REVISION OF *NYMPHAEA CANDIDA* RANGE
– NEW DATA ON THE DISTRIBUTION AND HABITAT PREFERENCES
OF THE SPECIES IN SOUTHERN POLAND

ARKADIUSZ NOWAK¹, MARCIN NOBIS², ZYGMUNT DAJDOK³, JOANNA ZALEWSKA-GAŁOŚZ²,
SYLWIA NOWAK¹, AGNIESZKA NOBIS², IZABELA CZERNIAWSKA-KUSZA⁴, MACIEJ KOZAK⁵,
ADAM STEBEL⁶, RENATA BULA⁷, PIOTR SUGIER⁸, ANDRZEJ SZLACHETKA⁹, WALDEMAR BENA¹⁰,
ANNA TROJECKA², RENATA PIWOWARCZYK¹¹, ALEKSANDRA ADAMIEC², RAFAŁ KRAWCZYK¹²

¹ Laboratory of Geobotany and Plant Conservation,
Department of Biosystematics, Opole University
Oleska 48, 45-022 Opole, Poland
e-mail: anowak@uni.opole.pl

² Department of Plant Taxonomy and Phytogeography,
Institute of Botany, Jagiellonian University

⁵ Department of Plant Ecology, Jagiellonian University
Kopernika 27, 31-501 Kraków, Poland

³ Institute of Plant Biology Wrocław University
Kanonka 6/8, 50-328 Wrocław, Poland

⁴ Department of Land Cover Protection,
Opole University
Oleska 22, 45-052 Opole, Poland

⁶ Department of Pharmaceutical Botany,
Medical University of Katowice
Ostrogórska 30, 41-200 Sosnowiec, Poland

⁷ Centre of Nature Heritage of the Upper Silesia
św. Huberta 1, 40-543 Katowice, Poland

⁸ Department of Ecology, Institute of Biology
¹² Department of Nature Conservation
Maria Curie-Skłodowska University
Akademicka 19, 20-033 Lublin, Poland

⁹ Parszowice 81, 59-300 Ścinawa, Poland

¹⁰ Olszewskiego 7, 59-900 Zgorzelec, Poland

¹¹ Department of Botany, Institute of Biology
Jan Kochanowski University
Świętokrzyska 15, 25-406 Kielce, Poland

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ABSTRACT

The paper presents results of geobotanical and taxonomic studies on the distribution and habitat requirements of *Nymphaea candida* in southern Poland. The researches were conducted in southern Poland in 2003-2009, in the provinces of Lower Silesia, Lublin, Małopolska, Opole, Silesian province as well as, in southern parts of Mazowieckie and Lubuskie. Flowers, leaves and fruits of *Nymphaea* species were collected from 27 locations. Altogether pollens from 73 populations of *N. candida* and 18 of *N. alba* from all the researched area were measured. The trophic level of an ecosystem was evaluated according to the results of the total nitrogen, total phosphorus, chlorophyll *a*, transparency and biological parameters.

As the result of the studies of more than 200 water bodies, 57 localities of *N. candida* were documented within the investigation area. The populations of *N. candida* occupy mid-forest water bodies and river ox-bow lakes. A

significant number of populations was also found in artificial reservoirs – fish ponds. The most suitable habitat conditions for *N. candida* occur in shallow waters in the shore zone with the amplitude of the water column vary from 0.5 to 2 m. Regarding the trophic level, *N. candida* occupies different habitats, mainly mesotrophic and also eutrophic with high content of organic matters. Considering the 15 checked morphological parameters, especially the stigma diameter, the number of carpellary teeth, flower and pollen diameters, the found and collected specimens of *N. candida* significantly differ from *N. alba*.

The study confirms that *N. candida* occurs in whole lowland Poland without any regional distribution gaps. According to the IUCN guidelines to species assessment the data gathered during the presented study do not allow to classify *N. candida* as a vulnerable species in Poland. Still existing populations for more than 150 years, numerous stable locations, abundant populations, a habitat accessibility, a biotope extent, an ecological amplitude against the trophic level and direct human impacts suggest, that the species should be regarded as a least concern (LC) taxon.

KEY WORDS: *Nymphaea candida*, distribution, ponds, aquatic vegetation, habitat, range.

INTRODUCTION

Nymphaea candida C. Presl. is an Euro-Siberian element of aquatic flora with the western range limit on the line of the Rhine (Hegi 1965; Meusel et al. 1965; Hulten and Fries 1986; Muntendam et al. 1996). According to Wayda (2000), *N. candida* occurs in Poland only in the northern part of the country reaching there the southern limit of its general continuous range. However, the species was also reported from the Czech Republic (Hejný and Slavík 1997), southern regions of Germany (Benkert et al. 1996), eastern France, Switzerland, south-western Romania, Austria, Hungary and former Yugoslavia (Tutin et al. 2002; Muntendam et al. 1996). The general distribution map of the species in Europe is presented in Fig. 1. Considering the fact that aquatic plants are distributed widely and limited mostly by climatic zones, a distribution gap in southern Poland is hardly possible to really exist. Moreover, *N. candida* was reported from southern Poland by Polish and German botanists in the 19th and early 20th centuries (detailed list of papers cited in Results). Unfortunately, the herbarium materials documented these localities and deposited in WRSL were destroyed during the Second World War, so they could not be re-examined. It is worth mentioning that the data published by German botanists were based on careful plant examinations. Moreover, most of their floristic reports have been later confirmed, so they are regarded as a credible source of botanical information. Nevertheless, these data were questioned by Wayda (2000), and in result not included in the “Atlas of Vascular Plants of Poland” (Zajac and Zajac 2001). On the other hand, the occurrence of *N. candida* in the area of Silesia and the Pojezierze Łęczyńsko-Włodawskie Lakeland was mentioned by Kłosowski (2001) in the “Polish Red Data Book of Plants”. Localities of the species were also reported from the southern part of Lubuskie province by Kujawa-Pawlaczyk and Pawlaczyk (2003) and from Lower Silesia by Bobrowicz and Konieczny (2000). Authors of the present paper have found the individuals of water lily in southern Poland, identified in the field as *N. candida*, based on the botanical key of Rutkowski (1998) or Kubát (2002). Further investigations proved, that *N. candida* occurs also in other regions of central and southern Poland (Nobis 2007; Nowak and Nowak 2007).

RECOGNITION

N. candida is closely related to *N. alba* L., with many varieties and subspecies described (Glück 1924; Heukels and Van der Meijden 1990). Despite the fact that the species has been extensively investigated (Glück 1924; Neuhäusl and Tomšovic 1957; Radics 1967; Casper and Krausch 1981; Jones and Clarke 1981; Muntendam et al. 1996), its identification still brings confusions. Most useful for identification both of the species during the field studies is the number of stigma rays. In the case of *N. candida*, the stigma consists of 9-14 rays, whereas in the case of *N. alba* between 15 and 25 (Muntendam et al. 1996). Several specimens with 12-13 stigma rays were hardly possible to determine according to pollen diameter or exine shape. Surely these cases are rather hybrids of both species. The individuals collected by the authors of this paper in southern Poland have usually had 9 or even 7 carpellary teeth in stigma. Also the equatorial diameter of pollen grains seems to be a comfortable feature in some cases, however these analyses are possible only in the laboratory. The highest values of the equatorial length of *N. alba* pollen do not exceed 42 µm. The pollen of *N. candida* are in general larger than those of *N. alba* (Muntendam et al. 1996).

