CHEMICAL PROPERTIES AND SIMILARITY OF HABITATS OF *UTRICULARIA* SPECIES IN LOWER SILESIA, POLAND

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ABSTRACT

The study object consisted of 28 microhabitats of five *Utricularia* species localized in the Province of Lower Silesia, Poland. The aim of the study was to analyse the chemical properties of water and to present the differentiation of microhabitats in respect of their chemism, i.e., whether there are differences between the microhabitats, and which of the *Utricularia* species show the highest tolerance to the chemical properties of water. Analysed were the contents of NO^{-}_{2}, NO^{-}_{3}, NH^{+}_{4}, PO^{-2}_{4}, K^{+}, Ca^{+2}, Mg^{+2}, Na^{+}, Fe^{+3}, SO^{-2}_{4}, total hardness of water, organic substance, pH and trophicity of water. The differentiation of microhabitats of *Utricularia intermedia* and *U. minor* appeared to be small, but much higher in case of *U. vulgaris*, *U. australis* and *U. ochroleuca*. The similarity of microhabitats has been determined by cluster analysis. The tree plot showed the least similarity of *U. minor* and *U. intermedia*, which occupy an extreme position in relation to microhabitats of the remaining species. Such a grouping suggests that this species is clearly distinct because of its connection with water properties.

KEY WORDS: *Utricularia*, microhabitat, trophicity, chemical properties of water, cluster analysis, similarity.

INTRODUCTION

Carnivorous plants are represented, among other, by bladderworts (genus *Utricularia*, family Lentibulariacae). The bladderworts are represented in Poland by five species: *U. vulgaris* L., *U. australis* R. BR., *U. minor* L., *U. intermedia* Hayne and *U. ochroleuca* R. W. Hartm. The sixth species, *U. bremii* Heer, was present several decades ago and is probably extinct (Zając, Zając 2001; Mirek et al. 2002). The number of localities of the particular *Utricularia* species differs considerably (Żukowski 1974; Zając, Zając 2001). A common species is *U. vulgaris* occurring frequently in the Lower Silesian Province (Fig. 1) (Żukowski 1974; Zając, Zając 2001). *U. intermedia* (Fig. 2), *U.ochroleuca* (Fig. 3) and *U. australis* (Fig. 4) are data deficient (DD) species (Kącki 2003). According to Zarzycki et al. (1992) *U. ochroleuca* like *U. minor* (Fig. 5) are most rare in Poland and are recognized as vulnerable (VU) (Kącki 2003). The position of *U. bremii* (Fig. 6) is uncertain and occurred, according to Żukowski (1974), decades ago in the vicinity of Zgorzelec and Lubań (Lower Silesia) and near Reszel (Mazurian Lake District).

The number of undiversified *Utricularia* localities in Poland (surface 312 685 km^2) according to the ATPOL Distribution Atlas, is the following: *U. vulgaris* – 896 localities, *U. minor* – 419, *U. intermedia* – 326, *U. australis* – 200, *U. ochroleuca* – 24 localities and in Lower Silesian Province (19 948 km^2) *U. vulgaris* – 40 localities, *U. minor* – 19, *U. intermedia* – 10, *U. australis* – 13 and *U. ochroleuca* – 3 localities.

Transformations and contamination of the environment are well known phenomena in result of intensive man's activity (Boyd 1968; Wiegleb et al. 1991; Smith et al. 1999). The impact of pollution on plants and their occurrence in Lower Silesia were investigated among others by Brej (1998), Fabiszewski, Brej (2000) and Fabiszewski, Kwiatkowski (1997, 2002), and the extinct, endangered, vulnerable and disappearing plant species in many regions of Poland are presented in Red Lists (Zarzycki et al. 1992; Kaźmierczakowa, Zarzycki 2001; Nowak, Spałek 2002; Kącki 2003). Therefore, due to the changing environmental conditions, it becomes necessary to estimate their resources, habitat conditions, not only of rare, but also common species (Kosiba 1990). Ecological studies constitute important circumstances for active protection of populations and their biotopes (Boyd 1968; Hutchinson 1975).

The aim of this study was to analyse the properties of water and to show the differentiation of microhabitat conditions in respect of chemical proprieties, and to find whether these microhabitats are similar between themselves, and which of the investigated species show the greatest tolerance in relation to water properties.

