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MORPHO-ANATOMIC FEATURES AND CHEMICAL COMPOUNDS IN SOME AQUATIC PLANT SPECIES – PRELIMINARY DATA

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Abstract

Plants live everywhere, populating all major habitats (air, land, water). Their life cycle takes place under the influence of environmental factors and is therefore subject to large variations in abiotic factors. In this context, plants have changed over time their structures, organ shape and appearance, resulting from their adaptation to living environment. Some changes in the structure and function of the vegetative organs, arising as a result of their adaptation to the plant were followed by one of the greatest figures in literature and the founder of morphology as a science – J.W. von Goethe, who in 1790 formulated a theory of plant metamorphosis (adaptive change). This paper highlights such adaptive changes but seeks and identifies chemical elements in plant composition under study (Hydrocharis morsus-ranae, Anubias barteri, Hygrophila odora, Bacopa caroliniana) – the first step in trying as thorough knowledge of aquatic plants to establish their possible uses.

***Key words**: aquatic plants, metamorphosis, chemical elements.*

INTRODUCTION

The aquatic plants can live underwater (submerged) or can float on water surface (natant).

Some of them have adapted their morphology to aquatic environment: large intercellular spaces in lamina are connected with aeriferous canals from petiole that extend as aerenchyma in the rhizome and roots, ensuring their oxygenation.

Other plant species compensate the underdeveloped aerenchyma by highlighting the mechanical and conducting tissues.

The aim of thus study was to investigate the morpho-anatomic features and chemical compounds in the following aquatic plant species: *Hydrocharis morsus-ranae*, *Anubias barteri*, *Hygrophila odora, Bacopa caroliniana.*

Hydrocharis morsus-ranae (Alismatales, Hydrocharitaceae) or frogbit, native to Europe and parts of Asia, is a free-floating annual herbaceous aquatic plant, but its leaves can become emergent when the vegetation is dense enough (O'Neil, 2007).

Anubias barteri (Alismatales, Araceae), a West African species, survives either totally or partially submersed (http://www.liveaquaria.com/).

The *Hygrophila* species usually are growing emersed along natural bodies of water (http://naturalaquariums.com/). *Hygrophila odora* (Lamiales, Acanthaceae) is a plant species distributed in Western Africa; its emersed form has a strong, ascending to upright stems that lignify at the basis, and lanceolate leaves (http://www.flowgrow.de/db/aquaticplants/).

Bacopa caroliniana (Lamiales, Scrophulariaceae) comes from South America, where it is found growing in swampy areas, emerged and submerged. One of the basic characteristics of this plant is lemon smell of the leaves when they are broken (www.aquascaping.ro).

MATERIALS AND METHODS

For identification and description purposes, we used preserved material belonging to four aquatic plant species: *Hydrocharis morsus-ranae*, *Anubias barteri*, *Hygrophila odora, Bacopa caroliniana.* Macroscopic observations were performed on plants with the help of identification handbooks. Microscopic

observations and micrometric measurements were made on numerous cross-sections of the studied plants (Andrei, 2003).
Observations were carried out with a ML-4M IOR microscope belonging to the laboratory of Biology, UASVM Bucharest. The photos were taken with the digital camera Panasonic Lumix DMC - LS60 (6MPX, 3X optical zoom).
Sodium and potassium levels were determined by flame photometry, using 2% acetic acid (extractant ratio 1:20).

RESULTS AND DISCUSSIONS

Results regarding morpho-anatomic structure of aquatic plant Hydrocharis morsus-ranae (frogbit)

Hydrocharis morsus-ranae (Figure 1) is a natant hydrophyte plant. It has long, slender stolons and long-petiolate, ovate kidney-shaped leaves. It is common in stagnant or slowly flowing waters.

Figure 1. *Hydrocharis morsus-ranae* (original)

Hydrocharis morsus-ranae leaf's petiole has an epidermis formed from a single row of cells, covered with a thin cuticle (Figure 2).