The morphologically closest to *N. candida* is *N. alba* var. *minor* DC. It is a starvation form differing from typical specimens of *Nymphaea alba* only in size. Recently, this form has been reported from Opole Silesia (Spalek 2007), but with no taxonomical evidences and herbarium documentation. According to Oberdorfer (1994) and Muntendam et al. (1996), the occurrence of *N. alba* var. *minor* is restricted to colder, northern regions of Europe.

A separate taxonomical problem related with *Nymphaea candida* is the possible hybridisation with *N. alba*. Morphologically intermediate forms between these two species are known for a quite long time (e.g. Conard 1905; Glück 1924). Also during *N. candida* survey in southern Poland such intermediate forms were collected. Molecular studies on hybrid specimens of *N. alba* and *N. candida* are planned in the future.

The *Nymphaea* genus is also of considerable importance from the conservation point of view. Both species are legally protected in Poland (Rozporządzenie Ministra Środowiska 2004). As a taxon with restricted range in

Poland *N. candida* was categorised as a vulnerable species in the Polish Red Data Book of Vascular Plants (Kłosowski 2001). So, it is important to have precise information about the distribution of both species to conduct the effective management and conservation.

The successive aims of the present study were: 1) to provide old, published floristic data on the distribution of *N. candida* in southern Poland; 2) to present the current distribution of the species in the discussed area; 3) to stimulate further molecular researches on infraspecific hybridisation in the genus in the area of co-occurrence of the two species representing the genus *Nymphaea*; 4) to provide data on habitat preferences of *N. candida* from selected localities, and finally 5) to discuss the present threat status of *N. candida* in Poland.

MATERIALS AND METHODS

The field studies were conducted in southern Poland in 2003-2009 (Figs 1 and 2). Flowers, leaves and fruits of the *Nymphaea* species were collected from 27 locations, mainly in Opole Silesia in July and September 2008 on the allowance DKFOPPogiz-4211/I-62/1887/08/ep issued by the Polish Minister of Environment. The plants were collected during warm days between 10 am. and 6 pm. The fresh material was identified and described in the field using the botanical key of Rutkowski (1998).

On the basis of botanical keys by Rutkowski (1998), Kubát (2002), Oberdorfer (1994), Hejný and Slavík (1997), as well as regarding the research works of Muntendam et al. (1996) and Wayda (2000), the following fifteen features were chosen to describe the specimens: the diameter of the stigma (column 1 in Table 1), the number of carpellary teeth (2), the position of the flower on water (3), the shape of the flower (4), the side view of the flowerbase (5), the underside view of the flowerbase (6), the stigma surface structure and colour (7, 8), the diameter of the flower (9) vertical/erect sepals (10), the colour of the underside leafblade (11), the nervation of the leafblade (12), the direction of the

main nerves leafslips (13) and the proportion of the stigma to the width of the ovary (14) and for some specimens also the pollen diameter and pollen exine morphology (values given in the distribution list). All collected individuals were determined in the field with careful measurement of the chosen features. Altogether, 64 flowers, 70 leaves and 15 ovaries belonging to 62 specimens were collected and checked. The average stigma diameters, the number of carpellary teeth and the flower diameter were compared to the values of *N. alba*. Pollen diameter was measured using the Olympus BX41 microscope with objective UPlan SA 100× 00/017/FN 26.5 and photographed by the Olympus Camedia camera C3040 200M. Altogether pollens from 73 populations of *N. candida* and 18 of *N. alba* from all the researched areas were measured. Half of them was sampled from fresh material, another half from herbarium collections (WRSL, KRA). The collected material was stored in the herbarium of the Division of Geobotany and Plant Conservation of the Opole University (OPUN).

The trophic level of an ecosystem is evaluated according to the results of the total nitrogen, total phosphorus, chlorophyll *a*, water transparency and biological parameters (Dodds et al. 1998). However, it is generally admitted that phosphorus plays an important role in the development of aquatic plants and, in most cases, is a limiting factor of eutrophication in temperate lakes (Parinet et al. 2004). In order to estimate the status of investigated water bodies, the Trophic State Index (TSI) was calculated according to Carlson's equations (Carlson 1977):

$$TSI = \frac{TSI(TP) + TSI(Chl) + TSI(SD)}{3}$$

where:

$$TSI(TP) = 10[6 - \ln(48 \cdot TP^{-1}) \cdot \ln 2^{-1}]$$

$$TSI(Chl) = 10[6 - (2.04 - 0.68 \ln Chl) \cdot \ln 2^{-1}]$$

$$TSI(SD) = 10(6 - \ln SD \cdot \ln 2^{-1})$$

TP – total phosphorus ($\text{mg} \cdot \text{m}^{-3}$); Chl – chlorophyll *a* ($\text{mg} \cdot \text{m}^{-3}$); SD – Secchi depth (m).

Fig. 1. The distribution range of *Nymphaea candida* in Europe with the investigation area.

Fig. 2. Distribution of *Nymphaea candida* in southern Poland on the background of ATPOL grid. 1 – locations known before the year 2001; 2 – locations known before the year 2001, documented with herbarium specimens verified according to methods described in the paper; 3 – locations noted after 2001.

The TSI values, constructed on a scale of 0 to 100, indicate the trophic level of ecosystems from oligotrophic (<40) to eutrophic (60-100). To minimize the sampling mistake the mean value of three indices (TSI_{TP}, TSI_{Chl} and TSI_{SD}) were taken while determining the trophy level (Pełechaty et al. 2007). Also the reference classification adopted by OECD was taken into account (OECD 1982; Solheim 2005).

The endanger status of *N. candida* in southern Poland was evaluated according to the IUCN categorization method (IUCN 2001). All doubtful specimens, probably hybrids, were excluded from the analyses. Only evident individuals of *Nymphaea candida* were taken into account when generating map and listing the location of the species.

The average values of the pollen diameter of both species were compared using the *t* test for independent variables.

RESULTS

THE DISTRIBUTION OF *NYMPHAEA CANDIDA* IN SOUTHERN POLAND

All localities of *N. candida* from southern Poland published before 2001 are listed below. Additionally, new records as well as old localities which have been confirmed recently (after 2001) in the field are also presented (Fig. 2).

Abbreviations (relate to Results):

GB – dense exine outgrowths; RB – rare exine outgrowths.

By location the position in ATPOL grid 10×10 km (Zając 1978) was given. If the precise localisation of a population in ATPOL grid was impossible, a question-mark (?) was given.

