape. Ramets grow as a rosette of leaves. The stem is swollen at the base and throws out creeping stolons or runners, which produce winter tubers composed almost entirely of starch. Flowers are pale pink in a spike. The phenotypic plasticity of the leaves of aquatic plants, especiallly that of the *Sagittaria sagittifolia* leaves, is well known (Haynes & Holm-Nielsen, 1994; Dorken & Barrett, 2003).

The plant propagation is mainly asexual through plantlets forming numerous lateral runners. *Sagittaria* can also be grown from seeds or tubers (Anonymous, 1992).

In the literature, some authors describe the morphological characteristics and the foliar dimorphism of this plant (Nyárády, 1966; Tarnavschi *et al*., 1974; Strasburger, 1991; Bavaru & Bercu, 2002). Information, however, on the anatomy of the vegetative organs of *Sagittaria sagittifolia* is actually lacking.

* Corresponding author: tel.: +4041 611565, e-mail: rodicabercu@yahoo.com

MATERIALS AND METHODS

Cross sections of roots, stems (stolons) and leaves (blade and petiole) were stained with alum-carmine and iodine green and were embedded in Canada balm. 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

Cross sections of *Sagittaria sagittifolia* roots exhibit a rhizodermis, a cortex and a stele. The rhizodermis consists of one layer of cells. Bellow the rhizodermis is the cortex which bears intercellular spaces (air