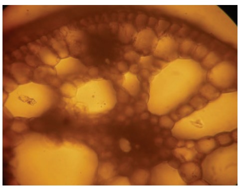


Figure 2. *Hydrocharis morsus-ranae*: petiole cross-section (original)

Fundamental parenchyma is highly developed, having many aerifer channels of varying sizes.
The mechanical elements are reduced. Phloem is limited and the wood is reduced to a single vessel.
Tissue dimensions from *Hydrocharis morsus-ranae* leaf's petiole are shown in Table 1.

Table 1. Tisues measurement from leaf petiole belonging to *Hydrocharis morsus-ranae*

NR.	TISSUE	MEAN (μ)
1	Epidermis	72
2	Cortex, Central cylinder	2448
3	Conducting fascicle	216

Hydrocharis morsus-ranae has a bifacial leaf with a dorsiventral heterofacial, structure, presenting a mesophyll tissue lie between upper and lower epidermis (Figure 3).

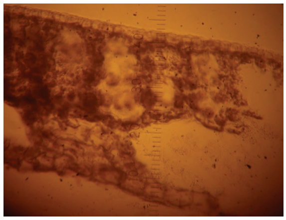


Figure 3. *Hydrocharis morsus-ranae* : leaf structure (original)

The mesophyll presents a palisadic tissue with long cells, rich in chloroplasts including idioblasts. The lacunar tissue has big, intracelular spaces (aeriferi parenchyma) (Figure 3).
The ribs present a very weak developed xylem. Between ribs and lower epidermis, an angular colenchyma is differentiated, that gives lamina's resistance.
Tissue's leaf dimensions in *Hydrocharis morsus-ranae* plant are indicated in Table 2.

Table 2. Tisues measurements from *Hydrocharis morsus-ranae* leaf structures

NR.	TISSUE	MEAN (μ)
1	Upper epidermis	28.8
2	Mesophyll	360
3	Lower epidermis	57.6

Results regarding morpho-anatomic structure of aquatic plant Anubias barteri

Anubias barteri (Figure 4) is a plant commonly found in aquariums.
In cross section, the adventitious root presents exodermis, cortex and vascular cylinder. No aerenchyma tissues are differentiated.

Figure 4. *Anubias barteri* (original)

In the vascular cylinder (Figure 5) numerous phloem vessels alternates with xylem, with lignificated cells between those two layers. The pith contains lignificated cells.

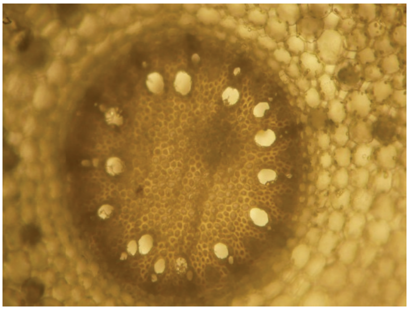


Figure 5. Cross section through *Anubias barteri* root (original)

Dimensions recorded for *Anubias barteri* root's tissues are shown in Table 3.

Table 3. Tisues measurements from *Anubias barteri* roots

NR.	TISSUE	MEAN (μ)
1	Exodermis	28.8
2	Cortex	576
3	Endodermis	14.4
4	Vascular cylinder	662.4
5	Pith	360

Table 4. Tisues measurement from leaf petiole belonging to *Anubias barteri*

NR.	TISSUE	MEAN (μ)
1	Cuticle	14.4
2	Epidermis	28.8
3	Conducting fascicle	57.6
4	Sclerenchyma	72

In cross-section (Figure 6), leaf's petiole has a unistratified epidermis, covered with a thin cuticle. The cortical parenchyma is very poorly developed; phloem and xylem vessels (with sclerencyma caps) are disorderly arranged, the petiole being polistelic. The tissue's petiole micrometric measurements in *Anubias barteri* are indicated in Table 4.

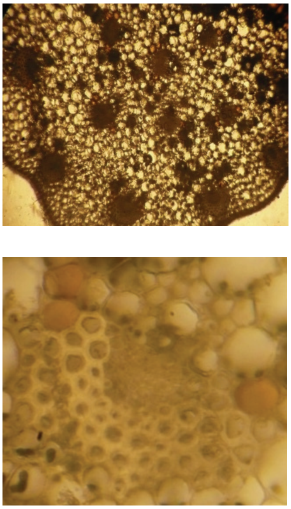


Figure 6. Cross-section through petiole belonging to *A. barteri*

The leaves are large, green, ovate-lanceolate, with pinnate venation. In cross section, presents a very thin cuticle, upper epidermis, mesophyll, lower epidermis (formed by cells of different size) (Figure 7).