Lower Silesian Province

AE16: Jagodzin (Barber 1937; Schube 1903a), Węgliniec – Dyczny Pond (Schube 1903a), Węgliniec – Wolno Stary Pond (Schube 1903a), Węgliniec – Wolno Nowy Pond (Berdowski and Narkiewicz 1996);

AE25: Zielonka – pond to the NE from the village (Zabawski and Matuła 1973), Zielonka – Krusza Pond (Berdowski and Narkiewicz 1996), Zielonka – Rygle I Pond – western reservoir (Berdowski and Narkiewicz 1996), Zielonka – Rygle I Pond – eastern reservoir (Berdowski and Narkiewicz 1996), Zielonka – bog to the NE from Rygle I Pond (Berdowski and Narkiewicz 1996), Zielonka – Rygle II (Berdowski and Narkiewicz 1996), Zielonka – midforest pond to the SE from Rygle II Pond – forest division section 201 (Berdowski and Narkiewicz 1996);

AE26: Zielonka – pond to the NE from the village (Zabawski and Matuła 1973), Zielonka – pond close to the railway, to the NE from Zielonka (Berdowski and Narkiewicz 1996), Węgliniec – bog to the NW from railway station (Schube 1903a; Zabawski and Matuła 1973);

BD62: Radzyń near Sława (leg. E. Kozioł 04.07.1974, WRSL 94073, pollen ø 42-45 µm, GB);

BE05: Przychowa near Legnica, Odra river ox-bow lake (leg. E. Kozioł 28.06.1993, WRSL 87085, pollen ø (40)42-43 µm, GB); Przyborów, Odra river ox-bow lake (Macicka and Wilczyńska 1992; Macicka-Pawlik and Wilczyńska 1996, 1998; Bobrowicz and Konieczny 2000);

BE09: Niezgoda (Schube 1903a), Ruda Sułowska (Schube 1903a), Radziądz (Anioł-Kwiatkowska et al. 1995);

BE10: Nature Reserve “Torfowisko Borówki” (Cieślak and Szlachetka 1987; Szlachetka and Szlachetka 1998), “Sześć Stawów” (Cieślak and Szlachetka 1987);

BE15: Tarchalice – Odra river ox-bow lake (Macicka-Pawlik and Wilczyńska 1996, 1998), Tarchalice, ox-bow lake (leg. T. Macicka 12.07.1991, WRSL 82980, pollen ø

TABLE 1. Cont.

Location, specimen	Organ		Morphological features (according to the text)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14		
Staw Nowokuźnicki	4	F	6.5	11	sub	cup	str	squ	dull	or/ye	6.5	ere	re/gr	pro	conv	
	5	L	6.5	12	sub	cup	str	squ	dull	or/ye	7	ere	re/gr	pro	conv	
	6	F	6	8	sub	cup	str	roun	dull	or/ye	5.5	ere	re/gr	pro	conv	
	7	L	13	7	sub	cup	str	squ	dull	or/ye	5.5	ere	re/gr	pro	conv	
	8	F	6	9	sub	cup	str	squ	dull	or/ye	6	ere	re/gr	pro	par	
	9	L	6	8	sub	cup	str	squ	dull	or/ye	6	ere	re/gr	pro	par	
	10	F	7.5	11	sub	cup	str	roun	dull	or/ye	7.5	ere	re/gr	pro	conv	
	11	L	5	10	sub	cup	str	squ	dull	ora	5	ere	re/gr	pro	par	
	12	F	6	9	sub	cup	str	roun	dull	or/ye	6	ere	re/gr	pro	conv	
	13	L	6	8	sub	cup	str	squ	dull	or	7.5	ere	re/gr	pro	par	
	14	F	6	11	sub	cup	str	squ	dull	ora	7.5	ere	re/gr	pro	par	
	15	L	5	8	sub	cup	str	squ	dull	ora	5	ere	re/gr	pro	par	
	16	F	5	8	sub	cup	str	squ	dull	ora	4	ere	re/gr	pro	conv	
	17	L	5	7	sub	cup	str	roun	dull	ora	5.5	ere	re/gr	pro	conv	
	18	F	5	8	sub	cup	str	squ	dull	ora	5	ere	re/gr	pro	par	
	Krogólna	1	F	6	12	sub	cup	str	squ	dull	or/ye	7.5	ere			
			F	7	10	sub	cup	str	squ	dull	or/ye	7.5	ere			
	Wronów	1	F	6.5	8	sub	cup	str	squ	dull	ora	4.5	ere	re/gr	pro	conv
		L											re/gr	pro	conv	
Winna Góra	1	F	5	8	sub	cup	conc	squ	dull	ora	4.5	ere	re/gr	pro	par	
		L											re/gr	pro	par	
Skorogoszcz	2	F	4.5	8	sub	cup	conc	squ	dull	or/ye	4.5	ere	re/gr	pro	par	
		L											re/gr	pro	par	
		L											re/gr	pro	par	
		L											re/gr	pro	par	
	1	F	6.5	9	sub	cup	str	squ	dull	or/ye	5.5	ere	re/gr	pro	conv	
	2	F	6	8	sub	cup	str	squ	dull	or/ye	5.5	ere	re/gr	pro	conv	

TABLE 1. Cont.

Location, specimen	Morphological features (according to the text)														
	Organ	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Skorogoszcz															
	L											re/gr	pro	conv	
	L											re/gr	pro	conv	
3	F	5.5	9	sub	cup	str	squ	dull	or/ye	7	ere				
	F	5.5	10	sub	cup	str	squ	dull	or/ye	6.5	ere				
Staniszcze Małe	L											re/gr	pro	conv	
Kościerzycze	1	5	8	sub	cup	str	squ	dull	or/ye	5.5	ere				
	F											re/gr	pro	par	
	L											re/gr	pro	conv	
	L														0.4
Dobrzyń	1	5.5	11	sub	cup	str	squ	dull	or/ye	5	ere				
	F											red	pro	conv	
	L											red	pro	conv	
Lubsza															
	1	5	10	sub	cup	str	squ	dull	or/ye	5	ere				
	F	5.5	10	sub	cup	str	squ	dull	or/ye	6	ere				
	F											re/gr	pro	conv	
	L											red/gr	pro	conv	
	L														0.25
O															

Explanations:

sub – partially submerged; cup – cup-shaped flower; star – star-shaped flower; str – straight flowerbase; conc – concavely curved flowerbase; squ – square flowerbase; roun – rounded flowerbase; dull – carpellary teeth dull; shin – carpellary teeth shiny; or – orange colour of a stigma; yel – yellow colour of a stigma; ere – erect sepals; re/gr – partially red, partially green colour of the underside leafblade; pro – nervation pronounced; conv – direction of main leafslip nerves converging; par – direction of main leafslip nerves parallel; div – direction of main leafslip nerves diverging; F – flower; L – leaf; O – ovary.

42.5–45 µm, GB), Tarchalice, ox-bow lake (leg. T. Macicka 23.07.1991, WRSL 82863, pollen ø 37.5–45 µm, GB), Boraszyn – Odra river ox-bow lake (Macicka-Pawlik and Wilczyńska 1996, 1998), Boraszyn near Wrocław, ox-bow lake (leg. T. Macicka 12.07.1991, WRSL 82979, pollen ø 37.5–45 µm, GB); Dziewin-Grzybów; Odra river ox-bow lake (leg. E. Koziół 29.06.1993, WRSL 87086, pollen ø 43 µm, GB); Dziewin by Ścinawa, ox-bow lake (leg. E. Koziół 04.07.1993, WRSL 87095, pollen ø 42–43 µm, GB);

BE21: Jaroszkówka near Chojnów (Schube 1903a);

BE25: Jurcz near Ścinawa, Odra river ox-bow lake (1 specimen leg. E. Koziół 29.06.1993, WRSL 87087, pollen ø 41–43 µm, GB; 2 specimens leg. E. Koziół 15.07.1993, WRSL 87088, pollen ø 40–41 µm, GB; 3 specimens leg. E. Koziół 15.07.1993, WRSL 87089, pollen ø 41–45 µm, GB); Lubiąż, Nature Reserve “Odrzyska” (leg. T. Macicka 26.07.1991, WRSL 82951, pollen ø 40–46 µm, GB);

