ECOLOGICAL DIFFERENCES BETWEEN *UTRICULARIA OCHROLEUCA* AND *U. INTERMEDIA* HABITATS

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Introduction

Utricularia ochroleuca R. Hartm. and *U. intermedia* Hayne (Lentibulariaceae) are rootless, aquatic to amphibious carnivorous plants with distinctly dimorphic shoots (*e.g.* Thor, 1988). Their green, more or less horizontal, photosynthetic shoots bear at most only a few traps, while their usually colourless carnivorous shoots bear numerous traps and are immersed deeply in a loose substrate. Morphologically, the species closely resemble each other, and their habitats are very similar. These two species can be distinguished by both floral and quadrifid gland characters.[1] They grow in shallow, standing, dystrophic waters, in fen lakes, bogs, and peaty fishponds. However, at least in central Europe they very rarely occur in the same wetland. In spite of an examination of the phytosociological characteristics of these two species (Pietsch, 1977), no evident differences have been found between *Utricularia ochroleuca* and *U. intermedia* in ecological factors in their respective stands. Generally, both species show a rather wide ecological tolerance of many factors (Pietsch, 1977), and their ecological limits greatly overlap (Kosiba and Sarosiek, 1989; Kosiba, 1993). This suggests that these species are able to grow together. In the Czech Republic, both species are considered Critically Endangered (Red Data Book of the Czech flora, 1999). The Trebon region in S Bohemia is the centre of their recent distribution in the Czech Republic. Here, twelve sites of *U. ochroleuca* and eight sites of *U. intermedia* have been verified during the 1990s (L. Adamec, unpubl.). As few as fifty shoot apices, to as many as one million shoot apices occur at each site (estimating from typical shoot number density and population area).

The aim of this study was to measure physical and chemical habitat factors in dominant stands of *U. ochroleuca* and *U. intermedia* in the Trebon region and to define possible ecological differences between the habitats of these species. Attention was also paid to the maximum stand biomass of these species and the length of their carnivorous shoots.

Material and Methods

On 16-23 July 1996, ecological factors were investigated at eight sites of *U. ochroleuca* and five sites of *U. intermedia* in the Trebon Basin Biosphere Reserve and Protected Landscape Area, South Bohemia, Czech Republic (approximately 49°N, 14°45'E). The sites were peat bogs, usually in the littorals of eutrophic fishponds.

[1]The species *U. stygia* Thor may also occur in the area of this study—indeed, all records of "*U. ochroleuca*" from neighbouring South Germany have been revised as *U. stygia.* Further study is needed to determine if the *U. ochroleuca* reported in this study consists partly or completely of *U. stygia.*

Relatively dense stands of both *Utricularia* species were selected at each site for measuring the physical and chemical factors and for water sampling.

The dissolved O_2 concentration and pH were measured between 9:00 and 17:00 local summer time in the zone surrounding the photosynthetic *Utricularia* shoots. Filtered water samples were collected. Total alkalinity (TA) was estimated by end-point titration (pH 4.40). The CO_2 concentration was calculated from TA and pH. NH_4^+-N, K^+, Na^+, Ca^{2+}, and Mg^{2+} concentrations were estimated in the water samples (for all analytical details see Adamec, 1999). The concentration of humic acids + tannins was estimated using a modification of a standard colorimetric method (Adamec & Lev, 1999). An estimate of the level of shading of the water surface by emergent vegetation was made in *Utricularia* stands using a sensor which measured photosynthetically active radiation (PAR; 400-700 nm; Adamec, 1999). The results are expressed as percentages of incident PAR reaching the water surface. Six parallel PAR estimates were conducted in one investigated stand in order to compensate for variation between measurements. Generally, at most of the sites investigated, physical and chemical factors were measured in two different *Utricularia* stands within the same pool or swamp. In such instances, means of the two values for each variable were used for statistical analyses. The values measured in different (usually distantly separated) isolated pools within a site were used as independent data.

In order to evaluate the possibility of the role of both *Utricularia* species in mineral nutrient cycling in these habitats, the biomass of *U. ochroleuca* and *U. intermedia* was harvested in two parallel harvests at the largest sites in dense stands from an area of 0.25 m^2. Both photosynthetic and carnivorous shoots were collected and pooled. *U. ochroleuca* was harvested at three sites and *U. intermedia* at three other sites. The plant biomass harvested was thoroughly washed with tap water and the lengths of ten randomly selected intact carnivorous shoots were measured in each harvest. This was used to estimate the substrate depth which these shoots can reach. Dry weight (DW; 80°C) of total biomass was estimated.

Physical and chemical factors in the habitats which may have differed between the two species were statistically tested by non-parametric Mann-Whitney two-sample t-test as some data sets did not have a normal distribution. Only the probability level $p=0.01$ was accepted as statistically significant, because of the very low number of data ($n=11$ in *U. ochroleuca*; $n=5-6$ in *U. intermedia*), while $p=0.05$ was considered as weakly significant.

