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Habitat requirements of nymphaeids in humic lakes of the Wielkopolska region (western Poland)

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Abstract: The study analyses habitat requirements of the associations with *Nuphar lutea* (L.) Smith, *Nymphaea alba* L. s.s. and the cross-breed forms of *Nymphaea ×borealis* Camus (*N. alba* x *N. candida*). The study comprised 15 highly coloured and rich in humus substances lakes of the Wielkopolska region. Altogether, 21 water and 16 substrate properties were analysed in the patches dominated by the studied nymphaeids. The former involved a wide spectrum of factors related to the hardness of water and nutrients concentration. Factors related to the hardness of substratum were decisive for the habitat differentiation of the associations of analysed species.

Key words: nymphaeids, habitat requirements, *Nymphea alba*, *Nuphar lutea*, *Nymphaea ×borealis*, water and substrate properties, humic lake

1. Introduction

Humic lakes are a specific group of water reservoirs whose functioning depends on the constant flow of dissolved humus substances coming from the drainage basin, especially from peat-bogs. Lakes, where natural dystrophication processes can be observed, are the rarest among the water reservoirs of the Wielkopolska region (Gąbka *et al*. 2004; Gąbka 2005).

The purpose of the study was to estimate habitat requirements of patches dominated by *Nuphar lutea* (L.) Smith, *Nymphaea alba* L. s.s. and cross-breed forms of *Nymphaea ×borealis* Camus (*N. alba* x *N. candida*) found in the darkly coloured and rich in humus substances lakes. These species are less and less frequent in the Wielkopolska region and the associations where they dominate are considered to be in danger of extinction (Brzeg & Wojterska 2001).

2. Material and methods

The study was conducted in 15 humic lakes of the Wielkopolska region. All of them were shallow (1-7 m. max. depth), small in area (1.5-20 ha) and characterised by the high participation of *Sphagnum* peat-bogs in their drainage basins, with oligo- to polyhumic waters (Gąbka *et al*. 2004; Gąbka 2005). The study comprised both dystrophic reservoirs and the lakes advanced in the process of succession.

The analyses were conducted in the vegetative seasons of 2001-2003, and concentrated on the associations of nymphaeids. Altogether, 14 phytocoenoses of *Nymphaea alba*, 6 phytocenoses of *Nuphar lutea* and 7 phytocenoses dominated by *Nymphaea ×borealis* were studied. For each patch, a phytosociological record was taken, as well as water and substratum samples for physico-chemical analyses. Each water and soil sample taken from the sites in the centre of the patches consisted of three random subsamples (Kłosowski & Tomaszewicz 1993; Kłosowski & Szańkowski 1997). Physico-chemical analyses comprised 21 water and 16 substratum parameters, and were made according to the methods suggested by the studies of Siepak (1992) and Hermanowicz *et al*. (1999). The range of the patches depth was measured as well. The determination of *Nymphaea* species was carried out on living material, particularly on the basis of morphological characteristics of pollen (Neuhäusl & Tomšovic 1957; Volkova 2004).

3. Results

The appearance of nymphaeids in the humic lakes of the Wielkopolska region is connected exclusively with the most shallow parts of water reservoirs and with

highly hydrated organic substrata. The patches dominated by *Nymphaea lutea* and *Nuphar alba* grow mostly in the vicinity of swamp communities, while the phytocoenoses dominated by *Nymphaea ×borealis* were frequently noticed in the central parts of shallow lakes. Nymphaeids occur in reservoirs characterised by a wide range of water hardness values and nutrients concentration (Table 1). *N. alba* and *N. ×borealis* appeared both in hard- and softwater basins, mostly fertile. Patches of *N. ×borealis* were often found in the reservoirs with advanced succession, dominated by the 'charophyta meadows'. *N. lutea* was observed mostly in soft and very soft waters, with neutral pH; less commonly in acidic waters poor in nutrients and sulphates. In acidic lakes with darkly coloured waters, nymphaeids constituted the most characteristic group of macrophytes, often being the dominating or the only element of water vegetation.

Phytocoenoses with *Nymphaea alba* were characterised by the considerably higher concentration of calcium,

Table 1. Physical and chemical properties of water and substrate found in associations with dominant: NA – *Nymphaea alba,* NL – *Nuphar lutea* and NB – *Nymphaea ×borealis*. Ranges and mean values