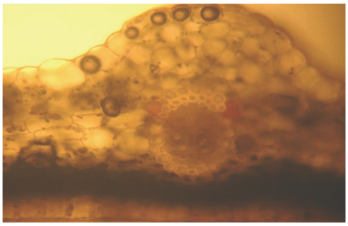


Figure 7. Cross section through a *A. barteri* leaf

The mesophyll is homogeneous, consisting of several rows of cells without intercellular spaces. Rows below the upper epidermis are rich in chloroplasts. The ribs have vascular bundles surrounded by sclerenchyma (Figure 7). Dimensions recorded for leaf's tissues measured in *Anubias barteri* are shown in Table 5.

Table 5. Tissue dimensions in *Anubias barteri* leaves

NR.	TISSUE	MEAN (μ)
1	Cuticle	14.4
2	Upper epidermis	72
3	Mesophyll	316
5	Lower epidermis	28.8
6	Midrib	144

Results regarding morpho-anatomy of Hygrophila odora aquatic plant

Hygrophila odora (Figure 8) is an aquatic plant species.

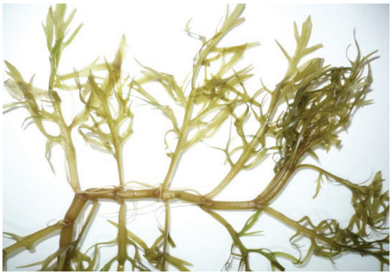


Figure 8. *Hygrophila odora* (original)

The cylindrical stem has nodes and internodes, with dorso-ventral flattened, pinnate leaves in nodes. It forms adventive roots.
In cross-section, the root appears to be formed by rhizodermis lacking absorbing hairs (one layer of cells); cortex is very well developed, with large intercellular spaces found in aerenchyma (Figure 9).

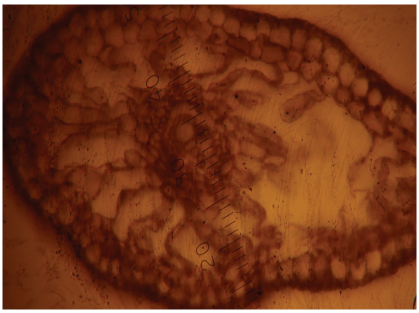


Figure 9. *Hygrophila odora*: root cross section (original)

The mechanical elements and central cylinder are very reduced (Figure 9).
The dimensions for measured tissues in *Hygrophila odora* root are indicated in Table 6.
The stem has a unistratified epidermis, covered by a thin cuticle (Figure 10).

Table 6. Tissue dimensions from *Hygrophila odora* roots

NR.	TISSUE	MEAN (μ)
1	Rizhodermis	28.8
2	Cortex	244.8
3	Central cylinder	115.2

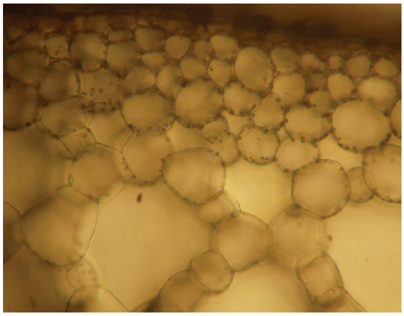


Figure 10. *Hygrophila odora*: cross section of a cortex (original)

In the highly developed cortex, there are three or four layers of colechyma but the major part is occupied by aerenchyma with intercellular spaces by different sizes (Figure 10), forming air chambers.
The last layer of the cortex, endodermis, is formed by one single row of different size cells.