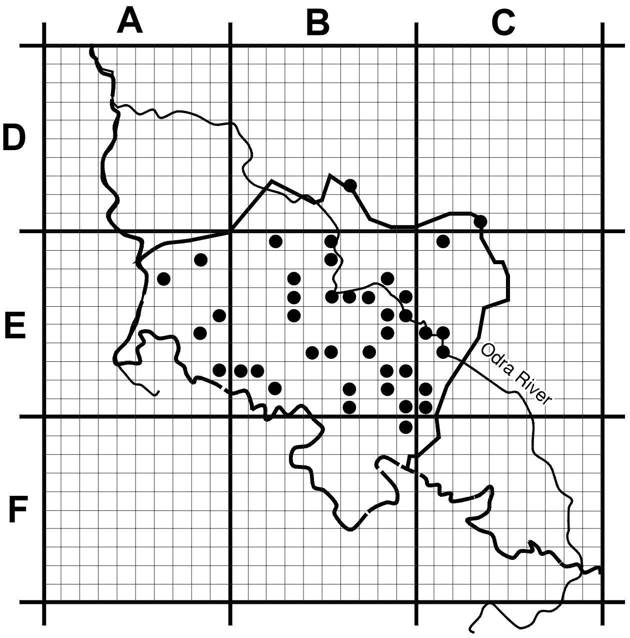

Fig. 1. Locality of undiversified sites of *Utricularia vulgaris* in the Province of Lower Silesia (according to Zając A. and Zając M. (eds). 2001. ATPOL Atlas).

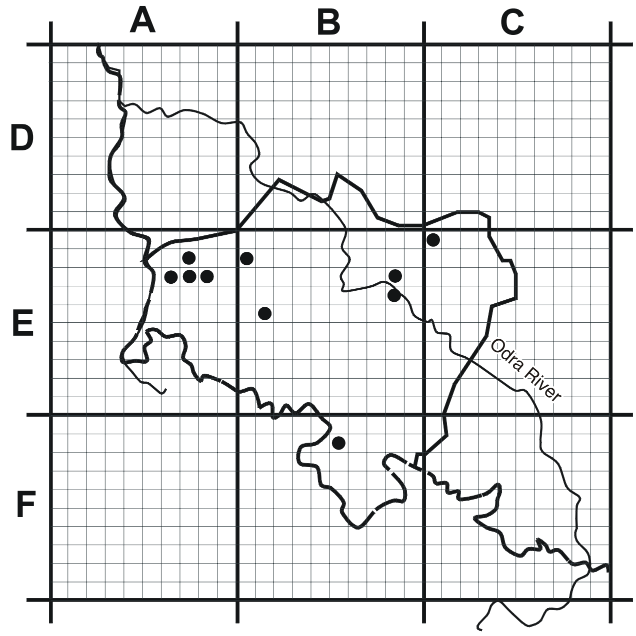

Fig. 2. Locality of undiversified sites of *Utricularia intermedia* in the Province of Lower Silesia (according to Zając A. and Zając M. (eds). 2001. ATPOL Atlas).

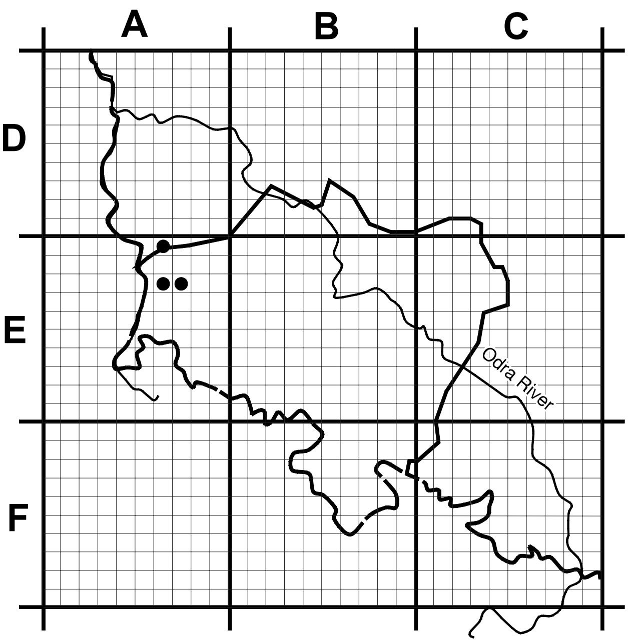

Fig. 3. Locality of undiversified sites of *Utricularia ochroleuca* in the Province of Lower Silesia (according to Zając A. and Zając M. (eds). 2001. ATPOL Atlas).