Results and Discussion

As shown in Table 1 the values for most physical and chemical factors in the different stands greatly overlap between the sites of *U. ochroleuca* and *U. intermedia*. Oxygen concentration at the level of photosynthetic shoots always exceeded 2.0 mg l^{-1}. Thus, these shoots cannot have suffered from O_2 shortage, but this should not be true for the carnivorous shoots. *U. ochroleuca* was found to grow within a wide pH range of 5.5 to 8.8, while *U. intermedia* grew in stands with pH 4.9 to 6.6. Pietsch (1977) reported pH limits between 4.1 and 8.5 for hundreds of European sites of *U. intermedia*, with the most common values falling between 6.1 and 7.0. Very high free CO_2 concentrations, up to 6.5 mM, were usually found in water in the stands of both *Utricularia* species. Such high CO_2 concentrations were also found at *Aldrovanda vesiculosa* sites in Poland (Adamec, 1997) and are typical of shallow dystrophic habitats of the majority of temperate aquatic carnivorous plants. High [CO_2] may be important for rapid growth of aquatic *Utricularia* species since probably all these species can only use free CO_2 for photosynthesis (Adamec, 1997). However, of the two species, only *U.*

ochroleuca can tolerate, at least temporarily, higher pH >8 and, thus, relatively low [CO_2] (Table 1).

	Utricularia ochroleuca				*Utricularia intermedia*				Statist.
Parameter	Mean	Med.	Range	SE	Mean	Med.	Range	SE	signif.
O_2 [mg l^{-1}]	6.4	5.4	2.0-12.7	1.0	5.3	4.5	3.2-8.0	0.7	NS
pH	6.07	6.32	5.48-8.77	—	5.41	5.93	4.85-6.62	—	NS
TA [meq.l^{-1}]	1.07	0.99	0.15-2.55	0.2	1.02	0.86	0.27-1.89	0.33	NS
CO_2 [mM]	1.58	1.16	0.02-4.88	0.49	2.28	1.12	1.00-6.51	1.07	NS
NH_4-N [mg l^{-1}]	29	24	0-225	10	77	51	2-237	33	*
K [mg l^{-1}]	7.2	7.6	1.9-14.5	1.3	1.0	1.2	0.4-1.8	0.2	**
Na [mg l^{-1}]	7.4	7.5	4.2-8.9	0.4	5.8	5.6	4.0-8.3	0.7	NS
Ca [mg l^{-1}]	23.1	23.5	4.8-31.8	2.3	13.7	13.6	8.1-19.4	2.2	*
Mg [mg l^{-1}]	5.8	5.5	1.0-11.2	2.7	3.1	2.8	1.8-5.9	0.7	*
HA+T [mg l^{-1}]	15.4	12.6	4.3-35.6	2.7	23.8	18.1	10.5-58.7	8.8	NS
PAR [%]	25	14	2-100	8	10	9	2-29	3	*

Table 1: Physical and chemical factors at *U. ochroleuca* and *U. intermedia* sites. TA, total alkalinity; HA+T, sum of concentrations of humic acids and tannins; PAR, mean level of shading on the water surface in stands; med., median. NS, not significant; * $p<0.05$; ** $p<0.01$

Median NH_4^+-N concentration in *U. ochroleuca* stands was about one half of that found in *U. intermedia* stands (24 vs. 51 mg l^{-1}), but this difference was not statistically significant at p=0.01 (Table 1). On the basis of NH_4^+-N concentrations, the waters within these stands may be characterized as mesotrophic, though many of them are adjacent to hypertrophic fishponds. However, both species can tolerate much higher NH_4^+-N concentrations (3.2 to 9.4 mg l^{-1}) as found by Kosiba and Sarosiek (1989) and Kosiba (1993) at anthropogenically influenced sites in Lower Silesia, Poland. In our results concerning all factors measured, these two species differed significantly only in terms of K^+ concentrations found in the water in which they occurred (Table 1). *U. ochroleuca* preferred waters with higher [K^+]. Nevertheless, Kosiba and Sarosiek (1989) and Kosiba (1993) found both species in waters with extremely low [K^+], 0.01 to 0.3 mg l^{-1}. In such waters, K^+ uptake from prey might be crucial for the growth of the plants. In the Trebon region, *U. ochroleuca* occurred in waters with higher [Ca^{2+}] and [Mg^{2+}] than were the concentrations in waters with *U. intermedia* (Table 1). However, this difference was only weakly significant and the values overlapped to a large extent. Similarly, Pietsch (1977) reported on the European occurrence of *U. intermedia* in waters with a very wide range of [Ca^{2+}], between <1 and >30 mg l^{-1}. The most common values fell between 1 and 25 mg l^{-1}. Both species were found in waters with variable concentrations of humic acids and tannins. However, *U. intermedia* probably tolerates more dystrophic (darker) waters (Table 1).