BE26: Wołów, clay pit (leg. Z. Głowacki 14.07.1964, WRSL 71967, pollen ø 43.75–46.25 µm, GB);

BE36: Grodzanów near Wołów (Schube 1925), Słup – Odra river ox-bow lake (Macicka-Pawlik and Wilczyńska 1996, 1998);

BE37: Szczepanów near Środa Śląska, forest pond (leg. A. Krawiecowa 04.07.1963, WRSL 66471, pollen ø 43–47 µm, GB);

BF07: Ząbkowice Śląskie (Schube 1904);

CE01: Grabownica near Milicz (Schube 1903a);

CE51: Jelcz, Odra river ox-bow lake (leg. E. Krawiecówna 06.07.1960; WRSL 34396, pollen ø 43–45 µm, GB);

CE61: Stary Otok (Anioł-Kwiatkowska et al. 1998).

Misleading locations: Klosterteich pond by Lubomierz (Schallow 1935) – according to the author comment it was an anthropogenic population.

Lublin Province

FD78: Mizak Lake, 04.07.1964, rev. M. Kucharczyk 1995; pollen ø 40–45 µm, GB; Fijałkowski 1962); Świerże, Tyśmienica river (Fijałkowski 1962);

FD86: Giżyce by Kock, Wieprz river (Fijałkowski 1964);

FD78: Skoki by Czemiernik, Tyśmienica river (Fijałkowski 1964);

FD89: Siemień, fish ponds (Fijałkowski 1962); **FD99:** Kleszczów Lake, Łęczyńsko-Włodawskie Lakeland (Fijałkowski 1959a; Popiołek 1971; Sugier and Czarnecka 1998); Czarne Gościńskie Lake (Fijałkowski 1959a; Popiołek 1974; Sugier 1998); peat-bog depressions by Miejskie Lake (Popiołek 1973; Czarnecka and Sugier 1998);

FE06: Samokłęski, fish ponds (Fijałkowski 1962);

- FE09:** Rudka Kijańska, ditches (Fijałkowski 1962);
FE43: Jezioro Bartków (Fijałkowski 1961);
FE62: Popów, Bliskowice, Świeciechów Duży, Wisła river (Fijałkowski 1960);
FE84: Zaklików, Stawy (Fijałkowski 1960);
FE95: Nature Reserve "Stawy Wilczowskie" (Fijałkowski 1997); Nature Reserve "Imielty Ług" (Fijałkowski et al. 1992; Fijałkowski 1997); Nature Reserve "Łasy Janowskie" (Fijałkowski 1997);
GD64: Holeszów by Sławatycze, meadow ditch (Fijałkowski 1963);
GD84: Dołhobrody by Włodawa, Bug river (Fijałkowski 1963);
GD95: Surroundings of Sobibor by Włodawa, Bug river (Fijałkowski 1964);
GD90: Skomielno Lake, Łęczyńsko-Włodawskie Lakeland (leg. D. Fijałkowski 01.08.1957, pollen $\varnothing$ 48 μm , GB; Fijałkowski 1959a);
GE01: Karaśne Lake by Wujek (Fijałkowski 1959a; Sugier, Popiołek 1995); Moszne Lake (Fijałkowski 1959a; Sugier and Popiołek 1998);
GE02: Lubowierz Lake, Lubowierzek Lake (Fijałkowski 1959a);
GE03: Dubeczyńskie Lake, Łęczyńsko-Włodawskie Lakeland (leg. D. Fijałkowski 14.08.1958; pollen $\varnothing$ (36)43-50 μm , GB; Fijałkowski 1959a; Fijałkowski et al. 1994a); Hańskie Lake, Pojezierze Łęczyńsko-Włodawskie (leg. D. Fijałkowski 26.08.1960, pollen $\varnothing$ 40-41 μm , R-GB; Fijałkowski 1959a);
GE04: Spilno Lake (Fijałkowski et al. 1994a); Perespilno Lake (Fijałkowski 1959a; Fijałkowski et al. 1994b);
GE05: Płotycze Lake, Sobiborskie Forests, Łęczyńsko-Włodawskie Lakeland (Fijałkowski 1959a; Fijałkowski et al. 1993); Brudno Lake, Sobiborskie Forest, Łęczyńsko-Włodawskie Lakeland (Fijałkowski 1959a; Fijałkowski et al. 1993);
GE11: Eastern shore of Uściwierz Lake, Grabniak by Łączna, Łęczyńsko-Włodawskie Lakeland (Fijałkowski 1959a; Popiołek 1988); Rotcze Lake (Fijałkowski 1959a; Popiołek 1988), Sumin Lake (Fijałkowski 1959a; Popiołek 1988); Bikcze Lake (Fijałkowski 1959a; Popiołek 1988); Nadrybie Lake (Fijałkowski 1959a; Popiołek 1988);
GE12: Świerszczów Lake (Fijałkowski 1959a, 1965; Karczmarsz and Malicki 1971);
GE13: Słone Lake (Fijałkowski 1959a);
GE25: Hniszów, in Bug river (Fijałkowski 1964);
GE34: Kol. Rudka, Kamień, Strupie, peat-bog depressions in calcareous moors (Fijałkowski 1959a);
GE36: Dorohusk by Chełm, Bug river (Fijałkowski 1964);
GE47: Uchańka by Dubienka, Bug river (Fijałkowski 1964);
GE57: Matcze by Horodła, Bug river (Fijałkowski 1964);
GE62: Stryjów, Orlów Murowany, ponds (Fijałkowski 1960);
GE82: Sitaniec, Łabuńka river (Fijałkowski 1959b);
GE84: Miączyn, peat-bog depressions (Fijałkowski 1959b);
GE92: Lipsko, peat-bog depressions (Fijałkowski 1959b);
GF15: Chodywańce by Tomaszów Lubelski, peat-bog depressions (Fijałkowski 1962).

Małopolska Province

- DF69:** Kraków – Dębniaki, data ?, leg. ?, KRA 11471; pollen $\varnothing$ 42-46 μm , GB);
DF78: Tyniec near Kraków – pond, leg. H. Błaszczuk may 1938, KRA 89674; $\varnothing$ pyłku 41-43 μm GB);
EF62: Puszcza Niepołomicka, Ispina, ox-bow lake "Wiślisko Kobyłe" in *Myriophyllo-Nupharetum* association, leg. E. Dubiel 5.08.1968, KRA 98181; pollen $\varnothing$ 42-45 μm GB);
DF69: Kraków – Dębniaki, leg. F. Berdau 1854, KRA 11470; pollen $\varnothing$ 42,5-47,5 μm , GB);
DF79: Kraków – Kobierzyn, leg. F. Berdau 1854, KRA 11470; pollen $\varnothing$ 42,5-47,5 μm GB).

Mazowsze Province

- EE38:** Pakosławskie bog (Młyn Bagno) in Pakosław near Iłża (Szafran 1925);
FE60: Puszcza Kozienicka, bog near Anielin; leg. H. Błaszczuk 07.1939, KRA89676; pollen $\varnothing$ 38-40 μm , GB);
 ? : Puszcza Kozienicka, bog near Laskowola, drainage ditch (leg. H. Błaszczuk 6.07.1939, KRA 89677; pollen $\varnothing$ 42 μm , GB).