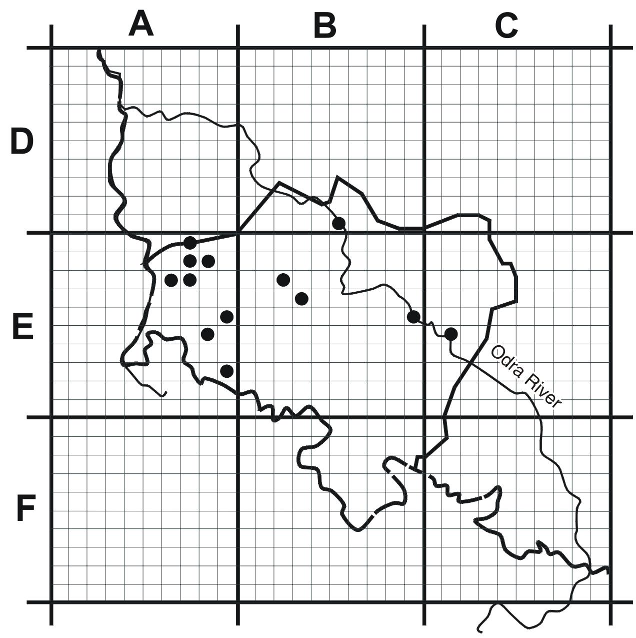

Fig. 4. Locality of undiversified sites of *Utricularia australis* in the Province of Lower Silesia (according to Zając A. and Zając M. (eds). 2001. ATPOL Atlas).

MATERIAL AND METHODS

The investigations were carried out in field in the Province of Lower Silesia. Figure 7 presents the situation of Lower Silesia in Poland according to the grid used in the ATPOL Distribution Atlas (Zając, Zając 2001). Twenty eight microhabitats were selected, and the study object consisted of five species: *U. vulgaris*, *U. intermedia*, *U. ochroleuca*, *U. australis* and *U. minor* (Table 1, Fig. 8).

All the microhabitats occur in one local climatic zone. This allows to compare the microhabitats in respect of their chemical characteristics (Herpin et al. 1996). The water samples were collected at the same time from various water reservoirs and were subjected to the same chemical analyses. The contents of NO^{-}_{2}, NO^{-}_{3}, NH^{+}_{4}, PO^{-3}_{4}, K^{+}, Ca^{+2}, Mg^{+2}, Na^{+}, Fe^{+3}, SO^{-2}_{4}, total hardness of water, organic substance and pH were analysed according to the principles of Hermanowicz et al. (1999). On the basis of results the following statistical analyses were performed: mean, standard deviation, variability coefficient, one-way analysis of variance (ANOVA), similarity of microhabitats in respect of chemical properties determined by the method of cluster

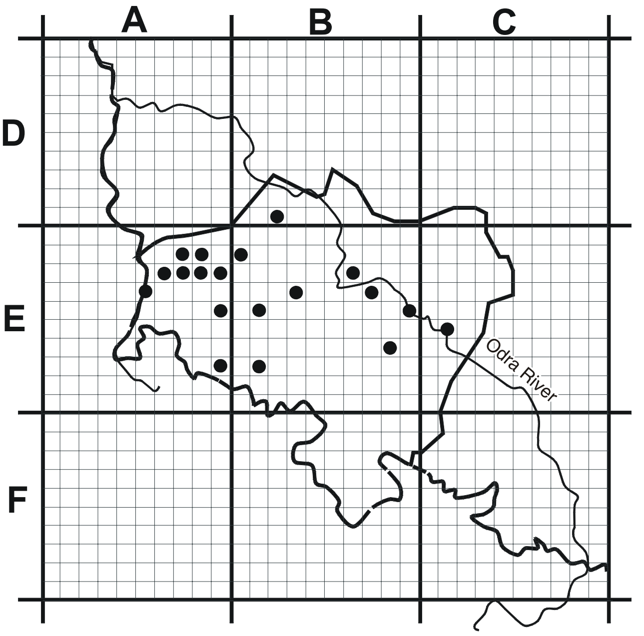

Fig. 5. Locality of undiversified sites of *Utricularia minor* in the Province of Lower Silesia (according to Zając A. Zając M. (eds). 2001. ATPOL Atlas).

