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MORPHO-STRUCTURAL ADAPTATIONS OF SOME AQUATIC CARNIVOROUS PLANT SPECIES (*ALDROVANDA VESICULOSA* L. AND *UTRICULARIA VULGARIS* L.)

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Abstract. In the present work the authors emphasize a few structure particularities of two aquatic carnivorous plant species, *Aldrovanda vesiculosa* L. and *Utricularia vulgaris* L., underlining their adaptation to the aquatic medium and to the carnivory menu.

Key words: bladder, aeriferous canals, *Aldrovanda vesiculosa*, *Utricularia vulgaris*.

Introduction

Aldrovanda vesiculosa was first called *Aldrovandia* by G. Monti, in the eminent botanist's honor, Ulysse Aldrovandi, and then Linné [4] gave it the name we know today. It is a little aquatic plant, rootless, which floats horizontally. It belongs to the *Droseraceae* family, together with *Dionaea muscipula*, *Drosophyllum lusitanicum* and to the gender *Drosera*. It pays for our attention because of its traps of a complexity that we hardly see in the botanical kingdom; we are facing the last survivor of a gender which knew its climax little after the dianosaurs' extinction.

The gender *Utricularia* belongs to the *Lentibulariaceae* family, together with the species which form the genders *Genlisea* and *Pinguicula*; it includes the greatest number of carnivorous plant species (almost 275), spread in the entire terrestrial globe, excepting polar and desert regions. The most interesting particularity of this second species (*Utricularia vulgaris*) is the trap; it is usually called bladderwort, because of the bladder-like shape of its little traps, which capture minute aquatic organisms.

There is much information about the morphology and physiology of these studied species; for example, the synthesis referring to the dicotyledons' anatomy [6, 8] or to the angiosperms [7]. Some histo-anatomical observations about carnivorous plants were presented [3]. In our country, the carnivorous plants accommodation to surroundings was underlined [15, 16].

In the present work we show a few adaptative characters to the aquatic medium and to the carnivory menu of *Aldrovanda vesiculosa* and *Utricularia vulgaris*, as a sequel of our investigation regarding the anatomy of some carnivorous plants [9, 10, 11, 12, 13, 14, 18].

Material and methods

The material subjected to the histological analysis (the vegetative organs of *Aldrovanda vesiculosa* şi *Utricularia*), collected from the Danube Delta, has been fixed and preserved in 70% ethylic alcohol. The sections were cut by microtome, subsequently

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coloured with iodine green and alaun-carmine, then mounted in gel and analyzed in a Novex (Holland) light microscope. The light micrographs were performed by means of the same light microscope, using Canon A95 camera.

Results and discussions

The stem

The main characteristic of the studied species is the absence of the root, the absorption of water and minerals taking place on the entire body superficies.

Aldrovanda vesiculosa has the stem formed of successive whorls of leaves separated by short internodes (**Fig. 1**). The stem has a circular profile in cross section at *Utricularia vulgaris* and circular, but modified by prominent frames at *Aldrovanda vesiculosa*. Both species have the epidermis consisting in small isodiametric cells (**Fig. 2** and **8**), with the external wall thicker than the others. From place to place a few bicellular secretory trichomes are present (**Fig. 2 and 9**).

The cortical parenchyma is thick, with a lot (7-8) of large aeriferous canals, separated by radially multicellular one-layered rays at *Utricularia vulgaris* (**Fig. 8**) beside those, *Aldrovanda vesiculosa* presents strait aeriferous canals, too, outwards of the larger ones (**Fig. 3**).

At *Aldrovanda vesiculosa* the central cylinder is thin (**Fig. 3**), presenting a ring of conductive elements, a thin perimedullar zone and a central aeriferous canal. The ring of conductive elements is formed of few small external isles of sieved tubes and companion cells and more xylem vessels with less thickened and less lignified walls which are not different from the surrounding cells of the parenchyma, unless by their bigger diameter. *Utricularia vulgaris* has a thin central cylinder, too, but it consists in an homogenous mass of polygonal cells (**Fig. 10**), the majority of them having thickened, but cellulosed walls; we can not distinguish the phloem elements by the xylem ones; the most internal layer of the cortical parenchyma is a primary type endodermis, having Casparian thickenings in the radially walls of the cells.