These two species of bladderwort differed considerably with respect to the level of shading of the water surface by emergent vegetation at their respective sites, but this difference was significant only at p=0.05. It follows from the data that *U. ochroleuca* is highly tolerant of PAR irradiance level and can grow in deep shade (ca. 2 % of incident PAR) as well as in full sunlight (100 % PAR), with an optimum of about 15 to 30 % PAR. On the other hand, *U. intermedia* prefers more shaded microhabitats with an optimum of only about 8 to 12 % PAR; *i.e.*, it is a facultative sciophyte which grows in full sunlight on rare occasion. But the main difference in light requirements between the two species is based on the fact that *U. ochroleuca* often grows over wet peaty soils in a terrestrial ecophase in full sunlight. In such instances, the plants acquire a red-yellow or rose coloring. In contrast, *U. intermedia* can only grow as submerged plant in full sunlight, and in this case its shoots are yellow-green or slightly reddish.

Relatively low total biomass of both *Utricularia* species was found even in their densest stands. Mean DW of *U. ochroleuca* was 15.2 (range 6.1 to 22.1) g m^{-2}, and a similar value of 16.6 (range 9.7 to 23.6) g m^{-2} was recorded for *U. intermedia*. The mean biomass in dense stands of both *Utricularia* species was comparable with the values reported by Kosiba and Sarosiek (1993) for *U. vulgaris* (mean DW 16.8 g m^{-2}), *U. australis* (DW 8.6 g m^{-2}), and *U. minor* (DW 6.0 g m^{-2}) stands at sites in Lower Silesia, Poland. Thus, the mean dry biomass of European aquatic *Utricularia* species at the peak of the vegetation season is by one to two orders of magnitude lower than that of other aquatic plants (cf. Pokorn? and Ondok, 1991). The most common dominant plants at *U. ochroleuca* sites were *Carex rostrata, Phragmites australis, Carex gracilis, Sphagnum* sp., *Calamagrostis canescens, Eriophorum vaginatum,* and *Juncus effusus*, while at *U. intermedia* sites, they were *Phragmites australis, Eriophorum vaginatum,* and *Comarum palustre.*

The mean length of carnivorous shoots of *U. ochroleuca* was 6.1 cm (range 2.0 to 14.1 cm; SE 0.34 cm; n=60) and that of *U. intermedia* was 6.7 cm (range 2.0 to 17.6 cm; SE 1.0 cm; n=60). Plants of the former species bore on average 1.93 carnivorous shoots and those of the latter species did 1.95 carnivorous shoots. It follows from the data recorded that carnivorous shoots of both species could reach ca. 13-15 cm deep to a loose substrate in which hypoxia or anoxia could occur.

Conclusions

Ecological differences were investigated in *Utricularia ochroleuca* and *U. intermedia* populations in the Trebon Basin Biosphere Reserve, Czech Republic. Out of all eleven factors investigated, only [K^+] in the aqueous environment was found to be significantly different (p=0.01) between the habitats of these two species; the other factors ([NH_4^+-N], [Ca^{2+}], [Mg^{2+}], and level of shading) were different only at a weakly significant (p=0.05) level or were non-significant. *U. ochroleuca* preferred microsites with higher pH, lower [CO_2] and ([NH_4^+-N], and higher [Ca^{2+}] and irradiance compared to sites preferred by *U. intermedia*. Judging from upper or lower limits of ecological factors found *U. ochroleuca* may be considered to be the more tolerant species. It follows from these results and from data in the literature that both species are ecologically very plastic, tolerant of a wide range of various factors. Both species may grow together at one microsite, but only rarely do they do so. Therefore, the differences in stand factors measured probably cannot account for the segregation of sites by these species. The reasons for the segregation may be based on the water régime at particular sites, competition between the species, and/or competitive interactions with dominant plants.

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New Cultivars

Keywords: cultivar: *Sarracenia* 'Triple Rarity'.

Sarracenia 'Triple Rarity'

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This plant's peculiar hybrid ancestry is *Sarracenia* (*oreophila* × *jonesii*) × *alabamensis*. The pitcher leaves are 30-40 cm (12-16 inches) tall, and are erect. The leaves are mostly green in overall tone, and have light green venation on the outer surface of the pitchers (see Front Cover). The venation is more prominent on the inner pitcher surface, especially near the pitcher opening. The pitcher lid is held close over the pitcher opening, and is weakly undulate. The best leaf development is in the late summer and fall. The flower petals are mostly bright crimson, but in areas can be washed with cream color.

In order to maintain the character of this cultivar, it should be propagated vegetatively.

I developed this cultivar in October 1993. I coined the name October 2000. The cultivar name notes that the three parental plants are very rare in the wild.

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