Opole Province

- CE67:** Kluczbork (Fiek 1887; Schube 1903a);
CE73: Nowe Kolnie (Kuźniewski 1964);
CE77: Szumirad near Olesno, pond (Fiek 1888; Schube 1903a);
CE79: Borki Wielkie (Schube 1903b);
CE83: Buszyce near Lewin Brzeski (Schube 1908);
CE84: Chróścice (Wimmer 1844; Schube 1903a);
CE85: Kup (Schube 1903a);
CE98: Mid forest pond in Staniszcze Małe (Dajdok et al. 1998);
CF03: Tułowice Małe, Grodziec (Wimmer 1844; Schube 1903a), Tułowice (Schube 1910);
CF04: Przysiecz (Fiek, Schube 1893; Schube 1903a);
CF05: Staw Nowokuźnicki (Michalak 1963);
CF09: Zawadzkie (Dajdok et al. 1998);
CF13: Stara Jamka (Schube 1910);
CF25: Dobra (Schube 1906);
CF48: Stara Kuźnia (Wimmer 1844; Schube 1903a);
DE50: Dalachów, pond in forest sect. No. 96 (Fojcik 1997).

Misleading locations: Lewin Brzeski (Kuczyńska 1974 – data from before 1939) – data refers undoubtedly to Buszyce near Lewin Brzeski (Schube 1908) not to Lewin Brzeski itself; Chróścina (Kuczyńska 1974 – data from before 1939) – data refers to Chróścice (Schube 1903a); Korfantów (Kuczyńska 1974 – data from before 1939) – data refers probably to Stara Jamka near Korfantów (Schube 1910);

Podkarpacie Province

- FF24:** Płaskowyż Kolbuszowski, Brzózka (S. Loster, E. U. Zajac, E. Dubiel, A. Zajac 17.06.1975, KRA 11735; pollen $\varnothing$ 43-45 μm , RB).

Silesian Province

- CF38:** Rudziniec (Schube 1903a);
CF57: Nature Reserve "Łęczczok" (Fiek 1881; Sendek 1986); Grabowiec Pond in Nature Reserve "Łęczczok" (leg.

S. Zerger 10.07.1960, WRSL 30632, pollen $\varnothing$ 46-49 μ m, GB); Brzeziniak Pond in Nature Reserve "Łęczczok" (leg. S. Zerger 18.07.1960, WRSL 30633, pollen $\varnothing$ 44-46 μ m, GB);

CF59: Stanice (Fiek 1881; Schube 1903a); Rybnik, ponds in the Ruda River valley (Uechtritz 1864b; Fiek 1881; Schube 1903a);

DE51: Stawy settlement near Parzymiechy (Hereźniak 1986);

DE 81: Brzoza Pond near Lubockie (ca. 10 km to the N from Lubliniec), leg. A. Czyłok, G. Kłys 04, 08, 2000, KRA 257174; pollen $\varnothing$ 40-50 μ m, GB);

DE82: Blachownia, Blachownia Lake (Hereźniak and Samosiej 1990); Blachownia near Częstochowa, pond, leg. H. Błaszczak 15.08.1948, KRA 11458; pollen $\varnothing$ 45-50 μ m, GB);

DE83: Gorzelnia in Blachownia commune (Hereźniak 1986);

DE86: Stawki in Przyrów commune (Hereźniak 1986); Knieja near Św. Anna (Hereźniak et al. 2001); Julianka (Hereźniak 1986);

DE91: Hadra (Uechtritz 1864a; Fiek 1881; Schube 1903a);

DE93: Kijas near Konopiska (Hereźniak 1986);

DE96: Bystrzanowice in Janów commune (Hereźniak 1993);

DF04: Stara Kuźnica (Denisiuk and Grynia 1969);

DF30: Czekanów by Pyskowice (Schube 1905);

DF40: Nieborowice (Fiek 1881; Schube 1903a);

DF43: Mysłowice (Sophienhütte) at present Mysłowice-Piasek (Schube 1903a; Schube 1904)

DF45: Sosnowiec-Cieśle (Sendek 1984); ponds near Biała Przemsza by Szczakowa (leg. J. Walas 06.1954, KRA 126558; pollen $\varnothing$ 41,5-42,5 μ m, GB);

DF50: Rybnik-Kamień (Urbisz 1996);

DF51: near Bełk (Fiek and Schube 1893; Schube 1903a); Orzesze-Zawisze (Celiński et al. 1979);

DF60: Rybnik Gotartowice (Fiek 1881; Schube 1903a); Ligota Rybnicka, Żory (Urbisz 1996); Staw Garbocz, to the North from Żory (Urbisz and Urbisz 1998);

DF61: Żory-Kleszczówka, Suszec-Rudziczka (Urbisz and Urbisz 1998);

DF62: Tychy-Paprocany (Uechtritz 1885; Fiek 1881; Schube 1903a; Toma 1994);

DF72: Near Pszczyna (Fiek 1881; Schube 1903a);

DF82: Goczałkowice-Zdrój; fish pond (leg. T. Stryczek 07.08.1960, WRSL 72171, pollen $\varnothing$ 42-45 μ m, GB).

Świętokrzyskie Province

EF08: Lakes in carst sink, to the E from Golejów near Staszów (Ochyra 1979);

EE71: Out of use bog by Marianów and Mieczyn in Małogoskie Hills in Świętokrzyskie Mts (leg. K. Pstrokońska, T. Tacik, 6.07.1955; KRA11483; pollen $\varnothing$ 45 μ m, GB);

?: Pasieki by Włoszczowa, Włoszczowski District – pond in pine wood (leg. H. Błaszczak, 6.07.1949; KRA 111973; pollen $\varnothing$ 45 μ m, GB);

?: Peat-bog near Włoszczowa (leg. H. Błaszczak 29.08.1927, KRA 89675; pollen $\varnothing$ 45 μ m, GB).

The list of new localities found or confirmed by authors:

Lower Silesian Province

AE16: Stary Węgliniec, drainage ditch to the W from Wolno Stary Pond (W. Bena 2003 npbl, Z. Dajdok, Z. Kącki and K. Pender 2004 npbl., K. Pender and Z. Dajdok 2007 npbl); Węgliniec – Tartaczny Pond (obs. Z. Dajdok, A. Nowak, W. Bena 22.08.2009; pollen $\varnothing$ 40-44 μ m, GB);

AE25: Zielonka – bog to the NE from Rygle I Pond (W. Bena, Z. Dajdok, A. Nowak and J. Zalewska-Gałosz 2008 npbl), Zielonka – mid forest pond to the S from Rygle II (obs. W. Bena, Z. Dajdok, A. Nowak and J. Zalewska-Gałosz 22.08.2009; pollen $\varnothing$ 44.5-46 μ m, GB);

BE10: "Sześć Stawów" (obs. Z. Dajdok, A. Nowak, W. Bena 22.08.2009; pollen $\varnothing$ 42-45 μ m, GB), between Krzyżowa and Borówki – fish pond in forest (Szlachetka 2007a, 2008);

BE15: Małowice – large ox-bow lake to the W from Małowice (Ruszwicz and Szlachetka 2007), Dziewin – ox-bow lake to the S from village (Szlachetka 2007b);

BE25: Grzybów – ox-bow lake ca. 300 m to the SE from village (Szlachetka 2007b), Jurcz – ox-bow lake ca. 2500 m to the SW from village (Szlachetka 2007b), Jurcz – four small ox-bow lakes, ca. 1300 m to the E from village (Szlachetka 2007b), Jurcz – ca. 1200 m to the SE from village (A. Szlachetka 2007 npbl.), Kwiatkowice – ox-bow lake ca. 1200 m to the NE from village (Szlachetka 2007b).