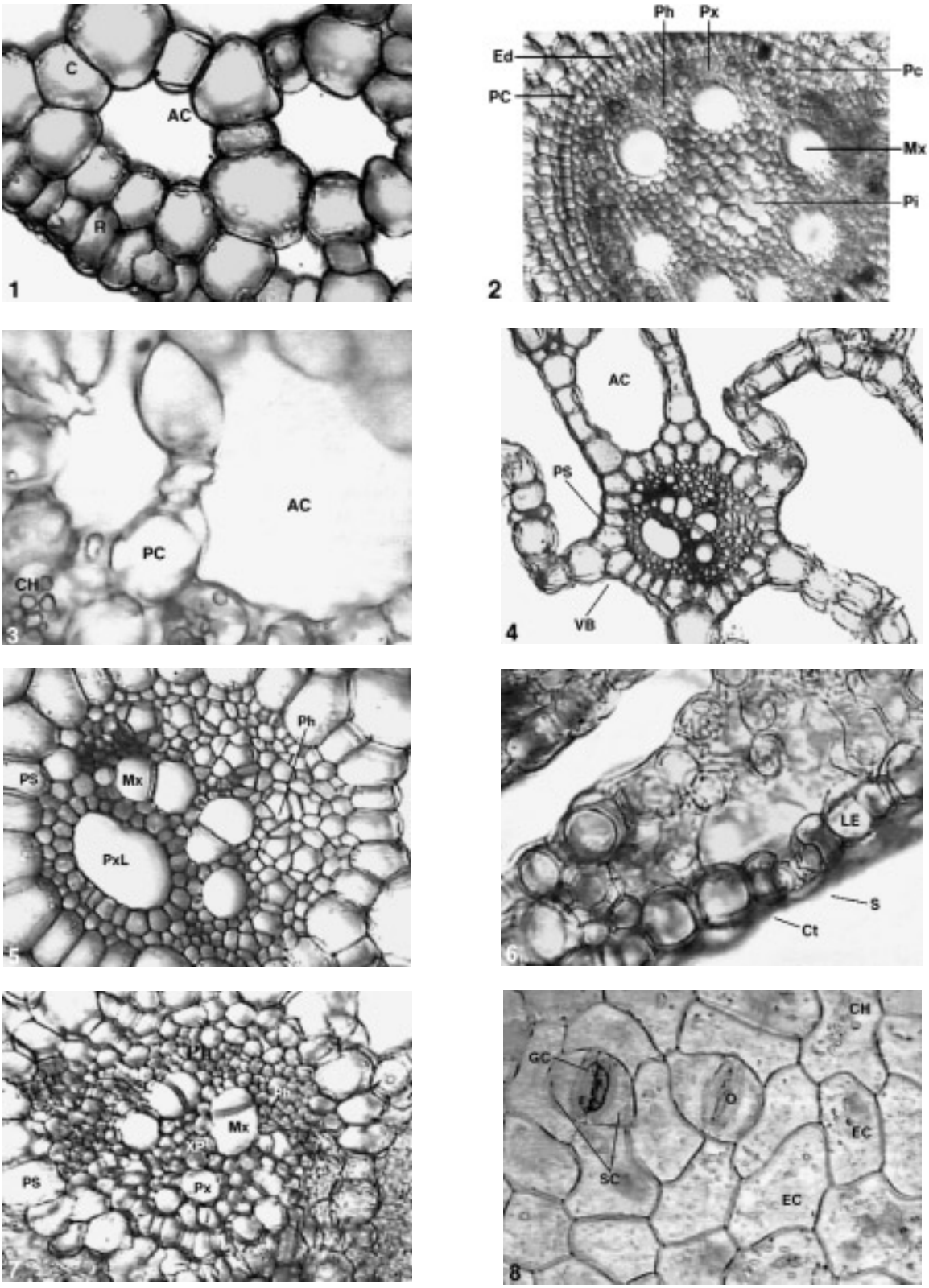

FIG. 1. Partial view of the root epidermis and cortex (×100). FIG. 2. The root stele (×360). FIG. 3. Portion of the inner cortex with Cross section of the stolon (stem) aerenchymatic tissue (×480). FIG. 4. Portion of the leaf petiole cortex with well-developed aerenchyma and a vascular bundle (×40). FIG. 5. A large vascular bundle (×240). FIG. 6. Cross section of the leaf lamina (×160). FIG. 7. A vascular bundle of the leaf midrib (×340). FIG. 8. Paradermal section of the leaf epidermis with stomata (×800).

cavities) separated from each other by uni-cellular partitions (Fig. 1). Internally, the endodermis encloses the stele. The endodermis consists of a single layer of U-shaped cells. The stele contains the vascular system and is surrounded by the pericycle (one-layered). The vascular system is represented by xylem and phloem. Xylem consists of protoxylem vessels (facing the pericycle), metaxylem vessels (towards the center) and pith rays (Fig. 2). Phloem is composed of sieve cells, companion cells and phloem parenchyma and is located between the xylem strings.

The stolon (stem) consists of a single layer of epidermal cells, which are internally connected to the cortex. The latter is composed of ground tissue (4-6 layers of cells) with large air spaces (Fig. 3). Remarkable is the abundance of starch grains in the stolon inner ground tissue. Batanouny (1992) has studied the stem structure, especially the vascular system, but made no mention about the presence of the aerenchymatic tissue. The vascular system is represented by close collateral bundles, irregularly embedded in the ground tissue. It is a polistele in structure. However, a number of vascular bundles surrounded by a parenchymatic sheath are present. The bundles are poorly developed and screened by the presence of starch.

Cross sections of the leaf petiole revealed that it consists of an epidermis, a cortex and a stele. The epidermal cells are thin-walled and do not bear hairs. The cortex occupies the major portion of the petiole. It is composed of an aerenchyma with large air chambers separated by unicellular partitions (Grinţescu, 1985) named trabeculae (Batanouny, 1992). Occasionally, the partitions branch with each other forming an anastomozing system (Fig. 4). Some air chambers possess a diaphragmatic tissue. The vascular system is represented by large vascular bundles irregularly embedded in the aerenchymatic tissue, and small vascular bundles just bellow the epidermis. Each large vascular bundle consists of phloem and xylem (several metaxylem vessels and a large protoxylem lacuna) (Fig. 5). The phloem is constituted of sieve cells, companion cells and phloem parenchyma.

The arrow-shaped leaf lamina, in cross section, reveals a more or less homogenous mesophyll (Fig. 6). The upper epidermis, as the lower one, consists of a single layer of cells covered by a thin cuticle. The epidermis continuity is interrupted by the presence of stomata. Beneath the upper and lower epidermises is the mesophyll, containing numerous chloroplasts.

At places, small vascular bundles with a few xylem and phloem elements are present in the mesophyll. The midrib is represented by two fused vascular bundles, unequally-sized. The small vascular bundle faces the upper epidermis and the large one, just in the middle of the midrib, faces the lower epidermis. The connection between the vascular bundles is made by parenchymatic cells. The vascular bundles consist of a number of xylem vessels and a protoxylem lacuna (Fig. 7). Each vascular bundle is surrounded by a parenchymatic sheath. The lower epidermis, as the upper one, consists of one layer of cells, possessing stomata.

The leaf lamina, in paradermal section, discloses polygonal epidermal cells with starch deposits. The epidermal cell continuity is interrupted by paracytic stomata (2 stomata per 13 epidermal cells) (Fig. 8) (Paliwal, 1972; Dilcher, 1974), characteristic for other Alismatales species as well (Watson & Dallwitz, 1992). Beneath the guard cells, a slightly slit ostiole occurs. The guard cells are of the *Amaryllis* type and contain a few chloroplasts.

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