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FIRST RECORD OF *AMPHORA OHRIDANA* (BACILLARIOPHYCEAE) IN POLAND*

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Abstract. Within the EU SWITCH project we studied benthic diatoms of the Sokołówka River and five reservoirs along it. In 4 of 14 selected sampling stations we recorded a species new for the diatom flora of Poland, *Amphora ohridana* Levkov. Diagnostic features such as valve dimensions and number of striae differed from its original description. *Amphora ohridana* Levkov was described in the near-oligotrophic Lake Ohrid; the water of the Sokołówka River has extremely different conditions: high conductivity, very high concentrations of nitrogen and phosphorus compounds, and a high amount of total suspensions.

Key words: *Amphora*, diatom, taxonomy, variability, ecology

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INTRODUCTION

Diatoms (Bacillariophyceae) are qualitatively and quantitatively important components of the microflora of all aquatic environments. Among the diatoms are ubiquitous species and others that have narrow and clearly defined tolerance ranges of selected environmental conditions. Is the tolerance of diatoms to environmental conditions constant? Do they adapt to the changes in the environment, and if so, how quickly. Some diatoms probably are expanding their range of occurrence, while others become local subpopulations which may initiate a new species in the future (Wilk-Woźniak & Wojtal 2005).

The habitats characterized by higher stability of environmental conditions include peat bogs and springs that have not been transformed by human impacts or are affected only to a limited extent (Ziułkiewicz & Żelazna-Wieczorek 2007). Highly contaminated waters such as small rivers in the urbanized areas are characterized by lower stability of environmental conditions.

The Sokołówka River has been included under European Framework Project SWITCH since 1996. The Project was set up in order to balance urban water resources management (Wagner *et al.* 2008). Under the Project, physical and chemical parameters of the water in the Sokołówka River have been monitored. In 2007–2008, hydrobiological studies were made, which included ecological and taxonomic analyses of the river's benthic diatoms. Based on qualitative and quantitative analyses of the diatom taxa, the ecological status of the river was determined (Żelazna-Wieczorek *et al*. 2008).

Amphora ohridana was described by Levkov (Levkov *et al.* 2007) during studies of the pelagial from Lake Ohrid in Macedonia. Presently this species was identified during diatomological studies of the Sokołówka River. *A. ohridana* was not recorded previously in Poland.

The aim of present research was to determine the variability of the taxonomical features of *Amphora ohridana* and its range of tolerance to environmental conditions, on the basis of our observations and the original description of this species.

CHARACTERISTICS OF STUDY AREA

The spring of the Sokołówka River is located at 210 m a.s.l. in the city of Łódź (central Poland); it then passes through the northern part of

* Dedicated to Dr. Kurt Krammer on the occasion of his 85th birthday

the city. The river ends its course in the suburbs after 13.4 km. The Sokołówka River is a left-bank secondary flow of the Bzura River (Czarnecka 1983). The catchment area of the Sokołówka River covers 44.5 km^2 (Wagner *et al.* 2008). The average longitudinal slope of the stream channel amount is 6%, and its average flow regime 0.17 $m^3 \cdot s^{-1}$ (Bocian *et al.* 2000).

The Sokołówka River is a typical urban stormwater receiver. The river's natural flow was altered, as the main channel was regulated with concrete slabs to straighten the course and deepen the bed for the purpose of runoff retention (Wagner *et al.* 2008). Agriculture uses 60% of the stream catchment, 33% is built over, and 7% is forest and wetlands (Bocian *et al.* 2000). The river is supplied mostly by stormwater outlets.