Lublin Province

FD99: Kleszczów Lake, Łęczyńsko-Włodawskie Lakeland (obs. P. Sugier 04.09.2009; pollen $\varnothing$ 43 μ m, GB);

GD90: Skomielno Lake near Orzechów, Łęczyńsko-Włodawskie Lakeland (obs. J. Zalewska-Gałosz 26.08.2002; KRA 207124; pollen $\varnothing$ 42 μ m, GB);

GE05: Płotycze Lake, Sobiborskie Forest, Łęczyńsko-Włodawskie Lakeland (obs. P. Sugier 05.09.2009; 1 specimen pollen $\varnothing$ 49-50 μ m, GB, 2 specimens, pollen $\varnothing$ 44-46 μ m, GB, 3 specimens, pollen $\varnothing$ 43-45 μ m, GB); Brudno Lake, Sobiborskie Forest, Łęczyńsko-Włodawskie Lakeland; 1 specimen, obs. P. Sugier 05.09.2009; pollen $\varnothing$ (35)46-49 μ m, GB; 2 specimens, obs. P. Sugier 04.09.2009, pollen $\varnothing$ 45-51 μ m, GB);

GE11: Uściwierz Lake, E part, Grabniak by Łęczna, Łęczyńsko-Włodawskie Lakeland, obs. 24.06.2004, J. Zalewska-Gałosz, KRA264290, 264261; pollen $\varnothing$ 40, 42, 45 μ m, GB).

Małopolska Province

DF36: Laski by Olkusz – small dam reservoirs on the Biała river (leg. W. Bartoszek, M. Radoszek, J. Żelazny, 11.06.2008, KRA 35764; pollen $\varnothing$ 50 μ m, GB).

Mazowsze Province

EE48: Ilża, Błaziny Dolne and Budki Seredzkie, reservoir on the Ilżanka river. Pond in Kolonia Seredzice (Nobis 2007; M. Nobis 2008 npbl.); dam reservoir on the Ilżanka river by Błaziny Dolne near Ilża – to the S from Radom (obs. M. Nobis 09.09.2003, KRA 265617; pollen $\varnothing$ 42, 45 μ m, GB); Ilża, dam reservoir (obs. M. Nobis 16.06.2003, KRA 357645; pollen $\varnothing$ 37,5-42, GB).

Opole Province

CE62: Ox-bow lake in Błota (obs. A. Nowak 16.07.2008);

CE64: Krogólna, fish ponds (Nowak and Nowak 2007; leg. A. Nowak 08.2007; pollen ϕ 35-43 μm , GB);

CE72: Ox-bow to the S from Lubsza and to the SW and NE from Kościerzycy (obs. A. Nowak 14.07.2008);

CE73: Odra river ox-bow lake in Stare Kolnie (Nowak and Nowak 2007; leg. A. Nowak 08.2007, pollen ϕ 43-46 μm , GB); Odra river ox-bow lake in Stobrawa (Nowak and Nowak 2007, leg. A. Nowak 08.2007; pollen ϕ 44-49 μm , GB);

CE75: Winna Góra, fish ponds (Nowak and Nowak 2007, leg. A. Nowak 08.08.2007; pollen ϕ of 2 specimens, each 46 μm , GB);

CE77: Szumirad near Olesno, pond (Nowak and Nowak 2007; leg. A. Nowak 08.2007; 1 specimen pollen ϕ 43-46 μm , GB; 2 specimens pollen ϕ 48-49 μm , GB; 3 specimens pollen ϕ 46-50 μm , GB); between Lasowice Małe and Lasowice Wielkie, pond (Nowak and Nowak 2007); Lasowice Małe – village pond, leg. A. Nowak 08.2007, 1 specimen KRA 358250; pollen ϕ 46-48 μm , GB; 2 specimens KRA 358006, pollen ϕ (44)45-48 μm , GB);

CE83: Odra river ox-bow lake in Wronów (leg. A. Nowak 09.08.2007; pollen ϕ 42-43 μm , GB) Nysa Kłodzka ox-bow lake in Skorogoszcz (Nowak and Nowak 2007; leg. A. Nowak 08.08.2007; pollen ϕ 43 μm , GB);

CE84: Wielopole by Popielów, Odra river ox-bow lake (Nowak and Nowak 2007; leg. A. Nowak 12.08.2007; pollen ϕ 41 μm , GB), Odra river ox-bow lake to the N from Narok and in Kopanie (obs. A. Nowak 14.07.2008);

CE94: Odra river ox-bow lake between Niewodniki and Żelazna (obs. A. Nowak 14.07.2008);

CE95: Odra river ox-bow lake in Żelazna (obs. A. Nowak 14.07.2008);

CE97: Poliwoda, ponds (Nowak and Nowak 2007);

CE98: Mid forest pond in Staniszcze Małe (Nowak and Nowak 2007; leg. A. Nowak 08.2007; pollen ϕ 43-46 μm , GB);

CF03: Pustelnik and Łoża ponds by Lipno, Ławnik pond by Tułowice (Nowak and Nowak 2007);

CF04: Przysiecz (Nowak and Nowak 2007; leg. A. Nowak 23.08.2007; 1 specimen pollen ϕ 40-43 μm , GB; 2 specimens, pollen ϕ 40-43 μm , GB);

CF05: Nature Reserve “Staw Nowokuźnicki” (Nowak and Nowak 2007; leg. A. Nowak 08.2007, 1 specimen pollen ϕ 46 μm , GB; 2 specimens pollen ϕ 40-43 μm , GB; 3 specimens pollen ϕ (38)40-43; μm , GB); Opole-Groszowice, pond (Nowak and Nowak 2007);

CF07: Utrata, pond (Nowak and Nowak 2007);

CF13: Mid forest pond to the S from Sowin (leg. A. Nowak 08.2007, Nowak and Nowak 2007; 1 specimen pollen ϕ 43-46 μm , GB; 2 specimens pollen ϕ 46-48 μm , GB).

Podkarpacie Province

FF16: Pond in Tanew river valley, to the N from Nadtamy settlements by Ulanów (A. Nobis 2005 npbl);

FE84: Jan Pond by Zaklików in Sandomierska Basin (leg. R. Krawczyk, 07.08.2003, KRA 357977; pollen ϕ 42-45 μm , GB);

FE95: Świdry in Sandomierska Basin, Oleńka pond (leg. R. Krawczyk 07.08.2003, KRA 357638; ϕ of pollen, 42-43 μm , GB).

Silesian Province

CF57: Nature Reserve “Łęczczok” (A. Stebel 2008 npbl);

DF05: Myszków-Osińska Góra (Fojcik 2003);

DE63: Kocin Nowy in Mykanów commune (R. Bula and K. Henel 2006 npbl);

DF61: Woszczyce, Widek pond (A. Stebel 2008 npbl).

