European aquatic carnivorous *Utricularia* species – record-holders, but vanishing beauties of our nature

Lubomír Adamec: *Institute of Botany, CAS, Třeboň, Czech Republic, e-mail: lubomir.adamec@ibot.cas.ct*

Bladderworts *(Utricularia, Lentibulariaceae),* with at least 240 species, represent the most numerous genus of carnivorous plants. Out of these, ca. 60 species are aquatic or amphibious; they all are rootless. Seven aquatic species (*Utricularia australis, U. vulgaris, U. minor, U. bremii, U. intermedia, U. ochroleuca, U. stygia)* grow in Europe and can be found – more or less commonly – in the whole Danube watershed in all Danube countries.

Why are these plants so remarkable?

For all aquatic Utricularia species it is characteristic to bear 1–5 mm large suction traps in the form of hollow bladders, which form a negative pressure inside the traps and suck in their prey (small animals) into their deadly traps. European species are submerged or amphibious plants with thin, flexible linear stems 10 cm to 2.5 m long, bearing regular leaf nodes with dissected, filamentous leaves with numerous traps. Some species have non-differentiated shoots joining the photosynthetic and carnivorous function but the other species have distinctly differentiated green photosynthetic and pale carnivorous shoots with traps *(Figs. 1, 2)*. European Utricularia species usually grow in shallow standing, dystrophic (humic, i.e., brownish), nutrient-poor waters with elevated CO_2 concentration: in lake and fishpond shorelines, floodplain backwater pools and oxbows, peatbogs, fen lakes, and also in shallow sand-pits. They grow typically in loose reed or sedge stands. In these barren waters, carnivory is an additional ecological strategy to gain the growth limiting N, P and K from animal prey. Except for very common U. australis, the other species declared as strongly or critically endangered are demanding on their habitat factors. They all do not tolerate eutrophication, polluted waters, but mainly drying out of the site. Thus, their natural occurrence can indicate unpolluted waters with a stable hydrology. Moreover, three species (U. intermedia, U. ochroleuca, U. stygia) can only grow in peatbog or fen lakes – very rare and threatened habitats nowadays.

Physiological world records

Negative pressure of -0.16 to -0.25 bar is formed inside traps of European Utricularia species and during trap opening, water is sucked in during only 3–4 ms. This represents the fastest movement in the plant kingdom at all! There is permanent anoxia inside the deadly traps and preys caught die of suffocation. Moreover, in all traps, microbial symbiotic (commensal) communities (bacteria, ciliata, algae, rotifers) live, form a miniature food web, and help the traps to digest the caught prey. Under favourable conditions, the apical growth of their linear shoots is very rapid and can attain 2–4.5 new leaf nodes/day, while the basal shoot segments age and die at the same high rate. Also as a result of rapid propagation by branching the main shoots, the total plant biomass can double in only 6–12 days. A need for very rapid cell divisions associated with very rapid apical shoot growth probably led to genome

Figure 1. *Very common Utricularia australis with monomorphic shoots can grow in different habitats Credit: Adamec 2016*

Figure 2. *Very rare U. intermedia with differentiated shoots grows only in peatbogs and fens. Its traps can be 5 mm large Credit: Adamec 2016*

Figure 3. A shallow sand-pit pool near Suchdol nad Lužnicí, S Bohemia, Czech Rep., hosts native U. australis and introduced very rare U. bremii and carnivorous Aldrovanda vesiculosa (water-wheel plant, Wasserfalle) as a successful case that extracted sand-pits can create favourable habitats for endangered aquatic plants Credit: Adamec 2016

miniaturization – some species have minimal genomes as compared to other plants. The record rapid apical shoot growth requires several ecophysiological adaptations to be met: high photosynthetic rate, very efficient reutilization (recycling) of N and P from aged shoots, very effective mineral nutrient uptake by shoots from the ambient water and mineral nutrient gain from carnivory. Although all Utricularia species fix only free CO_2, their high net photosynthetic rate represents a world record among aquatic plants. The high photosynthesis is not only needed to cover the rapid plant growth and high respiration rate of traps, but also to support trap microbial communities by secreting great amounts of organic substances (sugars, organic acids) into the traps. Due to high photosynthesis and attaining the rapid growth, all aquatic Utricularia species require high CO_2 concentration of >0.1-0.5 mM in the water, whereas the concentration is usually one order of magnitude lower due to algal photosynthesis in eutrophicated waters.