Beginning from the upper course of the river, the water in the Sokołówka River is highly degraded and highly polluted. The river carries a high load of total suspensions – from 3.4 $mg \cdot l^{-1}$ to 307.6 $mg \cdot l^{-1}$. The suspensions pile up at the bottom of the five reservoirs along the river bed. Water conductivity ranges from 180 to 1112 $\mu S \cdot cm^{-1}$. The water salinity fulfills freshwater conditions and ranges from 21 $mg \cdot l^{-1}$ in the upper course of the river to 89.4 $mg \cdot l^{-1}$ in the middle course. It is slightly alkaline, with 7.5–9.3 pH. During the spring season the range of chlorides exceeds 100–217 $mg \cdot l^{-1}$ and dissolved oxygen is highest, at 28 $mg \cdot l^{-1}$. During the summer, water in this small shallow river warms quickly, so the oxygen concentration falls locally as much as 10%. The water in the Sokołówka River also has a high concentration of biogenic compounds; potassium from 4.9 $mg \cdot l^{-1}$ to 26.3 $mg \cdot l^{-1}$, and phosphorus including phosphate from 0.01 $mg \cdot l^{-1}$ to 0.6 $mg \cdot l^{-1}$. The annual nitrogen load from urban terrain to the Sokołówka River amounts to 5.528 $kg \cdot ha^{-1}$, and phosphorus amounts to 0.378 $kg \cdot ha^{-1}$ (Bocian *et al.* 2000).

Materials and methods

Within the SWITCH Project, 14 sampling stations on the Sokołówka River were selected: 9 on the river channel and 5 at its reservoirs (Fig. 1). Benthic samples were collected three times a year in April, July and October during two years of study, 2008 and 2009. All 84 samples were prepared for LM observations.

The samples for biological studies and for physical and chemical water analysis were collected at the same time. Benthic samples were collected with a pipette aspirator into 125 ml containers alive and were transported to the laboratory. Then every sample was preserved with 4% solution of formaldehyde.

For diatom preparation, to obtain clean frustules the collected material was chemical immersed in concentrated sulfuric acid (H_2SO_4 – few drops) and 20% chromic acid ($H_2Cr_2O_7$). After repeated washing and centrifugation of samples, the cleaned diatoms were embedded in Naphrax® (refraction index 1.73) and permanent microscope slides were made.

Material in the form of wet samples, cleaned diatom sediment, and permanent microscope slides is deposited in the Department of Algology and Mycology, University of Łódź.

Taxonomical analysis of benthic diatoms was made

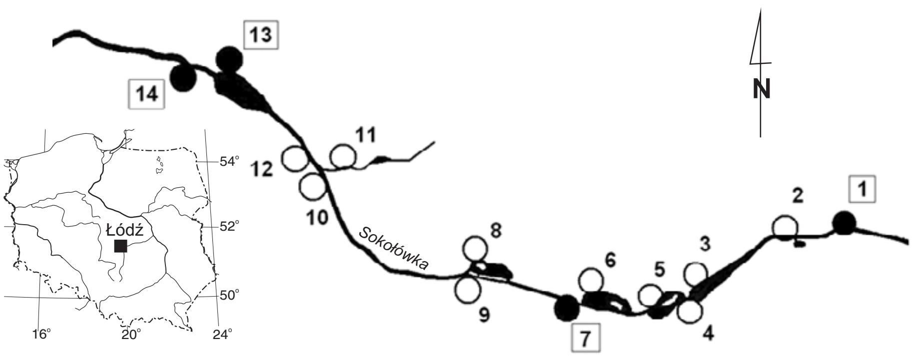

Fig. 1. Sampling stations along the Sokołówka River (filled circles – stations with *Amphora ohridana* Levkov records).

Table 1. Measurements and characters of a valve of *Amphora ohridana* Levkov noted in the Sokołówka River and in Lake Ohrid. * – median.

Features	Sokołówka River	Lake Ohrid
Length, µm	33.3–66.7(43*)	41–62
Width, µm	8–14(10)	10–13
Dorsal striae in 10 µm	10–13	11–14
Ventral striae in 10 µm	9–13	11–13

on the basis of permanent slides with a Nikon Eclipse E-400 light microscope at 1000× PLAN Achromatic (100 × 1.25 Plan oil-immersion objective). Photomicrographs were made with the NIKON E 400 LM and NIKON DS-L1 digital camera.