Świętokrzyskie Province

EE25: Mid forest lake on Jabłonica river in Rzuców near Chlewiska (obs. M. Nobis 26.08.2003, KRA 265084; pollen ϕ 42-45 μm , GB); Rzuców – mesotrophic pond (obs. M. Nobis 26.08.2003, KRA 357971; pollen ϕ 40-43 μm , GB);

EE32: Mesotrophic pond by Barycz near Końskie (A. Trojecka 2007 npbl);

EE33: Mesotrophic pond by Stary Młyn near Końskie (A. Trojecka 2007 npbl);

EE57: Pasternik reservoir on Kamienna river in Starachowice (obs. M. Nobis 08.09.2003, KRA 265037; Nobis 2007; M. Nobis 2008 npbl.; pollen ϕ 45, 50 μm , GB); Pasternik reservoir on Kamienna river in Starachowice (obs. M. Nobis 08.09.2003, KRA 265085; pollen ϕ 40, 43, 45, 48 μm , GB); Pasternik reservoir on Kamienna river in Starachowice (obs. M. Nobis 08.09.2003, KRA 265619, 265622; pollen ϕ 42, 45 μm , GB);

EE60: Peat-bog pond near Skąpe village (Łopuszańskie Hills), (obs. A. Adamiec, R. Piwowarczyk 12.08.2008);

EE61: Peat-bog pond near Mokre village (Łopuszańskie Hills; obs. A. Adamiec 12.08.2008 npbl);

EE72: Lake within transitional bogs “Żarnowski Ług” by Gnieździska (Łopuszańskie Hills; obs. 14.08.2008 A. Adamiec, R. Piwowarczyk npbl);

EF08: Lakes in carst sink, to the E from Golejów near Staszów (M. Nobis 2006, 2008 npbl).

MORPHOLOGICAL FEATURES OF THE COLLECTED SPECIMENS

The field and laboratory measurements of the collected 62 specimens are presented in Table 1. Altogether 64 flowers, 70 leaves and 15 ovaries were collected and determined. The three most diagnostic characters were compared in Table 2 with values known for *Nymphaea alba* (Nowak and Nowak 2007).

The mean value of the stigma diameter for the collected flowers and ovaries is ca. 5.87 mm ranging from 4 to 13 (Table 2, Fig. 3). The average number of carpellary teeth meets perfectly the strict *N. candida* range of this features and counts ca. 9.29, ranging from 7 to 12 (Table 2, Fig. 4). Also the flowers of the verified specimens were small with the diameter restricted to the *N. candida* profile. The average value of this characteristic was 5.95 cm ranging from 4 to 8.5 (Table 2, Fig. 5).

The pollen diameter was measured for 98 specimens representing 73 populations of *N. candida* and for 31 specimens representing 18 populations of *N. alba*. The average value of the parameter was for *N. candida* 43.95 μm and for *N. alba* 33.63 μm (Table 2, Figs 6-8). The pollen diameter for both species has statistically different values ($p < 0.001$; Fig. 8).

TABLE 2. Mean values of quantitative features for *Nymphaea candida* and *N. alba*.

	Stigma diameter [mm]	Number of carpellary teeth	Flower diameter [cm]	Pollen diameter [μ m]
<i>N. candida</i>	5.87	9.29	5.95	43.95
<i>N. alba</i>	13.4*	16.1*	11.2*	33.63

* according to Nowak and Nowak (2007)

Fig. 3. Values of stigma diameter of *N. candida* specimens. Fig. 5. Flower diameter of *N. candida* specimens. Fig. 4. Number of carpellary teeth of *N. candida* specimens.

HABITAT PREFERENCES OF *NYMPHAEA CANDIDA* C. PRESL IN SOUTHERN POLAND

The populations of *N. candida* in southern Poland occupy mainly water bodies especially surrounded by forests, but in some cases also river ox-bow lakes within the meadow-field landscapes. The most suitable habitat conditions for this species occur in shallow waters in the shore zone with the amplitude of the water column fluctuating from 0.5 to 2 m. Populations of *N. candida* develop on open water or close to the rushes with high insolation rate. Higher shading influences directly on the decrease of density and cover rate of the species. In thick reeds or high rushes the species occurs sporadically with a low population size.

The significant number of these populations were found in artificial reservoirs – fish ponds or forest ponds. Regarding the trophy level *N. candida* occupies different habitats, mainly mesotrophic but also eutrophic with high content of organic matters (Table 3).

THE STATE OF THREAT OF *NYMPHAEA CANDIDA* IN SOUTHERN POLAND

To show the conservation state of *N. candida* in southern Poland, the number of localities for separate regions were compared (Table 4).

DISCUSSION

During the presented studies the extent area of southern Poland was surveyed aiming to solve the distribution problem of *N. candida* and *N. alba*. Both species of water lily are closely related and many morphological features overlap without any distinct differences. However, the number of carpellary teeth and the pollen diameter seems to be the most useful characteristic features for recognition of the two species as it hardly overlaps (Muntendam et al. 1996). The most useful diagnostic feature, even during the field studies, is the number of carpellary teeth, which is countable in flower as well as in the ovary.

Using the current botanical keys we come to the conclusion that, with no doubts, *Nymphaea candida* occurs in south Poland. Moreover, the preliminary analyses of the rarity of both species show, that *N. candida* is quite frequent. The number of carpellary teeth, which should not exceed 14, was often below 10. The mean value for the examined specimens was 9.29 (from 7 to 12). The mean value of pollen diameter was 43.95 μ m (the maximum value for *N. alba* doesn't exceed 42 μ m) and in some cases even more than 50 μ m (see the distribution list and Figures 6 and 7). Thus, all the individuals suited the range designated for *N. candida* by Muntendam et al. (1996), Wayda (2000), Rutkowski (1998) and others. Also the other countable features, like the diameter of the flowers (5.95 in average) or the proportion of the stigma diameter to the ovary one (mean value 0.6) evidently indicated *N. candida* (Table 1 and 2). Almost all plants had cup-shaped flowers, the

Fig. 6. Morphology of pollens of *N. candida* from Opole Silesia.

Fig. 7. Pollen diameter of *N. candida* specimens.

Fig. 8. Results of comparison of pollen diameters for *N. candida* and *N. alba* checked by *t* test.

square-shaped flowerbase (sometimes with a rough edge), the orange stigma, and the flower partially submerged in the water with erected sepals. Leaves were in the majority red or red-green on the bottom side with converging nerves of leafslips.

The results of the study in comparison to the recent researches on *N. alba* (Nowak and Nowak 2007) revealed the considerable differentiation among *Nymphaea* species. Remarkable differences were found within some diagnostic

features, such as the stigma diameter (5.95 mm for *N. candida* and 13.4 mm for *N. alba*) and the number of carpelary teeth (respectively 9.29 and 16.1). At the same time, the flower diameters also differ significantly reaching 5.95 for *N. candida* and 11.2 for *N. alba* (Table 1). The most important difference is within the value of pollen diameter, which has the average 43.95 for *N. candida* and 33.63 for *N. alba*. These values closely correspond with results of Muntendam et al. (1996) (adequately 43.6 and 34.1).