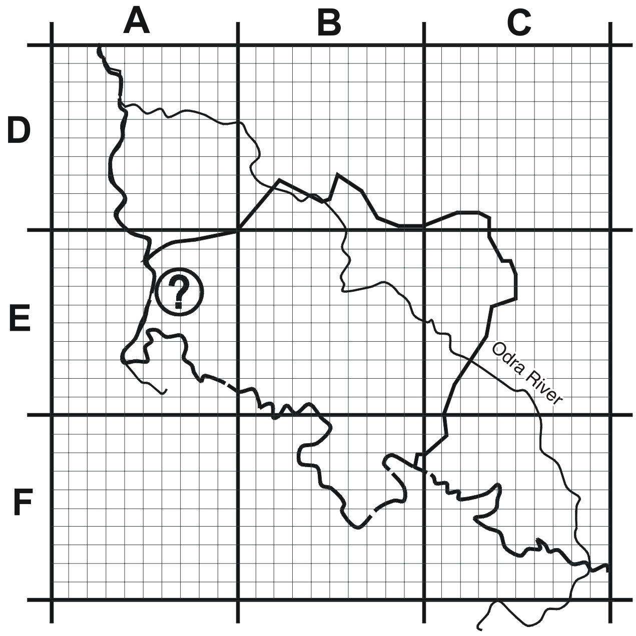

Fig. 6. Locality of undiversified sites of *Utricularia Bremii* in the Province of Lower Silesia (according to Zając A. and Zając M. (eds). 2001. ATPOL Atlas).

analysis, and a hierarchical tree plot was drawn using the single linkage method (nearest neighbour), basing on matries of Euclidean distance (x, y) = $\{\Sigma_i (x_i - y_i)^2\}^1/_2$ (Zając 1994; Legendre, Legendre 1998).

For statistical analysis of results the computer program Statistica 6.1 was used (StatSoft, Inc. 2003).

RESULTS AND DISSCUSION

The microhabitats of the examined bladderworts are localized in Province of Lower Silesia (Figs 7, 8). The Figures 1-6 show the presence of the taxon and the situation of undiversified localities in units of 10×10 km according to

TABLE 1. The designation of examined microhabitats of *Utricularia* species according to ATPOL grid squares.

Species of *Utricularia*	Number of microhabitats (N)	Localization	Designation of units (10×10 km)
Utriculari vulgaris	1÷10	Boraszyn	BE 15
	(10)	Brodno	BE 36
		Kunice	BE 33
		Lipie	AE 18
		Malczyce	BE 35
		Małowice Wołowskie	BE 15
		Tarchalice	BE 15
		Tyniec Mały	BE 56
		Węgliniec	AE 26
		Wrocław	BE 49
Utricularia intermedia	11÷15	Buczek	AE 28
	(5)	Lesieniec	AE 27
		Pęgów	BE 28
		Węgliniec	AE 26
		Zabór Wielki	BE 36
Utricularia ochroleuca	16÷20	Węgliniec (×2)	AE 26
	(5)	Zagajnik (×2)	AE 27
		Zawodzie	AE 06
Utricularia australis	21÷24	Kliczków	AE 18
	(4)	Krzydlina Mała	BE 25
		Nowa Wieś	AE 27
		Węgliniec	AE 26
Utricularia minor	25÷28	Parowa	AE 17
	(4)	Tarchalice	BE 15
		Wodnica	BE 15
		Zabór Wielki	BE 36