The leaf

Both investigated species have metamorphosed leaves (*Utricularia vulgaris* presents normal leaves, too); precisely, the leaves are transformed in traps which capture minute aquatic organisms, as a characteristic feature to the carnivory menu.

At *Aldrovanda vesiculosa*, as we mentioned before, the leaves form successive whorls and have a cuneiform petiole; the upper epidermis, in front side view, presents polygonal elongated cells, with incurved lateral walls. Here and there, two-armed sessile secretory trichomes are present. The lower epidermis is formed of elongated cells, with incurved lateral walls; there are no trichomes present.

The extremity of the petiole bears a few trigger hairs, fan out disposed, forming a little concavity were the bilobed trap is, similar to that of *Dionaea muscipula*. The cells of the upper epidermis of the blade folds have irregular shape, with curved lateral walls.

Some of the boundary cells present rigid expansions (corresponding to the stiff trichomes belonging to the edges of the blade folds of *Dionaea muscipula*) oriented to the midrib. The upper (internal) epidermis presents a lot of secretory multicellular structures, called digestive glands, similar to those occurring in the upper epidermis of the blade folds of *Dionaea muscipula*, with the difference that the digestive gland of *Aldrovanda vesiculosa* consists in a small number of glandular cells (**Fig. 5**).

Besides, there are a lot of two-armed sessile secretory trichomes, similar to those from the petiole; sometimes, these trichomes join together, resulting a four-armed sessile secretory trichome, seen in the lower epidermis (**Fig. 6**). Another similitude with *Dionaea muscipula* is the presence of the multicellular one-layered bristle-like trichomes. They are sensitive to mechanical stimulations and present a very interesting structure. Each bristle-like trichome is formed of 5-7 superposed cellular stages. In the inferior part each stage is formed of four cells, parallelly disposed, but in the upper part, there are stages formed of two cells. The basal stage consists of big cells. Another three layers of elongated cells are queued, having a thick external wall and a thinner internal one. The next layer is formed of short cells, with very thin external and internal walls. If a minute aquatic organism touches the bristle-like trichome, this layer functions as an articulation. The latest layer consists in elongated cells, with thick external walls [17]. So, a touched bristle-like trichome does not bend on its whole length, because the parts situated up and down the articulation are not flexible, the external walls of the cells are very thick; it bends at the articulation. A repetitive touch of the bristle-like trichomes determines trap closure, resulting a vesicle, which gives the name of this species. The more bristle-like trichomes are touched the faster is the closure of the trap. The lower epidermis consists in polygonal cells, with curved lateral walls and two or four-armed sessile secretory trichomes.

So, *Aldrovanda vesiculosa* does not have a real cavity, unless the moments when the blade folds form the vesicle full of minute aquatic organisms. *Utricularia vulgaris* presents normal, small leaves and metamorphosed leaves, the little bladders which capture the aquatic organisms; in this case we can talk about a real cavity.

These pear-like bladders have very thin, semitransparent walls. The aperture, which presents a small lid with inward opening, is funnel-like shaped, and presents at its edges long one-layered sensitive trichomes; they guide the minute animals to the aperture of the bladder; their second role is to avoid the approach of the big animals, which could damage the bladders. The internal epidermis presents polygonal cells, with right or curved lateral walls. Here and there, a lot of four-unequal-armed (two long arms and two short arms) trichomes are present (**Fig. 11**); secretory glands (**Fig. 12**) consisting in one stalk cell, between the epidermic ones and an external layer of two hemispheric cells are accompanying the first group of secretory structures.

