

# The locality of *Trapa natans* L. within the region of Międzyodrze – dangers and protection perspective (the Lower Oder Valley, West Pomerania)

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**Abstract.** Research on a critically endangered and protected population of *Trapa natans* was carried out during growing season in 2016 at the site located on the Obnica channel within the region of Międzyodrze. It is a location that is close to the one indicated in historical sources by Winkelmann over 120 years ago. The post-war research did not confirm presence of this species within the region of Międzyodrze despite favourable biological conditions. The sites were declared relict and documented only in stratigraphy of peat deposits, detritus gyttja and bottom mineral sediments. Recently, an assessment of the population and habitat status were carried out. The appropriate indicators of the species status were examined according to the methodology of Chief Inspectorate of Environmental Protection. The floristic composition of *Trapa natans* association patches found within the researched site were analysed, reed bed associations belonging to the class of *Phragmitetea* and plant communities of pleustophytes, nymphaeids and elodeids belonging to the class *Potametea* and *Lemnetea* were recognised in the contact zone. On the basis of the collected data, particular attention was paid to the relevance of *Trapa natans* monitoring at the site located on the Obnica channel within the Międzyodrze region due to its indicative character. The conservation status of the population could be influenced by the change of water trophy within Międzyodrze channels caused by different forms of anthropopressure, including commercial use of this water body, hydromeliorative works, changes that are due to the progressive succession of water plants and reeds, which slow down the water flow rate within the area of Międzyodrze, favour accumulation of organic matter and increase of water trophy as well as fluctuations of surface water thermal activity caused by changing weather conditions.

**Key words:** *Trapa natans*, nature habitats, endangered species, protected species, Western Pomerania, Międzyodrze

## 1. Introduction

*Trapa natans* L. is a species that is critically endangered in Poland and in neighbouring countries (CE) (Każmierczakowa *et al.* 2014) and is protected by virtue of the Bern Convention. Placed on the “Polish Red Data List of Pteridophytes Species and Flowering Plants”, it is categorised in Poland as a “Vulnerable Species” (VU), while in Europe as “Near Threatened” (NT) one (Każmierczakowa *et al.* 2016). In Poland, this taxon is classified as a disappearing species within regions of West Pomerania and Wielkopolska (Żukowski & Jackowiak 1995), and it is under strict legal protection

by virtue of the Regulation of the Polish Minister of Environment of October 9, 2014 on the protection for species of plants (Regulation 2014).

It is an annual aquatic plant rooted in the silty bottom at a depth of 1-2 meters and forming long, flaccid, underwater shoots creating a rosette of floating leaves and bisexual flowers. The fruit of *Trapa natans* is a large nut with woody pericarp forming four hook-shaped outgrowths with harpoon-like endings. *Trapa natans* is a light-loving species requiring warm waters with neutral pH and high nitrogen and phosphorus compounds content, mainly found in shallow oxbow lakes and fish ponds (Szańkowski & Kłosowski 1999; Kamiński

2012). Heat-loving phytocoenoses of *Trapa natans* association (Müll et Görs 1969), which represent the subcontinental-Mediterranean type of range prefer shallow, eutrophic bodies of water that heat up strongly in summer (Matuszkiewicz 2013).

From a historical point of view, this species was of great importance as a domesticated plant, naturally widespread in Europe and Asia, brought to America and Australia where, in some countries, it became an invasive species that was eradicated (Pemberton 1999; Tall *et al.* 2011).

Nowadays, this species can be found in Poland mostly in southern foothill areas of the country. Its sites are located mostly near upper and middle courses of the Oder, Vistula and San rivers within the area of the Sandomierz Basin, Oświęcim Basin and Silesian Basin (Każmierczakowa *et al.* 2014). Over the last century, the range of *Trapa natans* decreased considerably and the species disappeared from about 190 sites, among them from about 60 sites during the last 25 years (Piękoś-Mirkowa & Mirek 2003).