Properties	Water				Substrate			
	NA (n=14)	NL (n=6)	NB (n=7)	units	NA (n=14)	NL (n=6)	NB (n=7)	units
Min. – max depth of patch	0.5-2.2 1.3	0.8-2.2 1.3	0.3-1.8 0.9	m	-	-	-	-
Secchi disc visibility	0.5-2.0 1.0	0.5-1.0 0.8	0.4-1.2 0.8	m	-	-	-	-
Colour	0-46 12.8	5-40 22	0-34 8.3	mg Pt l^{-1}	-	-	-	-
DOC	9.82-27.93 16.5	12.18-24.06 16.9	6.24-25.76 16.3	mg C l^{-1}	-	-	-	-
pH	6.2-8.3 7.2	6.0-7.8 6.8	5.9-7.7 6.9		6.0-6.7 6.3	5.3-6.4 5.9	6.3-6.8 6.5	
Saturation with O_2	44.0-147.9 73.2	49-143 88.7	39.6-172 95.2	%	-	-	-	-
O_2 dissolved	3.3-12.6 6.3	5.3-10.7 7.5	3.44-15.4 8.2	mg O_2 l^{-1}	-	-	-	-
Hydration	-	-	-	-	84.5-97.8 95	84.53-96.72 93.5	92.79-97.84 96.3	%
Org. matter content	-	-	-	-	12.1-67.3 35.8	25.14-61.76 37.4	15.25-68.98 27.7	%
Conductivity	23.88-430 267.6	56-367 162.8	61-567 366	µS cm^{-1}	-	-	-	-
NH_4–N	0.08-0.52 0.28	0.06-0.27 0.13	0.11-0.61 0.3	mg N l^{-1}	0.03-0.92 0.31	0.03-0.24 0.16	0.06-0.49 0.22	N g kg^{-1} dry wt.
NO_3–N	0.1-0.5 0.27	0-0.4 0.1	0.1-0.4 0.27	mg N l^{-1}	0-0.17 0.05	0-0.07 0.03	0-0.08 0.03	N g kg^{-1} dry wt.
Total PO_4	-	-	-	-	0.83-3.12 2.03	1.19-3.09 2.26	1.38-3.81 2.62	PO_4 g kg^{-1} dry wt.
PO_4–P	0-0.54 0.15	0-0.02 0.005	0.03-0.14 0.07	mg PO_4 l^{-1}	0-0.11 0.02	0-0.18 0.04	0-0.1 0.04	PO_4 g kg^{-1} dry wt.
Total Fe	0-0.26 0.04	0.01-0.07 0.03	0.01-0.04 0.03	mg Fe l^{-1}	2.03-113.3 102.4	2.35-14.44 9.8	1.53-13.91 4.75	Fe g kg^{-1} dry wt.
Total hardness	0.28-3.92 2.18	0.07-3.52 1.22	0.16-3.45 1.8	mval l^{-1}	-	-	-	-
Carbonate hardness	0.11-3.38 1.53	0.06-3.1 1.03	0.12-3.20 1.46	mval l^{-1}	-	-	-	-
Ca	2.14-67.84 29.4	1.14-62.12 20.7	2.36-64.27 29.9	mg Ca l^{-1}	0.78-758.09 177.5	5.82-211.67 75.16	10.19-248.15 48.84	Ca g kg^{-1} dry wt.
Mg	1.08-12.59 5.19	0.02-5.21 2.29	0.48-7.81 3.91	mg Mg l^{-1}	0.27-105.34 22.8	0.43-1.11 0.79	0.38-1.44 0.72	Mg g kg^{-1} dry wt.
Na	0.84-16.34 4.93	1.54-9.58 5.31	0.68-3.76 1.79	mg Na l^{-1}	48.1-1213.6 296.9	78.6-228.2 153.8	95.3-217.41 133.6	Na mg kg^{-1} dry wt.
K	0.28-1.56 0.94	0.78-18.40 6.03	0.29-2.03 1.04	mg K l^{-1}	103.6-6148.0 1092	267.0-665.3 428.8	144.36-659.72 286.3	K mg kg^{-1} dry wt.
SO_4	0-72 17.4	0-42 8.83	0-34 12.8	mg SO_4 l^{-1}	8.85-46.47 22.3	6.85-46.47 14.7	0.25-2.97 1.3	SO_4 g kg^{-1} dry wt.
Cl	3-34 13.1	7-13 9.2	4-10 6.9	mg Cl l^{-1}	0.05-1.04 1.01	0.39-4.38 1.58	9.2-35.47 21.95	Cl g kg^{-1} dry wt.
SiO_2 dissolved	0.20-3.61 1.77	1.50-1.53 1.51	0.51-4.9 3.08	mg SiO_2 l^{-1}	0.39-1.76 0.42	0.03-0.24 0.18	0.14-1.08 0.49	SiO_4 g kg^{-1} dry wt.

magnesium and iron ions in the substratum, in respect to the analysed patches dominated by *Nuphar lutea* and *Nymphaea ×borealis*.

In all the analysed nymphaeid patches (PCA ordination), factors connected with the hardness complex turned out to be crucial for the arrangement of habitat variables, both in the case of water and substratum (Fig. 1). They played the most important role in the habitat differentiation of nymphaeid patches in humic lakes of the Wielkopolska region.

tat-generating charophyta communities, e.g. *Nitellopsidetum obtusae* or *Charetum intermediae*), and the substrata rich in calcium connected with them.