The finest contact of the minute aquatic organisms with the sensitive trichomes creates an aspiration force; the bladder distends, the lid opens inward and the water full of small animals is guided to the cavity. Then, the lid closes. The glands inside the bladder absorb most of the internal water and expel it on the outside, so, a partial vacuum is produced inside the bladder and the pressure from the outside becomes greater than inside. This causes the walls to squeeze inward and explains their slightly concave appearance. Soon, only the chitinuous parts of the small animals remain. We are facing an underwater process; the capture happens very fast, so the observations are quite impossible without special techniques [2]. Darwin did not point out weather the bladders of *Utricularia vulgaris* secrete, through the glands, enzymes or not. This problem had been positively resolved [5]; the secretory structures elaborate proteolytic enzymes, like trypsin, and the benzoic acid which, in his opinion, plays for an antiseptic. These substances are secreted by the armed-trichomes, and the resulted products are absorbed by the hemispheric secretory cells which belong to the internal epidermis of the blade.

Conclusions

The absence of the root, the absence of the cuticle, the presence of weak developed vascular tissues (especially the xylem one) represent some adaptations to the aquatic medium of the studied species. On the other hand, both species present a specialized mechanism which helps them capture minute aquatic organisms. So, the leaf is a metamorphosed organ, its different secretory structures (digestive glands of the upper epidermis of the blade folds belonging to *Aldrovanda vesiculosa*, the trichomes and the armed-glands from the internal epidermis of the bladder belonging to *Utricularia vulgaris*) represent the adaptations of this interesting plants to the carnivory menu.