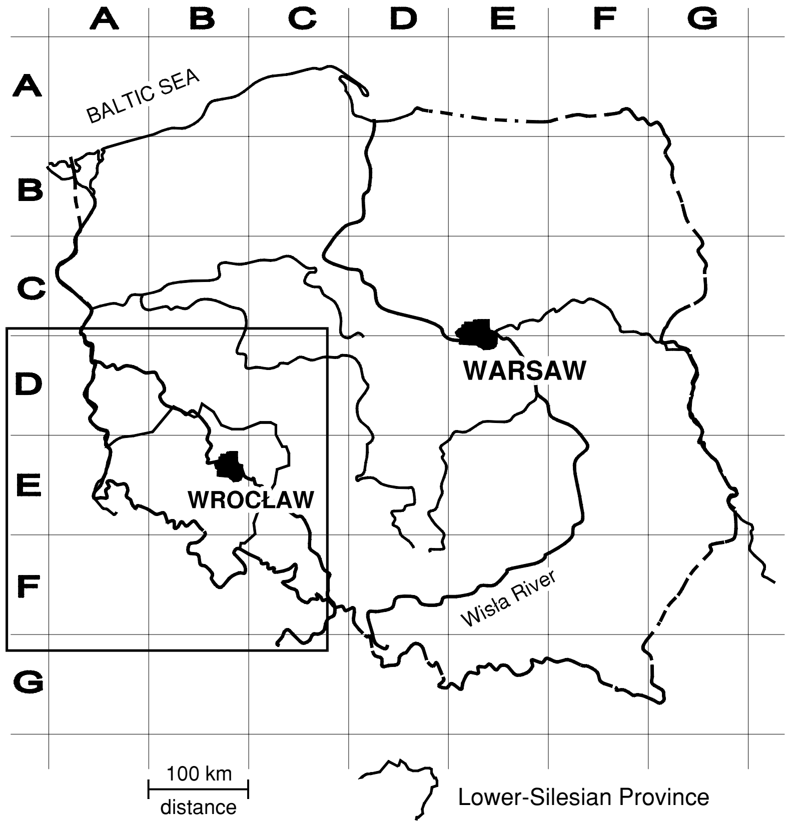

Fig. 7. Situation of the Province of Lower Silesia in Poland.

the ATPOL Atlas (Zając, Zając 2001). The number of undiversified localities in relation to species differ considerably, e.g.: *U. vulgaris* 40, *U. minor* 19, *U. intermedia* 10, *U. australis* 13 and *U. ochroleuca* 3 localities. The number of localities of *U. bremii* is unknown.

The characteristics of the investigated microhabitats of bladderworts in respect of chemical proprieties are shown in Table 2. They differ significantly in respect of NO^-_2, NO^-_3, NH^+_4, K^+, Fe^{+3}, SO^{-2}_4, organic substance and pH. According to Wetzel (1983), the chemism of water reflects

TABLE 2. Chemical properties of water of examined microhabitats of *Utricularia* species.

Microhabitats	NO^-_2	NO^-_3	NH^+_4	PO^{-3}_4	K^+	Ca^{+2}	Mg^{+2}	Na^+	Fe^{+3}	SO^{-2}_4	Organic substance	Hardness of water	pH
	[mg/dm³]											[°HD]	
	mean±SD. variability coefficient [%] and ANOVA test												
Utricularia vulgaris A (1÷10)	0.02±0.01 58.5	0.68±0.53 77.8	0.69±0.60 87.5	0.47±0.27 57.5	1.17±0.56 48.3	42.78±17.64 41.2	8.36±4.29 51.4	3.10±1.71 55.1	0.31±0.17 55.4	16.55±5.64 34.1	2.73±0.77 28.2	4.49±1.54 34.3	7.15±1.67 23.4
Utricularia intermedia B (11÷15)	0.06±0.01 22.8	1.16±0.36 31.0	1.08±0.41 38.2	0.62±0.12 19.4	0.36±0.16 44.0	27. 95±8.61 30.8	7.39±1.76 23.8	1.26±0.46 36.4	1.23±0.48 39.1	39.29±6.61 16.8	10.54±1.64 15.6	2.82±1.21 42.9	5.22±0.62 11.9
Utricularia ochroleuca C (16÷20)	0.03±0.01 53.8	1.90±0.85 44.7	0.61±0.29 47.7	0.44±0.29 66.2	0.70±0.30 43.6	35.53±12.10 34.1	6.19±1.93 31.1	2.45±0.86 35.1	0.66±0.55 84.2	21.77±5.51 25.3	4.53±2.04 45.0	2.92±1.41 48.3	6.05±0.73 12.1
Utricularia australis D (21÷24)	0.04±0.01 21.4	1.69±0.37 21.9	1.58±0.42 26.6	0.34±0.14 41.2	0.60±0.31 51.3	32.15±14.60 45.4	5.92±1.21 20.4	2.21±0.67 30.4	0.54±0.38 71.3	15.31±4.66 30.5	5.87±1.84 31.3	4.73±3.07 64.9	6.20±0.84 13.6
Utricularia minor E (25÷28)	0.05±0.02 30.2	1.64±0.43 26.3	1.27±0.52 40.9	0.11±0.03 27.3	1.25±0.47 37.8	38.45±11.23 29.2	7.31±1.48 20.2	3.05±1.03 33.8	0.51±0.18 34.6	41.09±11.78 28.7	5.23±0.83 15.8	4.82±0.97 20.1	6.05±0.46 7.6
F	5.17*	3.93*	3.26*	1.70	3.08*	1.32	0.43	1.82	5.96*	16.04*	15.82*	0.84	9.59*
$F_{(0.05; 4. 23)}$	2.80												