It is interesting to compare the habitat conditions of patches with the participation of the cross-breed forms of *Nymphaea ×borealis*, found in humic lakes, to the abiotic environment of the communities dominated by *Nymphaea candida* in the lakes of the Pomorze region (Kłosowski & Tomaszewicz 1993, Kłosowski & Szańkowski 1997). Soft and medium-soft waters, poor in

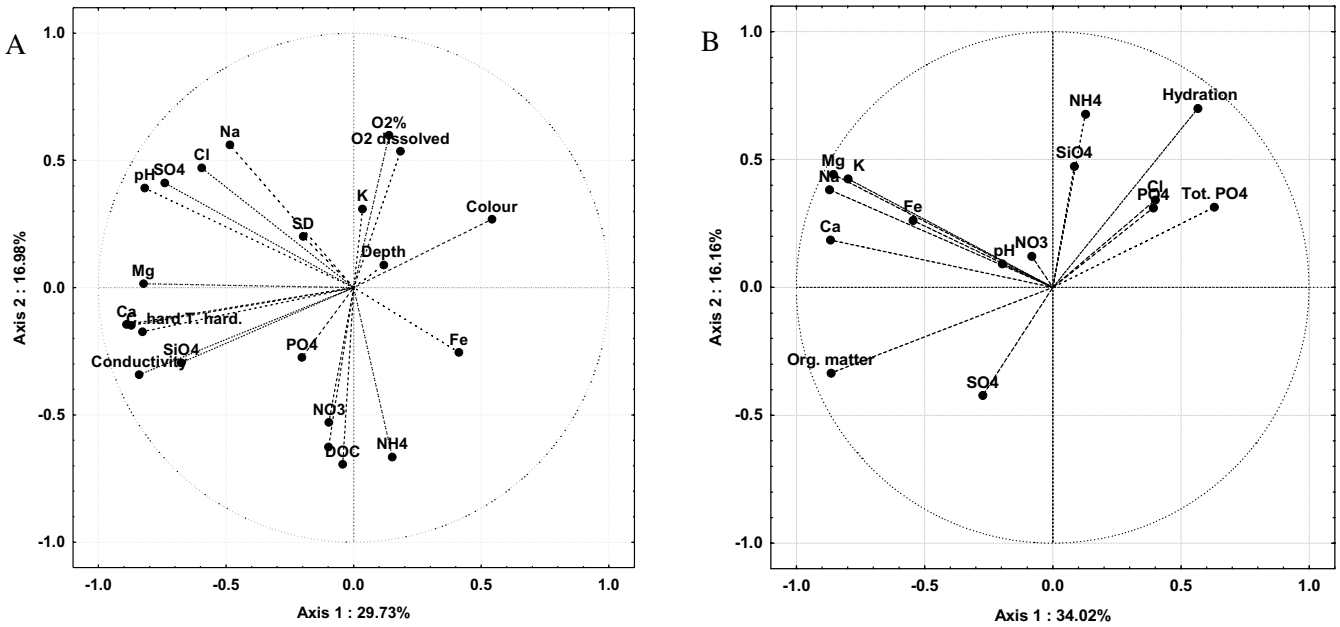

Fig. 1. PCA ordination diagram. The contribution of properties of water (A) and substrate (B) in explanation of the variances observed in associations with dominant nymphaeids

4. Discussion

The habitat analysis made for the phytocoenoses of 3 species of nymphaeids demonstrates that they tend to occur in a wide range of conditions connected with hardness of water and nutrient concentration. Small differences in the habitat requirements of patches dominated by *Nymphaea alba* and *Nuphar lutea* in the lakes of the Pomorze region were commented in the earlier works (Kłosowski & Tomaszewicz 1993; Kłosowski & Szańkowski 1997; Szańkowski & Kłosowski 1999). Interestingly, the phytocoenoses of *Nuphar lutea* in humic lakes of the Wielkopolska region appeared mostly in soft and very soft waters, with neutral pH, and considerably less often in acidic waters poor in nutrients. Thus, the abiotic requirements of this facies resemble those of the *Nupharetum pumilae* habitat characterised by Kłosowski and Tomaszewicz (1990). In the analysed group of humic lakes, however, the specific habitat character of the *Nuphar lutea* facies may result from the tendency to avoid the vicinity of charophyta meadows (dominated by the strongly habi-

nutrients, with a considerable hydration of substratum and high content of sodium ions are characteristic of the *Nymphaeetum candidae* communities of the lakes in Pomorze. Generally, it can be noted that patches dominated by this cross-breed taxon were connected with the basins considerably advanced in the process of succession, dominated by charophyta meadows, mostly by *Charetum intermediae*. Rarely they were met in strongly acidic reservoirs. The results of this study indicate that in the phytocenoses dominated by *N. ×borealis,* hardness measured by calcium and magnesium content, reaction and electrolytic conduction was generally low.

The presence of patches dominated by *Nymphea alba* points to the advanced stages of the ageing process noticeable in the reservoirs or their parts, resulting from the accumulation of organic matter in the substratum (Kłosowski & Tomaszewicz 1993). Strongly hydrated organic bottom sediments and the shallow character of the analysed lakes make this facies the most characteristic element of water vegetation in humic lakes of the Wielkopolska region. However, the community

of common white water-lily appeared in the basins irrespective of the degree of their succession.

It seems, then, that in humic lakes of the Wielkopolska region the bioindicator value of nymphaeid associations in respect to the concentration of nutrients is limited. However, these associations point to the different habitat requirements of the communities for carbonate complexes, particularly connected with the substratum.

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