*Trapa natans* was considered an extinct species in West Pomerania. The most recent pieces of information concerning this species occurrence within this part of the Oder Valley come from German botanists' research papers (Homann 1828, 1830, 1835; Winkelmann 1896; Hueck 1937). In northern Poland, *Trapa natans* occurs in Gdańsk Pomerania in Mirachowskie Lake (Conwentz 1893, 1900), within the region of Ostrów Island in Gdańsk (Conwentz 1890, 1892, 1895) as well as within the region of Lębork, Puck and Wejherowo (Kumm 1897).

First information concerning historical range of *Trapa natans* occurrence in West Pomerania was given by Hueck (1937). The spreading of this species in historical, fossil and interglacial sites in Poland and in neighbouring countries was presented by Hryniewiecki (1950). These data are also included in the study written by Zając & Zając (2001). On the basis of available data, it can be stated that West Pomerania was an area of occurrence of only rare fossil sites of species, and for more than 100 years, this species sites in aquatic plants communities were not reported within this area.

Particular evidences of the relict site and historical range of this species are provided by subfossil remains of *Trapa natans* identified in mineral and organic sediments. The fruits of *Trapa natans* do not decompose and persist in a perfect state among the subfossil remains cumulated in bottom sediments. During research on peat deposits and flora of Międzyodrze carried out between 1957 and 1958 (Kwarta & Jankowski 1958), a large amount of *Trapa natans* fruits was found in stratigraphic profiles of mineral sediments. The layers of sediments with preserved water chestnuts reached the thickness of 1.00-1.50 m, and they persisted in detritus gyttja in lower

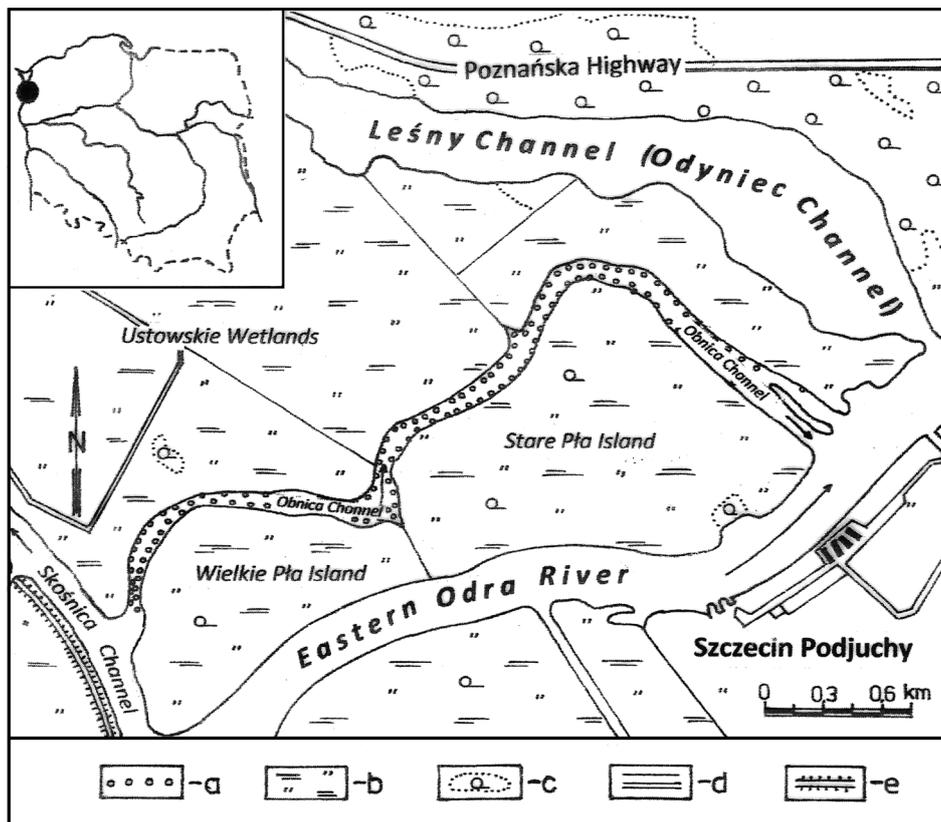
parts of the deposit at the depth of 2.75-3.75 m. Field research carried out at that time within the Oder Valley did not confirm the occurrence of this species site.

