BUTOMUS UMBELLATUS MORPHO-STRUCTURAL CONSIDERATIONS ON ADAPTIVE PLASTICITY

ANCA SÂRBU*, DANIELA SMARANDACHE*, ANCA PARASCHIV*, DANIELA MIHAI*

Abstract. This work points out a series of adaptive modifications of the species Butomus umbellatus L. as an answer to the variations of water factor. Being one of the plants evaluated as dominant in the Romanian part of the Danube (the principal course and the associated connectives), research has oriented towards its growing forms in which we can find it, forms that support its adaptive plasticity. The variability of some structural characteristics (epidermis, assimilative tissue, aerenchyma, mechanical tissue and conducting tissue) is noticed both at the leaf level and at the flowering stem, and support the efficient transition of the species, from the aquatic to the terrestrial medium.

Key words: dominance, growing forms, structural adaptations

Introduction

Plants represent one of the biological reference elements (the UE Water Framework Directive) in characterization and evaluation of the quality of aquatic ecological systems [4, 5]. The composition of the aquatic vegetation, the species dominance, their adaptive plasticity, the growing forms and the morpho-structural characteristics of the corm are significant aspects, used in evaluation of the stadium and dynamics of water ecological systems [7, 8, 9].

The standardized research of the Danube’s fluvial corridor and its aquatic vegetation has allowed both realization of an aquatic plants inventory, accessible clearly and orderly, on the basis of the produced theme map sets and elaboration of an informational numerical system for the vegetation composition, system which can be used in characterization of the reference conditions and in evaluation of the intensity of the anthropic impact [6].

During 2002-2004 there was made the inventory of aquatic plants in the Romanian part of the Danube: the main channel (1122 km), the arms of the Danube (951 km) and the reference channels in the Danube Delta (186 km). At the level of the entire studied area only two aquatic plants accomplished the dominance indexes: Ceratophyllum demersum L. and Butomus umbellatus L.

Butomus umbellatus (flowering rush), perennial hygro-hydrophite with a stout rhizome and basal-cut and apically sulcated leaves, is frequently found in the stagnant or moderately flowing waters, rice plantations and thickets in the steppe zone and reaching the common oak sub-floor [1, 2]. According to the habitat conditions one can find it as a rooted submersed or as a helophyte.

In this work, we analyze the structural particularities of the lamina and the flowering stem, which sustain the adaptive plasticity of plant and can also explain to a certain extent the species dominance in the Romanian part of the Danube.
Material and methods

The inventory of the water plants from the Baziaş – the Black Sea Danubian section and from the associated connectivity types was made using the Kohler method [3]. In conformity to it, the inventory was made along the whole length of the water course and inside the associated connectivity types, in adjacent units (50 – 1000 m length), and all the present species in each inventory unit were evaluated in terms of distribution, abundance (5-steps Kohler Scale) and growing forms: acro-pleustophytes, submersed pleustophytes, submersed anchored/rooted plants, rooted plants with floating leaves, amphiphytes (plants which develop inside the same inventory unit 50% as helophytes and 50% as submersed rooted plants) and helophytes. Complete information on the methodology is available on the Home page www.midcc.at.

The evaluation of the relative biomass and of the indexes of average abundance of species permitted the identification of dominant species (*Ceratophyllum demersum* și *Butomus umbellatus*) at a level of inventory unit, river section and river as a whole.

For the structural analyses of the species *Butomus umbellatus* there were used eight testing units (four submersed plants and four helophytes), collected during July – August 2004 from the Măcin arm and the Mila 35 channel respectively (The Danube Delta). The leaves and flowering stems collected from the submersed and helophyte exemplars were preserved in 70% ethylic alcohol. For both types of growing forms there were made transversal sections through lamina (basal zone, median zone, apical zone) and flowering stem (median zone). The clarified sections (Javelle water) were processed in conformity with the technique of the double colouring (iodine green and carmine alaunat), analyzed (Ducoval optical microscope) and micro-photographed. The numerical data presented in this work represent average values/30 sections/section level.

Results and discussions

The results analysis regarding the distribution, abundance and growing form of the hygro-hydrophite *Butomus umbellatus* highlighted its status of dominant species at the level of the whole studied Romanian part of the Danube (2259 km).

One could find it in three growing forms (helophyte, amphiphyte, submersed rooted), their percentage varying in conformity with the analyzed sector and implicitly with the habitat conditions (Fig. 1, Fig. 2, Pl I). In the main channel of the river, the dominant growing form was helophyte (87%), followed by amphiphyfite (10%) and submersed (3%). Inside the arms of the Danube, the dominance of helophyte growing form (62%) maintained, but there were also well represented the other two growing forms (amphiphyte 26% and submersed 12%), while in the Danube Delta channels dominated amphiphyte (53%), followed by submersed (25%) and helophyte form (22%).

The morpho-structural analyses made on the leaves and flowering stems which grow in water (rooted submersed form) and in the aerial medium respectively (helophyte) showed sensible differences in the form of lamina, in epidermis, aerenchyma, assimilative tissue, mechanical tissue and conducting tissues.

At the submersed form, lamina presents at the basis a “horseshoe” outline with the adaxial face well displayed and a bifacial structure with an inverse dorsiventrality, and at
the median and apical zones a triangular outline (equilateral triangle) and a unifacial structure.

At the helophyte, the basis of lamina has a “V” shape and shows already a beginning of unifacial structure formation. In the median and apical zones the outline of lamina is triangular, but evidently winged, and the structure is unifacial.