TABLE 3. Habitat characterisation of the surveyed population of *Nymphaea candida* in Opole Silesia.

Location	T [°C]	pH	E [$\mu\text{S}/\text{cm}$]	SD [cm]	TSI [SD]	Chl A [$\mu\text{g}/\text{dm}^3$]	TSI (chl)	TP [mg/dm^3]	TSI (TP)	TSI (mean)	Trophy
Gęsi Staw	22.7	6.8	673	100	60	3.68	43	0.28	52	52	Mezo/Eu
Skorogoszcz	24.7	7.1	939	160, bottom	-	2.39	39	0.48	60	49	Mezo
Łoża Pond	25	6.5	191	70	65	4.67	46	0.46	59	60	Eu
Sowin	24.5	6.2	262	60	67	4.62	46	0.74	66	63	Eu
Staw Nowokuźnicki	25.1	6.1	257	115	58	0.8	28	0.5	60	44	Mezo
Smolnik	26.5	6.6	139	175	52	2.23	38	0.3	53	51	Mezo/Eu
Lasowice	27.6	6.2	142	120, bottom	-	2	37	0.5	60	48	Mezo
Poliwoda	29	6.4	216	50, bottom	-	4.5	45	0.52	61	53	Mezo/Eu
Stobrawa	23.6	7.1	470	75	64	2.03	37	0.48	60	54	Mezo/Eu

Explanations: E – conductivity; T – temperature; TP – total phosphorus content; Chl – chlorophyll A content; TSI – Carlson Trophic Index

Former habitat analyses show that *N. candida* prefers mesotrophic, clear waters with mineral-organic substrates (Szańkowski and Kłosowski 1999; Kłosowski 2001). Some reports conclude that also eutrophic water reservoirs could give suitable conditions for development of *N. candida* populations (Tomaszewicz 1979). In the Czech Republic *N. candida* was found in varied types of water, among others in meso- and oligotrophic fish ponds, oxbow lakes and bog ponds (Tomšovic 1997). Within the researched area the species were noted in waters of intermediate character in terms of trophic level, between the values for meso- and eutrophy. Only in three sites populations of *N. candida* were found in evidently mesotrophic waters and in two cases in eutrophic. A slight shifting of the trophic level in the mesotrophy direction for the analysed samples is detectable when investigating the chlorophyll *a*. This analyse classifies the waters generally to mesotrophy and in the case of the Staw Nowokuźnicki pond even to oligotrophy (OECD 1982). Thus, we found the species able to thrive in poor waters of small, mid-forest ponds or bog ponds as well as in rich with mineral substances waters of fish ponds or oxbow lakes. Such adaptation potential significantly broadened the habitat amplitude of *N. candida* in southern Poland.

However, in comparison to *N. alba* habitats, it seems to be sure that *N. candida* occurs in waters of slightly lower trophic level, what was suggested earlier by Tomaszewicz (1979).

The outcomes of the conducted researches have considerable meanings for the phytogeography of the *Nymphaea* genus in Central Europe. They fill up the distribution gap in the southern part of *N. candida* range in Europe and definitely explain and prove the results of former researches. The continuous distribution of *N. candida* in southern Poland is also well-founded in climatic and ecological conditions (see Kłosowski 2001). With no doubts the south part of Poland is the transition area where the distribution ranges of both species overlap. Existence of hybrids within the genus could cause the morphological characters very unstable and labile making the easy determination of the species, its hybrids or introgressive forms hardly possible. Further cytological and genetic researches of different specimens of *Nymphaea* genus in southern Poland should

be conducted to solve the problem of genetic flow between the populations of both relatives and their hybrids.

The taxonomic and chorological surveys in neighbouring areas should be attentively monitored. Some interesting new data on the distribution of *N. candida* were published for the Saxony region in south-east Germany. The revision of the collected specimens and new field studies changed the regional range of the species, considerably diminishing the distribution acreage and splitting it into some small patches (Otto et al. 2000; Otto 2004). Thus, there is a question whether the natural south-western range of *N. candida* in Germany, Austria, the Czech Republic, Switzerland and Poland is continuous or patchy due to uncomfortable ecological conditions, e.g. too high elevation or a lack of suitable waters. This situation is possible for some areas in south Poland where we found scarce number of the *N. candida* population (e.g. Małopolska).

THE STATE OF THREAT OF *NYMPHAEA CANDIDA* IN SOUTHERN POLAND

The detailed study on the taxonomy and distribution of the species within the *Nymphaea* genus is obviously indispensable tool in proper management and effective conservation of both taxa (comp. Nowak and Nowak 2004). Without precise data relating to chorology, dynamic and range changes of these plants the legal protection of water lilies could be ineffective.

In the neighbouring countries *N. candida* is considered as a taxon with different dynamic and endangerment status. In the Czech Republic it was categorized as a critically endangered (Procházka 2001). Generally, in the area of Germany it is regarded as an endangered but in Bavaria as a critically endangered (Korneck et al. 1996). In the last edition of the Polish Red Data Book of Plant, Kłosowski (2001) treats *N. candida* as a vulnerable. Surprisingly, the species has not been red listed in Poland (Zarzycki and Szeląg 2006). In separate regions of southern Poland, *N. candida* was evaluated against criteria of IUCN and was classified as a vulnerable taxon in Opole Province (Nowak et al. 2008).

It is hardly possible to precisely determine the real degree of endangerment in the whole country using only informa-

TABLE 4. The endangerment status of *N. candida* in south Poland.

Province	Number of locations		Threat category
	Before 2001	2001-2008	
Lower Silesian	34	11	NT
Lubelskie	52	5	EN
Małopolskie	4	1	VU
Opolskie	18	27	LC
Podkarpackie	1	2	VU
Silesian	31	4	EN
Świętokrzyskie	4	7	LC
S Poland	144	57	LC

tion from southern regions of Poland. Because of the taxonomical discrepancies there is also a lack of credible data in some regions. So, it seems to be indispensable to verify the synanthropodynamic situation of *N. candida* as well as *N. alba* in whole Poland.

The comparative analyses within the different time periods for separate regions of southern Poland show, that for some provinces *N. candida* increases the number of locations. Inconsiderable decrease is observed in case of Lower Silesia, much worse is the situation in Upper Silesia (Table 4). Even worse is the situation in Lubelskie voivodeship, however, there are some additional information relating to pollen findings of *N. candida* in several lakes, which were not included in presented assessment (see Bałaga et al. 2002; Bałaga 2007a, b). In some regions (e.g. Podkarpacie) the species was found for the first time. However it does not prove its expansive properties, but rather reflects the intensification of floristic surveys and shows the potential of *N. candida* to settled in mountainous areas. It is also worth to mention that in some regions (north-eastern part of the Małopolska Uppland or Opole Silesia) the species is more frequent than *N. alba* (comp. Nobis 2007).

According to the IUCN guidelines to species assessment (IUCN 2001) the data gathered during the presented study do not allow to consider *N. candida* as a vulnerable species in Poland. Still existing populations known from the XIX century, numerous stable locations and abundant populations in some regions at present suggest that the species should be regarded as a least concern (LC). Also the analyze of the habitat accessibility, a biotope extent, an ecological amplitude against the trophy level and direct human impacts support this categorization. Nevertheless it is probable, that in some regions the species could have the considerable withdrawing tendency and has to be red listed in higher categories.

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