The occurrence of *Trapa natans* in waters within channels in the northern part of Międzyodrze was stated in June 2016 during a field workshop for employees of the Regional Directorate for Environmental Protection in Szczecin devoted to plant species and phytocoenosis which define protected natural habitat Natura 2000 "Oxbow lakes and natural eutrophic water bodies with *Nymphaeion*, *Potamion*-type of vegetation" (code: 3150). The location of the site indicates that it is a probable place of occurrence of species mentioned by Winkelmann (1896). The research on flora carried out so far, among others between 1994 and 1999 in the waters of numerous channels and oxbow lakes located near the so-called general Batow war route, which passes through the town of Daleszewo situated by the East Oder and the town of Moczyły situated by the West Oder, failed to confirm the occurrence of *Trapa natans* in other regions of Międzyodrze, despite the fact that this region is characterised by the presence of numerous channels, oxbow lakes and large bodies of water that create favourable conditions for the occurrence of this species (Jasnowska *et al.* 2002a, 2002b).

The aim of the study was to assess the status of the *Trapa natans* population according to the Chief Inspectorate of Environmental Protection methodology and to supplement our knowledge about the spread of this taxon in the area of Międzyodrze over 100 years after its disappearance in this area.

## 2. Material and methods

The site of the rich population of *Trapa natans* is located in the open water zone before reeds on both sides of the Obnica channel along its entire length. The Obnica channel is one of numerous water arms of Międzyodrze. It joins the East Oder (Regalica) with the current of Skośnica oxbow lake (Fig. 1). The length of this part of Obnica from the East Oder to its mouth to Skośnica is 2820 m (53°20'26"N 14°32'06"E source; 53°21'55"N 14°34'51"E river mouth). In the narrowest places, the channel width is about 27 m; in the widest places, it reaches up to 90 m. On the crucial river stretch, the channel width oscillates from about 50-60 m. The total water surface within the channel is 18.15 ha. The location as well as the south-western direction of Obnica channel route makes it possible to keep its waters away from the influence of the East Oder water current. This kind of location creates very favourable conditions for the development of this species. The entire area, including the sites of *Trapa natans*, is located within borders of the bird refuge Natura 2000 "the Lower Oder Valley" PLB 320003.



**Fig. 1.** Location and spread of *Trapa natans* in the Obnica channel in Międzyodrze  
 Explanations: a – the zone of *Trapa natans* occurrence, b – rushes, c – alluvial forests, d – ditches, canals, e – shafts

In August and September 2016, during field research, the status of *Trapa natans* population and its habitats on the new site were assessed according to the Chief Inspectorate of Environmental Protection methodology (Kamiński 2012). The cardinal indicators of the population and habitat status, such as the number of individuals measured by the number of floating rosette leaves, average number of fruits and their primordia in rosette, habitat surface settled by the population, positive and negative changes observed in habitat, were examined.

The phytosociological characterisation of both phytocoenosis with domination of *Trapa natans* and neighbouring vegetation of river-margin and littoral zone were carried out. Samples of phytoplankton with the volume of 5 l from the depth of 0.5-1.0 m were taken from the subsurface water zone using a water sampling dipper with a volume of 10 l. Samples were thickened with plankton net number 25. At the same time, water pH and temperature were measured with a pH meter CP-411. Water transparency was measured with a Secchi disk.

### 3. Results

Assessment of the *Trapa natans* population according to the Chief Inspectorate of Environmental Protection methodology made it possible to compare with other

monitored populations in the country (Table 1). The average density of rosettes in *Trapa natans* plant community, the lack or the small number of flowers and fruit in rosettes, and the mean habitat fragmentation resulting from the use of canals as medium-intensity waterways, led to an overall assessment of the monitored population at the Obnica Channel as inadequate (U1). However, the re-appearance of this population is a valuable material for comparative research, which should be based on systematic monitoring of this population.