* – statistically significant when: $F>F_{(0.05; 4. 23)}$

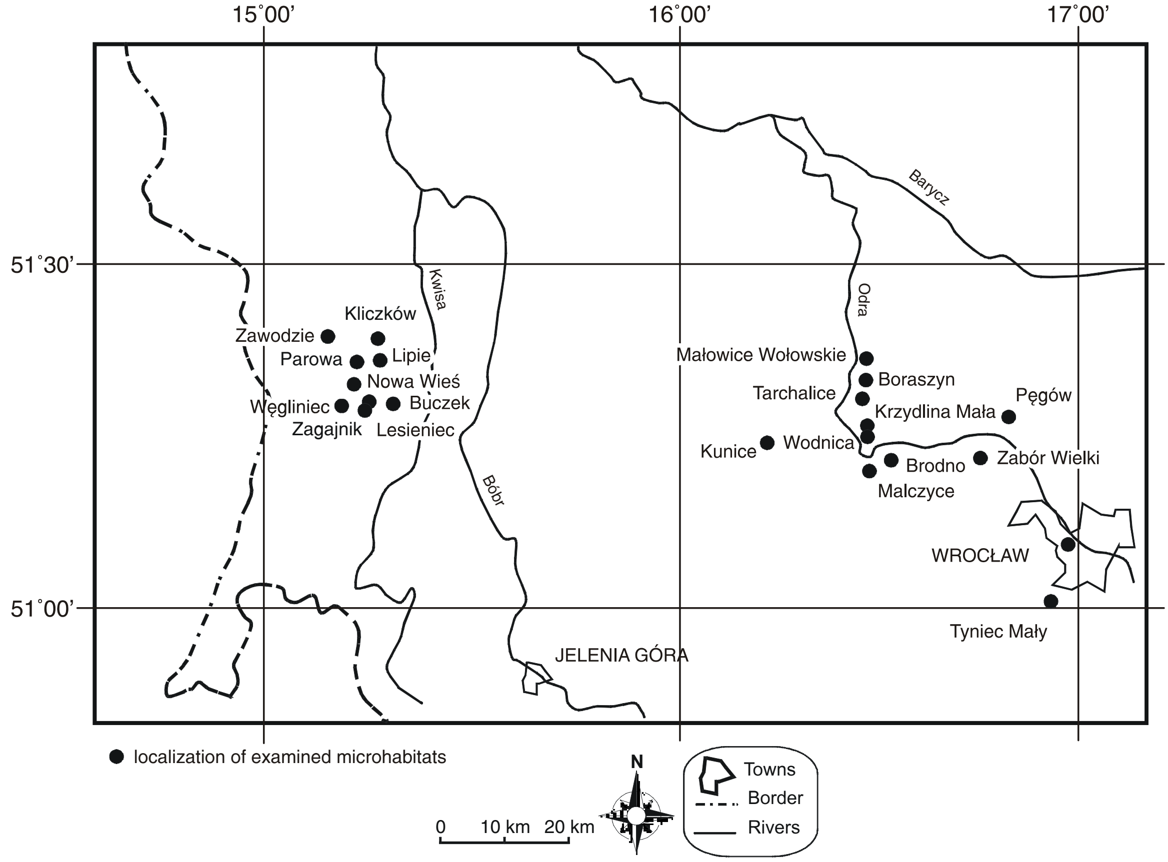

Fig. 8. Localization of examined microhabitats of *Utricularia* species.