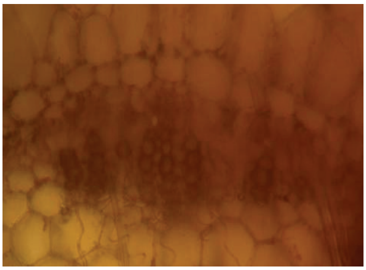


Figure 11. *Hygrophila odora*: cross section of a central cylinder (original)

The conducting tissue is formed by poor developed collateral fascicles, orderly arranged (Figure 11).
The dimensions for measured tissues in *Hygrophila odora* stem are shown in Table 7.
In cross section, the leaf of *Hygrophila odora* presents the upper epidermis with smaller cells on one single row, covered by a thin cuticle and the lower epidermis formed by bigger cells (Figure 12).

Table 7. Measurements for stem tissues in *Hygrophila odora*

NR .	TISSUE	MEAN (µ)
1	Cuticule	14.4
2	Epidermis	43.2
3	Cortex	1584
4	Endodermis	28,8
5	Collenchyma	144
6	Pith	1008
7	Central cylinder	1224
8	Conducting fascicle	259.2

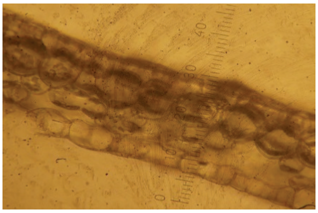


Figure 12. *Hygrophila odora*: cross section of leaf (original)

Below the upper epidermis, the mesophyll, presenting cells rich in chloroplasts (Figure 12), and it is crossed by different size air chambers.

The ribs are poorly developed. The dimensions for measured tissues in *Hygrophila odora* leaves are presented in Table 8.

Table 8. Tissue dimensions from *Hygrophila odora* leaves

NR.	TISSUE	MEAN(µ)
1	Upper epidermis	28.8
2	Lower epidermis	57.6
3	Mesophyll	115.2
4	Rib	100.8

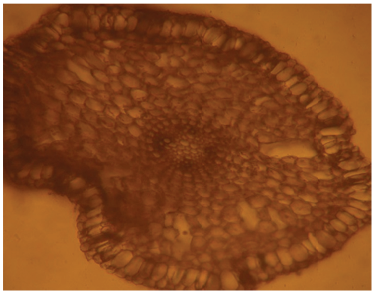
Results regarding morpho-anatomic structure of aquatic plant Bacopa caroliniana (water hyssop)

Bacopa caroliniana is an aquatic plant (Figure 13), ubiquitous in aquariums for many years.

In stem's nodes there are adventive roots and leaves (oblong, succulents, opposite arranged).

In cross-section, the adventive root presents rhizodemis, exodermis, cortical parenchyma and central cylinder (Figure 14). The rhizodermis is lacking in absorbent hair; the cortex has cells with thin cell walls and few intercellular spaces (aerenchyma). The last layer of the cortex, endodermis, is well differentiated, presenting Casparian strips.

Figure 13. *Bacopa caroliniana* (original)



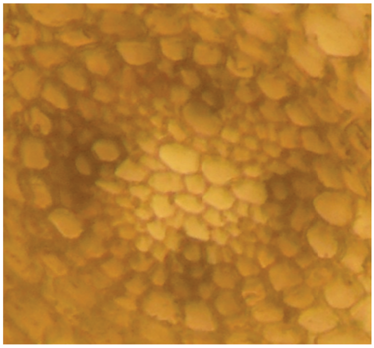


Figure 14. *Bacopa caroliniana:* root cross section (original)

In central cylinder, there are four liberian fascicles, respectively four wooden fascicles, separated by medullary rays formed by cells with cellulosic, thin walls.

The pith is formed by cells with slightly lignificated walls.

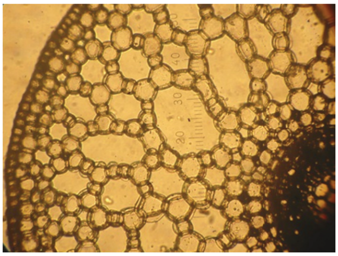
The dimensions for measured tissues, in *Bacopa coroliniana* roots, are shown in Table 9.

In cross-section, the stem presents the epidermis, cortex and central cylinder (Figure 15).