#### 3.1. Spreading, range and structure of *Trapa natans* phytocoenosis

The phytocoenosis of *Trapa natans* (Müll. et Görs 1969) develops in the open-water zone of Obnica channel, which is dominated by dense aggregations of *Phragmitetum australis* reeds (Gams 1927; Schmale 1939), less often by *Glycerietum maximae* (Hueck 1931). Local, small surfaces of the terrestrial water-edge zone of the channel are occupied by reeds belonging to the order *Magnocaricion* (Koch 1926), represented by *Thelypteridi-Phragmitetum* (Kuiper 1957), *Caricetum ripariae* (Soó 1928), *Caricetum acutiformis* Sauer 1937 and *Caricetum gracilis* (Graebn and Hueck 1931 and R. Tx. 1937). Shallow waters of the river-margin

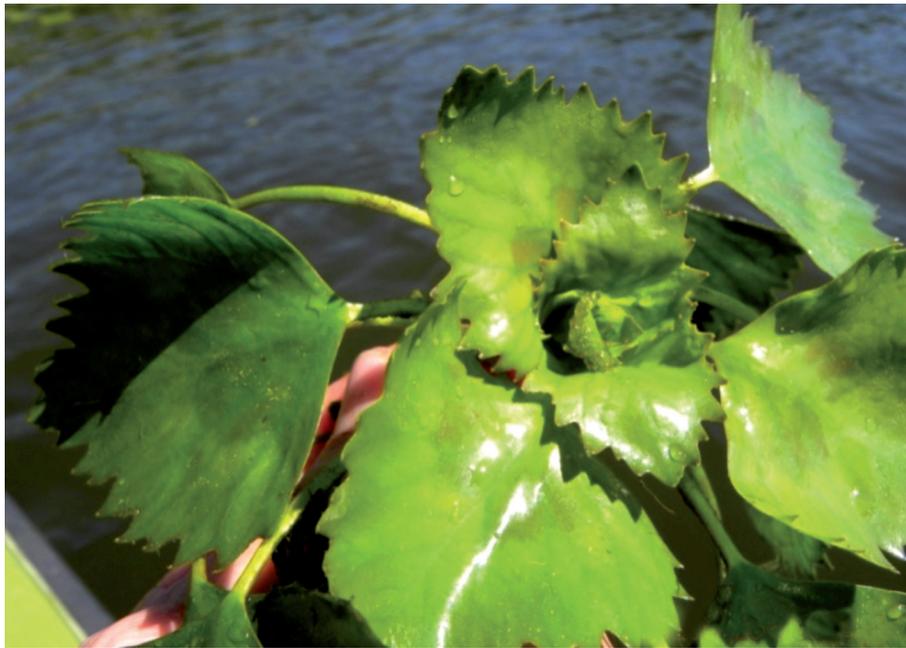
**Table 1.** Assessment of *Trapa natans* population in the waters of the Obnica channel in the northern part of Międzyodrze

Indicators	The value of the indicator and comment	Rating
Population		
Population size (number of rosettes)	4500-5500 specimens	xx
Concentration of individuals (rosettes) in patches	3 (1-5) rosettes/m <sup>2</sup>	U1
Average number of fruit and fruit bunches in rosettes	4 (0-9) specimens	U1
Rosette diameter	31 cm (25-47 cm)	FV U1
Phytosanitary condition of plants	No signs of pests or the presence of other pathogens	FV
Number of leaves in rosette	17 (13-28)	FV
Number of patches	Loose spread of the patches about 6-7 clusters	FV
Habitat		
Area of occupied habitat	15% of the old river bed area, about 0.24 ha	FV
Area of potential habitat	1,8 ha	FV
Fragmentation	average	U1
Shading of the site	lack	FV U1
Competitive species	<i>Nupar lutea</i> 10%, <i>Nymphaea alba</i> 5%	FV
Protection perspective	If the exploitation of the channels within the area of Międzyodrze does not intensify and any works regulating water flow, including the cleaning and removal of aquatic vegetation that slows down the water flow, are not carried out, the population will be stable. The extent of the area of Międzyodrze minimises the risk of water environment contamination.	FV
Active conservation measures	Have not been taken so far	
Overall rating		U1

zone are settled by small concentrations of *Sagittario-Sparganietum emersi* (R. Tx. 1953). Formations of reed vegetation border with the associations belonging to the *Potametea* (R. Tx. and Prsg.) class or the class of