its trophic status. Basing on results obtained by Pip (1979, 1984), Weigleb (1991) the waters analysed in the present paper are in most cases eutrophic (microhabitat 1-10 and 16-24), seldom dystrophic ones (microhabitat 11-15 and 25-28). In our case it was found that *U. vulgaris, U. ochroleuca* and *U. australis* prefer eutrophic waters, whereas *U. minor* and *U. intermedia* exist usually in dystrophic waters, which are characterized by the lowest pH and the highest contents of NO^{-}_{2}, SO^{-2}_{4}, as well as organic substance. These results find confirmation in earlier investigations on habitat conditions of bladderworts (Kosiba, Sarosiek 1989; Kosiba 1992a, c, 1993). This differentiation within species is slight for *U. intermedia* and *U. minor*. A greater differentiation occurs between species. On the basis of the variability coefficient the differentiation of microhabitats of *U. intermedia* and *U. minor* appeared to be small, respectively from 11.9% for pH to 44.0% for K^{+} and from 7.6% for pH to 40.9 for NH^{+}_{4}, but much higher in microhabitats of *U. vulgaris*, *U. australis* and *U. Ochroleuca*, respectively suitable from 23.4% for pH to 87.5% for NH^{+}_{4}, from 13.6% for pH to 71.3% for Fe^{+3} and from 12.1% for pH to 84.2% for Fe^{+3} (Table 2).

On the basis of results, using the method of cluster analysis (Table 3), a hierarchical tree plot was constructed (Fig. 9), presenting the similarity of the investigated microhabitats. It shows the least similarity of *U. intermedia* and *U. minor* microhabitats, which take extreme positions and are characterized by the lowest pH and the highest contents of NO^{-}_{2}, SO^{-2}_{4}, organic substance and lower variability range of water properties in relation to the microhabitats of the remaining species, which again show a higher similarity between them. These microhabitats form seperate ecological types in respect of water chemism. Microhabitats of *U. vulgaris*, and *U. ochroleuca* populations form another group, characterized by the lowest contents of NO^{-}_{2}, NH^{+}_{4}, SO^{-2}_{4}, organic substance, higher pH and a wide range of variability of water properties. In this group of similarity there occur microhabitats of *U. australis*, which are characterized by a lower contents of NO^{-}_{2}, Fe^{+3}, organic substance, pH and average values in most of the remaining chemical elements. Such grouping of *Utricularia* microhabitats suggests, that the particular analysed species are bound with water chemism. This was confirmed by investigations of Seddon (1972) and Wiegleb (1978a, b, 1981), who found relations between plant composition and chemism of water. This makes the ground for identification of ecological formations of different plant species and the knowledge on trophic requirements and tolerance of plants (Roman et al. 2001), and allows to conclude on the trophic level of water (Roy et al. 1992). Eutrophication, urbanization and contamination of the environment enrich the water by biogenic and anthropogenic elements. These factors cause stress, are highly significant for plants, and in consequence generate changes in plant communities (Roy et al. 1992; Murphy 2002). This shows that the analysis of trophic state of water is necessary, because the use of one or a few criteria may result in a distorted picture of the trophic state (Moiseenko et al. 2001). Species of a high tolerance to che-

TABLE 3. Amalgamation schedule of examined microhabitats of *Utricularia* species.