The epidermis consists of more or less isodiametric cells and is covered by a cuticle with distinct crests. At the helophyte, the outer walls of the epidermal cells are thickened, the cuticle is thick and the stomata are with 15% more numerous.

At both analyzed forms, the mesophyll points out a sub-epidermal assimilative parenchyma (1-3 layers at submersed form; 3-4 layers at helophyte), and apart from that, it is traversed by aeriferous canals approximately polygonal in shape, delimited by a single stratum of parenchymal cells with thin cellulosic walls and rich in chloroplasts. The aeriferous canals have angular polygonal nodal cells, with slightly uniformly thickened walls. The submersed form has large aeriferous canals (Fig. 3, Fig. 4, Pl II), with an average value of 216/leaf (400 at the basis, 180 in the median zone and 70 at the top), while the helophyte form differentiates small aeriferous canals, with an average value of 103/leaf (180 at the basis, 100 in the median zone and 30 apical). The diaphragmatic tissue appears at the level of the aeriferous canals and consists of cells with thickened walls, provided with evident intercellular spaces (Fig. 9, Pl V).

The conducting tissues form numerous fascicles of closed collateral type characteristic of monocotyledons and of different sizes (small, provided only with phloem elements, medium which contain some elements of xylem and large, with a well-developed meta-xylem). Most smallest conducting fascicles are in the sub-epidermal assimilative parenchyma. All fascicles have domes of un lignified sclerenchymatical elements of different thicknesses. The weight of the three categories of conducting fascicles differs both with the type of tissue (sub-epidermal assimilative parenchyma and aeriferous parenchyma), and with the growing form of plant (submersed or helophyte). At the submersed form, in the sub-epidermal assimilative parenchyma there are ~ 60 small and medium conducting fascicles, and in the aeriferous parenchyma there are on average 7 large conducting fascicles, at which the xylem is represented by just only 3-5 elements (Fig. 5, Fig. 6, Pl III). At the helophyte form, in the assimilative parenchyma there are ~ 80 medium conducting fascicles, and in the aeriferous parenchyma 13-15 large conducting fascicles, with a well represented xylem (7-10 elements) (Fig. 7, Fig. 8, Pl IV).

The flowering stem of the plant has a circular outline and a length different from the submersed form (till 1,5 m depending on the water level) and the helophyte (on average 0,8 m). It has a monocotyledonous type structure, with modifications associated to the environment.

At the submersed plants, the isodiametric epidermal cells have the outer cellular walls thin, and at the helophytes, evidently thickened.

The assimilative parenchymatical cortex of the submersed plants presents large aeriferous canals displayed in 2-3 superposed rows, and that of the helophyte form presents reduced aeriferous canals distributed in a single row. The multi-stratified pericycle, made of 5-7 layers of small sclerenchymatical cells, was noticed at both analyzed forms.

The central cylinder contains closed collateral type conducting fascicles and an aeriferous parenchyma. The helophytes, comparative with the submersed form, differentiate
more than 20% conducting fascicles, with a well developed meta-xylem and perifascicular mechanical elements (Fig. 10, Pl V).

Conclusions

*Butomus umbellatus* is a dominant species over the whole Romanian part of the Danube and appears in three growing forms: helophyte, amfiphyte and submersed.

The adaptive plasticity expressed through the diversity of the growing forms sustains its dominance at the whole level of the fluvial corridor.

The variability of some structural characteristics noticed both at the leaf level and the flowering stem level sustains the species success in occupying different types of habitats evaluated according to the water factor (water course, lake, pond, swamp etc.).

In this respect, the passing from the aquatic medium (rooted submersed form) to the terrestrial one (helophyte) associates modifications of the epidermis (thickening of outer cellular walls and cuticle, increasing in stomata number) with diminution of the air reserve inside the plant (a maximum 50% reduction of aeriferous canals in leaf and flowering stem), with increase of corm resistance and with efficacy of its water supply (30% increase of xylem and sclerenchymatical mechanical tissue importance).

These eco-morphological answers analyzed at *Butomus umbellatus* exemplify the existence of morpho-structural diversity of its growing forms (submersed and helophyte), diversity which in fact is one of the expressions of the genetic diversity of this species.

REFERENCES


Explanation of figures

Fig. 1. *Butomus umbellatus* – submersed form, Măcin arm, 2004,orig.
Fig. 2. *Butomus umbellatus* – helophyte form, Mila 35 channel, 2004, orig.
Fig. 3. *Butomus umbellatus* – submersed form; transversal section through the median zone of lamina (12,5x3,2x8), orig.
Fig. 4. *Butomus umbellatus* – submersed form; transversal section through the median zone of lamina (12,5x10x6,3), orig.
Fig. 5. *Butomus umbellatus* – submersed form; transversal section through the median zone of lamina – detail of a medium conducting fascicle (12,5x10x16), orig.

Fig. 6. *Butomus umbellatus* – submersed form; transversal section through the median zone of lamina – detail of a large conducting fascicle (12,5x10x12,5), orig.

Fig. 7. *Butomus umbellatus* – helophyte form; transversal section through the median zone of lamina (12,5x10x6,3), orig.

Fig. 8. *Butomus umbellatus* – helophyte form; transversal section through the median zone of lamina – detail of a large conducting fascicle (12,5x10x12,5), orig.

Fig. 9. *Butomus umbellatus* – submersed form; transversal section through the median zone of lamina – detail of diaphragmatic tissue (12,5x10x20), orig.

Fig. 10. *Butomus umbellatus* – helophyte form; transversal section through the flowering stem – detail of a conducting fascicle (12,5x10x16), orig.
Fig. 1.

Fig. 2.
Fig. 3.

Fig. 4.
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