*Lemnetea minoris* (R. Tx. 1955). Communities of hydrophytes occurring in contact with patches of *Trapa natans* are formations of pleustophytes, nympheids and elodeids. They are represented by: *Spirodeletum*

**Fig. 2.** *Trapa natans* rosette in the middle of the water of Obnica (photograph by W. W. A. Kowalski)



**Fig. 3.** *Trapa natans* rosette with the resulting fruit (photograph by W. W. A. Kowalski)

*polyrhizae* (Kelhofer 1915, Koch 1954 em.), *Ricciocarpetum natantis* (Segal 1963 em. R. Tx. 1974), *Nuphar-Nymphaeetum albae* (Tomasz. 1977), *Hydrocharitetum morsus-ranae* (Langendonck 1935) and an association of *Myriophyllum spicatum* (Soe 1927). In some places, there are patches of *Potamogeton nodosus* Poir that vary on the surface (= *Potamogeton fluitans* Roth) (Kowalski & Wróbel 2011).

The phytocoenosis of *Trapaetum natantis* on the researched site occupies a stretch of water varying in width from 4 to 12 m on both sides of the Obnica channel along the entire length covering about 15% of water surface of the oxbow lake with a surface of 1.8 ha (Fig. 2). Rosettes floating on the water surface create more or less dense patches with an average coverage of about 65-75%. The eutrophic character of water, its small depth and quick

**Table 2.** Association of *Trapaetum natantis* Müll. et Görs 1969 in the waters of the Obnica channel in the northern part of Międzyodrze

Successive number of <i>relevé</i>	1	2	3	4	5	6
Date: Day/Month/Year	16. 07. 2016					
Area of <i>relevé</i> (m <sup>2</sup> )	25	20	25	25	25	25
Cover of layer c (%)	75	55	55	55	75	85
Number of species in <i>relevé</i>	4	8	5	8	2	7
<b>Ch. Ass. <i>Trapaetum natantis</i></b>						
<i>Trapa natans</i>	5.5	4.5	4.5	4.4	5.5	1.2
<b>Ch. All. <i>Nymphaeion</i></b>						
<i>Nuphar luteum</i>	.	.	+	1.3	.	5.5
<i>Hydrocharis morsus-ranae</i>	+	1.3	.	1.3	.	.
<i>Nymphaea alba</i>	.	.	.	+	.	+
<i>Stratiotes aloides</i>	.	+	.	.	.	.
<b>Ch.O., Cl. <i>Potametalia, Potametea</i></b>						
<i>Ceratophyllum demersum</i>	.	+	+	.	.	+
<i>Myriophyllum spicatum</i>	.	.	.	+	+	+
<i>Potamogeton fluitans</i>	.	1.2	.	.	.	.
<b>Accompanying species</b>						
<i>Spirodela polyrhiza</i>	+	1.2	1.2	1.3	.	+
<i>Lemna minor</i>	+	+	+	1.1	+	+
<i>Ricciocarpus natans</i>	.	+	.	+	.	.

heating up with almost entirely reduced water flow encourage the development of rosettes that reached the diameter of 35-40 cm and significant density in the last stage of vegetation (Fig. 3). The structure of association and presence of other taxons of macrohydrophytes in habitat are documented by phytosociological relèves (Table 2).

*Trapetum natantis* in Obnica waters is almost monospecific association. A few species of pleustophytes occur only in several patches. They are represented by *Spirodela polyrhiza*, *Ricciocarpus natans* and, less often, by *Lemna minor*. Aggregations of *Trapa natans*, which are dense on the surface, are separated by rare patches of *Nupharo-Nymphaeetum albae* association of about 15-25 m<sup>2</sup>. Small patches of *Hydrocharitetum morsus-ranae* association penetrate the contact zone with reeds growing in the river-margin zone. In the waters of the Obnica channel, *Trapa natans* occurs also in patches of *Nupharo-Nymphaeetum albae* association. Its presence in this association is significantly limited by dense leaves of *Nuphar lutea*, less often by the leaves of *Nymphaea alba* floating on the water surface.