Linkage distance	No of microhabitat																											
	U.v. (1)	U.v. (2)	U.v. (3)	U.v. (4)	U.v. (5)	U.v. (6)	U.v. (7)	U.v. (8)	U.v. (9)	U.v. (10)	U.i. (11)	U.i. (12)	U.i. (13)	U.i. (14)	U.i. (15)	U.o. (16)	U.o. (17)	U.o. (18)	U.o. (19)	U.o. (20)	U.a. (21)	U.a. (22)	U.a. (23)	U.a. (24)	U.m. (25)	U.m. (26)	U.m. (27)	U.m. (28)
3.59	19	21																										
4.11	3	24																										
5.46	9	17																										
5.64	6	18																										
5.97	1	4																										
6.05	2	6	18																									
6.51	9	17	16																									
6.81	9	17	16	22																								
6.85	2	6	18	3	24																							
7.12	2	6	18	3	24	10																						
7.21	2	6	18	3	24	10	19	21																				
7.46	2	6	18	3	24	10	19	21	9	17	16	22																
7.72	8	20																										
8.15	5	7																										
8.20	15	27																										
8.55	12	14																										
8.63	2	6	18	3	24	10	19	21	9	17	16	22	8	20														
8.64	1	4	2	6	18	3	24	10	19	21	9	17	16	22	8	20												
9.06	1	4	2	6	18	3	24	10	19	21	9	17	16	22	8	20	23											
9.75	1	4	2	6	18	3	24	10	19	21	9	17	16	22	8	20	23	5	7									
9.78	1	4	2	6	18	3	24	10	19	21	9	17	16	22	8	20	23	5	7	28								
9.85	1	4	2	6	18	3	24	10	19	21	9	17	16	22	8	20	23	5	7	28	13							
10.16	12	14	25																									
11.00	1	4	2	6	18	3	24	10	19	21	9	17	16	22	8	20	23	5	7	28	13	12	14	25				
12.24	11	15	27																									
12.29	1	4	2	6	18	3	24	10	19	21	9	17	16	22	8	20	23	5	7	28	13	12	14	25	11	15	27	
19.42	1	4	2	6	18	3	24	10	19	21	9	17	16	22	8	20	23	5	7	28	13	12	14	25	11	15	27	26

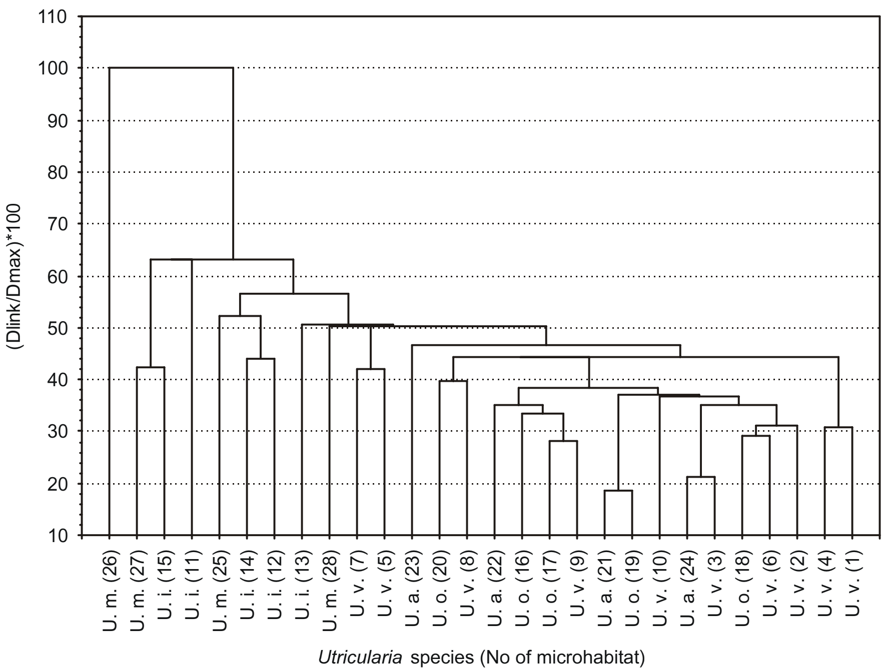

Fig. 9. Hierarchical tree plot of microhabitats similarity of the *Utricularia* species examined.

mical properties can survive in sites of high differentiation of water properties, and *U. vulgaris* is particularly just such a species.

Ecological studies of water ecosystems are valuable tests (Malty, Dugan 1994). The results of this type of investigations should be taken into account in active protection of plants, cultivation and protection of their biotopes (Kosiba 1992b, c, 1995).

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