The unistratified epidermis is covered by cuticle. The cortex is occupied with aeriferous canals by different size (aerenchyma) separated through a single layer of cells. The cells have cellulosic, thin walls. The endodermis is well developed. The central cylinder is represented by many xylem and phloem vessels arranged on two concentric circles.

Table 9. Tissue dimensions measured in *Bacopa caroliniana* roots

NR.	TISSUE	MEAN (μ)
1	Rizhodermis	72
2	Cortex	288
3	Central cylinder	144



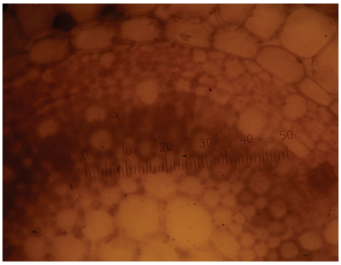


Figure 15. *Bacopa caroliniana:* stem cross section (original)

The pith is formed by parenchimatous cells.
The dimensions for measured tissues from *Bacopa caroliniana* stem are shown Table 10.

Table 10. Tissue dimensions measured in *Bacopa caroliniana* stalk

NR.	TISSUE	MEAN (μ)
1	Cuticle	14.4
2	Epidermis	57.6
3	Cortex	1728
4	Central cylinder	864

In cross-section, the morpho-anatomic structure of *B. caroliniana* leaves presents: a very thin cuticle; the upper epidermis formed by larger thin walled cells; mesophyll; the lower epidermis containing different size cells (smaller than those of the upper epidermis) (Figure 16).

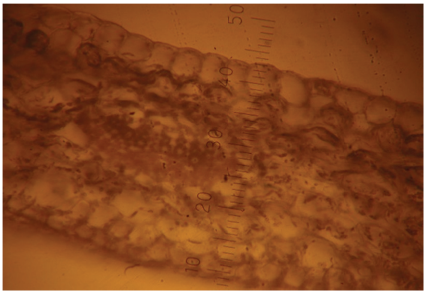


Figure 16. *Bacopa caroliniana:* cross section of a leaf (original)

The mesophyll is homogeneous, undifferentiated, formed by several layers of cells lacking intercellular spaces or these spaces are reduced. Beneath the upper epidermis there are layer of cells rich in chloroplasts.
The ribs have poor developed collateral fascicles (woody-adaxial and liberian-abaxial).
The measurements for leaf's tissues in *Bacopa coroliniana* are indicated in Table 11.

Table 11. Tissue dimensions measured in *Bacopa caroliniana* leaves

NR.	TISSUE	MEAN (μ)
1	Upper epidermis	28.8
2	Lower epidermis	28.8
3	Mesophyll	288
4	Midrib	187.2

Results regarding determination of potassium and sodium in aquatic plant: Hydrocharis morsus-ranae, Anubias barteri, Hygrophila odora, Bacopa caroliniana
Results regarding sodium and potassium chemical identifying in the studied plant composition are shown in Table 12.

Table 12. Potassium and sodium determination in the studied aquatic plants

Samples	K^+, ppm	Na^+, ppm
Hydrocharis morsus-ranae	1112.97	639.40
Anubias barteri	839.08	747.17
Hygrophila odora	919.17	779.52
Bacopa caroliniana	461.18	638.82

CONCLUSIONS

Although the specialist literature presents aquatic plants having a well developed aerenchyma and reduced mechanical and conducting elements, the submerged plant species *Anubias barteri*, *Hygrophila odora* and *Bacopa caroliniana* show important differences regarding these morpho-anatomic structures.

Aerenchyma's absence both in root, petiole and leaves (*Anubias barteri*) is correlated with developed conducting elements and sclerenchyma's presence. The aeriferous tissues recorded in *Bacopa caroliniana* are reduced, correlated with numerous conducting elements.

Hygrophila odora presents a well developed aerenchyma in organ's structures; the mechanical and conducting elements are reduced, although the xylem vessels are numerous in stem's structure.

Potassium and sodium identification in the studied plant species (*Hydrocharis morsus-ranae, Anubias barteri*, *Hygrophila odora*, *Bacopa caroliniana*) represent a first step in trying as thorough knowledge of aquatic plants to establish their possible uses.

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