### 3.2. Habitat conditions

A part of Obnica channel between East Oder (Regalica) and current of Skońnica oxbow lake, in relation to its south-western stretch, is an open water body which is not subjected to the intensive process of reed vegetation penetration and terrestrialisation. In the deepest parts, in the middle part of the channel width, its depth reaches about 3 m. The river-margin zones in the frontal part of reeds, settled by *Trapetum natantis* phytocoenosis,

are definitely shallower, and the depth of their waters oscillates between 1.5-1.8 m. The channel bottom is composed of shallow organic peat sediments covered with a layer of aggragate mud varying in thickness. Their character is mineral and organic. An important factor encouraging the development of *Trapa natans* population in the water of the Obnica channel was the rapid heating up of oxbow lake waters. Their temperature in the subsurface zone in August reached 24°C. The water pH stood at 6.9-7.2.

### 3.3. Species of phytoplankton

To determine the quality of the water of the *Trapa natans* population, the phytoplankton study was carried out in July and August in 2016. The table below summarizes the dominant species of plankton and the value of water quality indicators given by Sládeček & Sládečková (1996) (Table 3).

Phytoplankton of the Obnica waters within the *Trapetum natantis* site is dominated by species from the order *Chlorococcales* (*Chlorophyta*), with the participation of *Bacillariophyceae* planktonic forms. The qualitative structure of phytoplankton as well as periphyton forms growing on the shoots of macrohydrophytes clearly indicates the eutrophic nature of the habitat (Sládeček & Sládečková 1996). At the same time, indicators of water contamination of the Obnica channel indicate their affiliation to the  $\beta$ -mezosaprophytic zone. Analysis of phytoplankton confirms the compliance of the quality of habitat waters with the ecological requirements of *Trapa natans*.

**Table 3.** Indicators and indices of water trophy in the occurrence zone of *Trapa natans*

No.	Phytoplankton dominants	Value of the saprophytic zone indicators				Saprophytic index of taxa	
		<i>o</i>	$\beta$	<i>a</i>	<i>p</i>	Ii*	Si**
1.	<i>Pediastrum boryanum</i> (Turp.) Menegh.	2	7	1	-	3	1.9
2.	<i>P. duplex</i> Meyen	3	6	1	-	3	1.8
3.	<i>P. tetras</i> (Ehrenb.) Ralfs	3	6	1	-	3	1.8
4.	<i>Coleastrum microporum</i> Näg.	2	5	3	-	2	2.1
5.	<i>C. asteroidem</i> De-Not.	2	6	2	-	3	2.0
6.	<i>Scenedermus acuminatus</i> (Lagerh.) Chod.	-	8	2	-	4	2.2
7.	<i>S. obliquus</i> (Turp.) Kütz.	-	3	6	1	3	2.8
8.	<i>Desmodesmus opoliensis</i> (P. Richter) Hegewald	1	6	3	-	3	2.2
9.	<i>D. communis</i> (Hegewald) Hegewald	2	5	3	-	2	2.1
10.	<i>Ankistrodesmus falcatus</i> (Corda) Ralfs	2	5	3		2	2.1
11.	<i>Oocystis lacustris</i> Chod.	4	6	-	-	3	1.6
12.	<i>Crucigenia tetrapodia</i> (Kirchn.) W.& G. S. West.	3	5	2	-	2	1.9
13.	<i>Aulacoseira granulata</i> (Ehrenb.) Simonsen var. <i>granulata</i>	2	8	-	-	4	1.8
14.	<i>Cyclotella meneghiniana</i> Kütz.	-	4	5	1	2	2.7
15.	<i>Tabellaria flocculosa</i> (Roth) Kütz.	6	-	-	-	3	0.6