Fig. 1

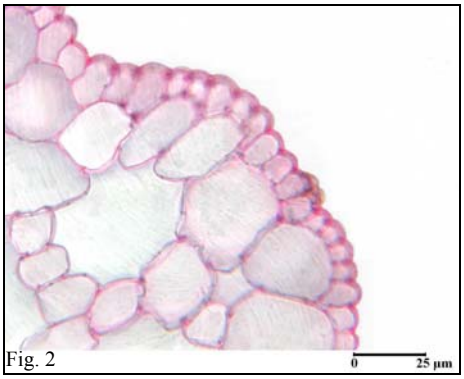

Fig. 2

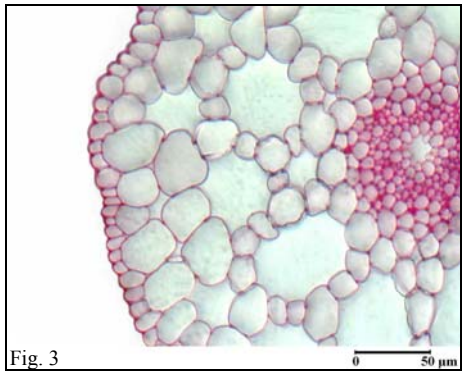

Fig. 3

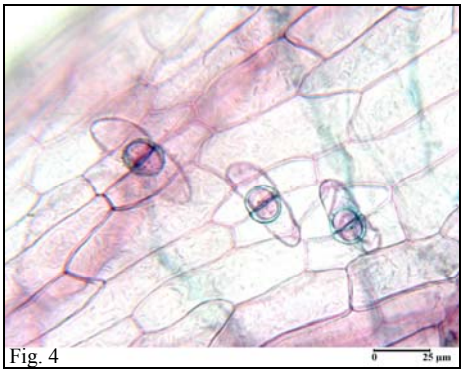

Fig. 4

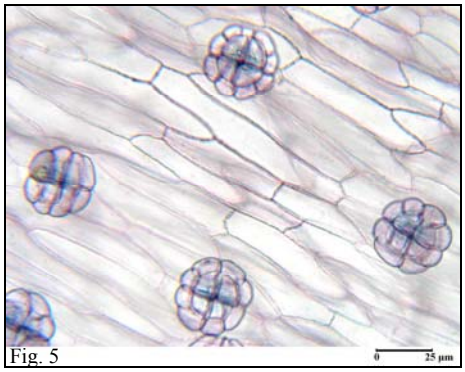

Fig. 5

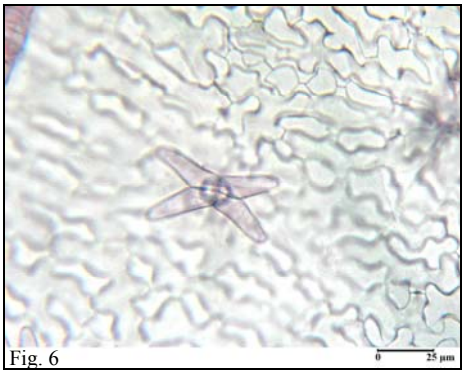

Fig. 6

Aldrovanda vesiculosa. Fig. 1: Macrosopic aspect. Fig. 2 and 3: Cross section trough the stem. Fig. 4: The upper epidermis of the petiole (front side view). Fig. 5: the upper epidermis of the blade folds (front side view). Fig. 6: the lower epidermis of the blade folds (front side view)

Fig. 7

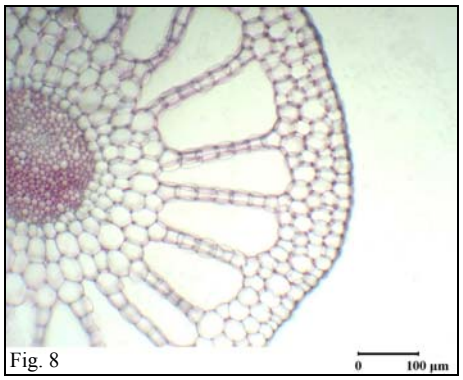

Fig. 8

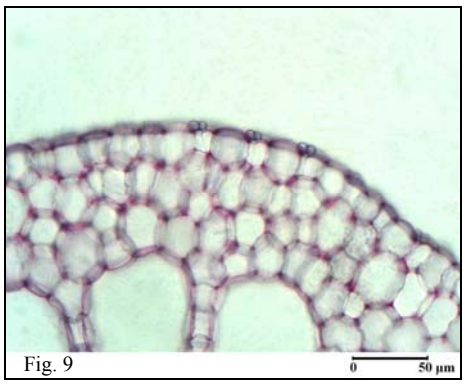

Fig. 9

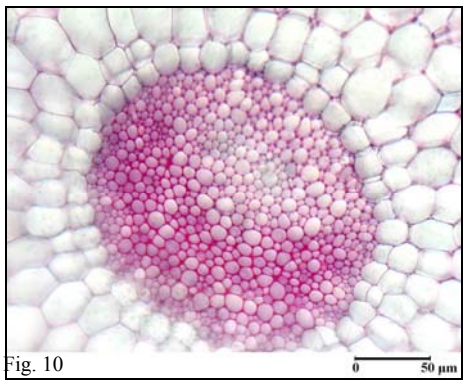

Fig. 10

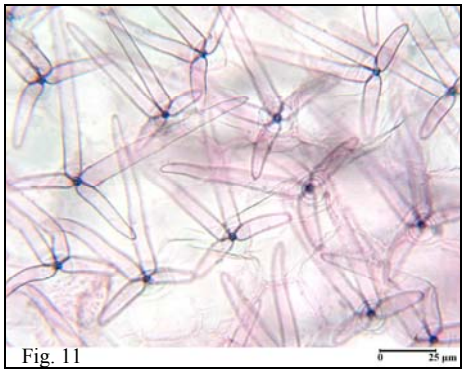

Fig. 11

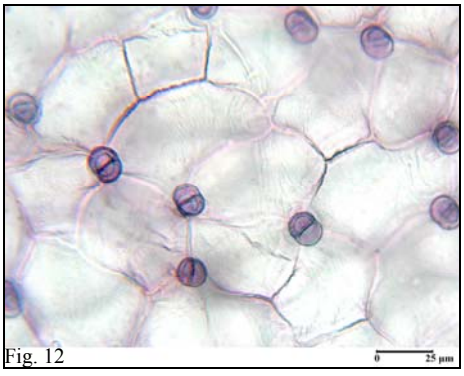

Fig. 12

Utricularia vulgaris. Fig. 7: Macroscopic aspect. Fig. 8-10: Cross section trough the stem. Fig. 11 and 12: The internal epidermis of the trap (front side view)

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