Figure 4. Translucent traps of Utricularia stygia traps filled with organic detritus containing precipitates of humic acids and remains of algae. It is considered that traps can utipise a part of the nutrients for plant growth.

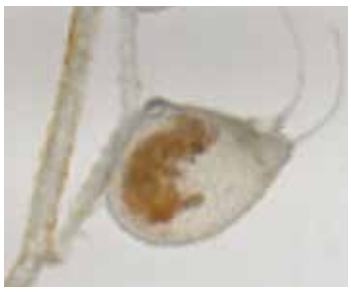

Figure 5. Utricularia stygia trap which had caught a macroinvertebrate prey (probably tiny insect larva)

The European Utricularia species usually do not produce dense stands at their sites, and except *U. australis,* they all are listed as strongly or critically endangered or as extinct species according to national floras in many countries. Also due to their remarkable characteristics, they all merit conservation *(Fig. 3).*

Figure 6. Winter buds (turions) of Utricularia vulgaris are round-shaped, condensed storage organs (numerous individual leaves sitting on an extremely shortened axis), size up to 25mm. Usually they overwinter on the bottom of water bodies, while the rest of shoots decays during the winter period. In the spring time, turions rise to the water surface, where higher light intensities and warmer water are available.

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Highlights of the 41st IAD conference "Tributaries as Key Elements in Sustainable Management of the Danube River Basin" and the CEEPUS Network

Thomas Hein: Institute of Hydrobiology and Water Management, University of Natural Resources and Life Sciences, Vienna, Austria. e-mail: thomas.hein@boku.ac.at

The IAD would like to thank the organizers of the 41st international IAD conference held at the "Lucian Blaga" University of Sibiu, Romania, Angela and Doru Banaduc, and their team for the perfect organization and the great time all IAD members enjoyed.

From 13th to 16th September, 2016, more than 60 scientists and representatives of the Danube River Basin have met in Sibiu at the 41st international IAD conference with the guiding topic "Tributaries as Key Elements in Sustainable Management of the Danube River Basin". There was general agreement that research is the basis for environmentally sound and sustainable decisions by managers and politicians. IAD as a well-established network of experts active since 1956 in the Danube region can bridge the gap from science to management and implementation, mainly lying within the responsibility of the ICPDR, where the tools for the implementation of the EU WFD and the new EU Danube Strategy are elaborated.

At the conference topics ranging from biodiversity, connectivity, ecosystem functions, ecosystem services, climate change effects, restoration, and management with special emphasis on the WFD, had been addressed in more than 70 presentations. The political dimension and implication for the Danube Region had also been discussed by high level representatives from Hungary and the EUSDR. The keynote lectures covered the role of biological water quality elements, the use of water resources, the EUSDR and the status of the sturgeon in the Danube River System. Topics of the scientific sessions presented during the week ranged from significant water management issues in the DRB, like various aspects of pollution and hydromorphological alterations and experiences in the WFD assessment, to issues addressed in the EUSDR priority areas 1, 2, 4, 6 and 7.

The 41sth international IAD conference is well in line with the successful past of 60 years of IAD and highlighted the sensitive issues with regard to the Danube and its tributaries as key elements and future challenges for particular sub-catchments and their contribution to the whole region. The worldwide dimension of global change including temperature increases, alteration in hydromorphology, hydropower development, eutrophication and invasive alien species are some of the selected topics presented at the conference. A key effort for the future is the consideration of sustainable development of society, including economic, ecologic and social aspects of development and environmental history as tools to meet these challenges by understanding the past and integrating societal and economical aspects in sustainable development perspectives. Still, the interplay of ecology, economy and social aspects is not addressed in equal manners in current management approaches. Thus, new scientific approaches and more interaction with stakeholders might be needed to bridge these gaps. A resolution based on the results of the conference was approved and has been published on the website of IAD (www.iad.gs).

Further details can be found on the website of the organizers (http://conferences.ulbsibiu.ro/conf.iad/html/index.php). Printed copies of the extended abstracts and the book of abstracts are available from the organizers at the "Lucian Blaga" University of Sibiu.