Explanations: Zone, *o* – oligosaprophytic,  $\beta$  – mesosaprophytic, *a* – mesosaprophytic, *p* – polysaprophytic; Ii\* – taxon trophy index; Si\*\* – saprophytic index of taxa

#### 4. Discussion

The observations of the *Trapa natans* population state and the habitat conditions show that, currently, the site located in Międzyodrze is not endangered despite the fact that the overall rating of the monitored population at the Obnica Channel was inadequate (U1) due to the small number of flowering and fruiting specimens as well as the fragmentation of *Trapa natans* patches at the described site (Table 1). In accordance with the assumptions of the population monitoring methodology, the overall rating is influenced by the lowest rating of any population indicator used in the assessment of the monitored population (Kamiński 2012). In this case, the predominance of vegetative specimens indicates the developmental potential of the population that renewed itself after many years at the historical site and is at the stage of dynamic development and increasing its range. The observed recovery of this species on historical sites confirms the reports from other regions of the country where the successful reintroduction or population growth occurred in monitored sites, along with the improvement of habitat conditions and reduced competitiveness, mainly from nymphs, improving light conditions and water flow rates after cleaning works of tanks from excess organic matter (Tall *et al.* 2011; Dżigurski *et al.* 2013; Smieja & Ledoń 2013; Bryl *et al.* 2016). It remains invariably attached to this species of high trophic state of waters, which confirms the nature of aquatic vegetation and submerged vessel that accompanies population *Trapa natans* on documented positions, including planktonic and periphytonic algae (Hryniewiecki 1950; Sládeček & Sládečková 1996; Piórecki 2001). It is necessary to continue physico-chemical studies of water, including the content of ammonium nitrogen and phosphates, especially in sites where the population of *Trapa natans* is regenerating or fluctuations in the number of individuals are observed as a result of previous works improving the flow of water in rivers and reservoirs. This allows to develop methods of active protection that encourage the regeneration of *Trapa natans* at endangered sites and to eliminate actions that significantly negatively influence the behavior of the species (Kamiński 2012). Particularly valuable is monitoring of the rate of rebirth of the *Trapa natans* population, where the habitat conditions are formed by

self-regulation mechanisms related to the water flow rate of water trophies, succession of water vegetation and the nature of surface waters use. These are the advantages of the position of the site from the area of Międzyodrze (Kowalski & Wróbel 2011). Intensive process of overgrowth of the lake caused by formations of reed vegetation was observed in the entire Obnica oxbow lake. High water trophy and poor water flow in channels encourage heating up of surface water layers, providing stable and favourable conditions for the development of *Trapa natans* population on this site. An important factor regulating this process is quite significant depth of waters and the oxbow lake width. The location of the site in the vast wetland of Międzyodrze also eliminates the risk of potential contamination of the water environment (Ziarnek & Ziarnek 2002).

The hydromeliorative works planned in the future, regulation of channels and passability of oxbow lakes aiming to increase water flow rates and weakening, at the same time, the process of slow succession and overgrowth of the water body of Międzyodrze may cause unpredictable consequences for the population of *Trapa natans*. Despite the fact that anthropogenic causes of surface water eutrophication and hydromeliorative works are considered one of the main reasons of expansion and spreading of this species, these actions lead to the creation of mono-specific aggregations of macrohydrophytes, impoverishment of species composition of phytocoenosis and decrease in general biodiversity at the level of species and plant communities (Szańkowski & Kłosowski 1999; Dżigurski *et al.* 2013).

Long-term monitoring of the *Trapa natans* site on the Obnica channel within the region of Międzyodrze is necessary due to its indicative character and reveals:

- a) changes of water trophy within Międzyodrze channels caused by different forms of anthropopressure, including commercial use of this water body and hydromeliorative works,
- b) changes caused by progressing succession of aquatic and reed vegetation that slow down the water flow rate within this water body, encouraging the accumulation of organic matter and an increase of water trophy.
- c) fluctuations in surface waters thermal activity caused by changing weather conditions with periods of extreme high temperatures in summer.

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