RESULTS

Morphological characters of *Amphora ohridana* Levkov: semi-elliptical to lanceolate valves with convex, arched dorsal margin and slightly concave ventral margin, tumid in its middle part; valve length 41–62 µm, width 10–13 µm. Axial area very narrow. Central area on dorsal side small, rounded or rhombic, on ventral side narrow, semi-elliptical, usually closed by a groove that interconnects areolae on ventral striae. Proximal raphe ends dorsally deflected. Striae on dorsal side parallel in middle part of valve, 11–14 in 10 µm, becoming radiate at ends, finely punctate. Striae on ventral side 11–13 in 10 µm, radiate in middle part, becoming convergent at ends, composed of two areolae (Levkov *et al.* 2007).

The specimens of *A. ohridana* identified in the Sokołówka River are characterized by a wider range of valve dimensions than described from the Lake Ohrid specimens (Table 1, Fig. 2: 1–8 & Fig. 3: 5–9).

In the Sokołówka River, *A. ohridana* occurred in every sample collected from stations 1, 7, 13 and 14, with less than a 1% share in the samples. It was noted in larger numbers in the final course of the river (station 14) and in Pabianka reservoir (station 13). In this part of the river there is a thick layer of organic and inorganic sediment on the bottom. Specimens of *A. ohridana* were also found at the first station, but this part of the river, located close to its spring, was constantly affected by pollution escaping into the river from the storm channel. At some stations *Amphora ohridana* occurred with *Amphora ovalis* (Kützing) Kützing (Fig. 3: 1–4). The dominant taxa, with higher abundance in the diatom assemblages from sampling stations where *A. ohridana* occurred, were *Achnanthidium minutissimum* (Kütz.) Czarn., *A. saprophila* (Kobayasi & Mayama) Round & Bukht., *Craticula accomoda* (Hust.) Mann, *Cyclotella atomus* Hust., *C. meneghiniana* Kütz., *Cyclostephanos invisitatus* (Hohn & Hell.) Theriot, Stoermer & Håkk., *Eolimna minima* (Grun.) Lange-Bert., *Gomphonema micropus* Kütz., *G. parvulum* (Kütz.) Kütz. var. *parvulum*, *Mayamaea lacunolaciniata* Lange-Bert. & Bonik, *Melosira varians* Ag., *Navicula gregaria* Donk., *N. lanceolata* (Ag.) Ehrenb., *N. trivialis* Lange-Bert., *N. veneta* Kütz., *Nitzschia capitellata* Hust. in Schm., *N. palea* (Kütz.) W. Sm., *Platessa conspicua* (A. Mayer) Lange-Bert., *Rhoicosphenia abbreviata* (Ag.) Lange-Bert. and *Stephanodiscus hantzschii* Grun. in Cl. & Grun. The dominants had shares higher than 5% in the samples. Most of these were eutraphentic and hypereutraphentic taxa, and α-meso-/polysaprobous and polysaprobous (Van Dam *et al.* 1994).

DISCUSSION AND CONCLUSION

TAXONOMICAL REMARKS. *Amphora ohridana* Levkov described from the pelagial of Lake Ohrid has not been recorded in Poland previously. One reason for this is probably the similarity of its frustule dimensions and ornamentation to *Amphora ovalis* (Kützing) Kützing, which is frequently recorded in Poland. Under LM, *A. ohridana* might be misidentified with *A. ovalis* and *A. hemicycla*, whose diagnostic characters are similar. The morphological features of *Amphora ohridana* Levkov, *A. ovalis* (Kützing) Kützing and *A. hemicycla* Stoermer & Yang are compared in Table 2, according to Levkov (2009).

ECOLOGICAL REMARKS. The environmental conditions of Lake Ohrid, where *Amphora ohridana* was first noted, were characterized in 2004–2006 as neutral to weakly alkaline, with pH 6.8–7.8 and conductivity 181–434 µS · cm^{-1} (average

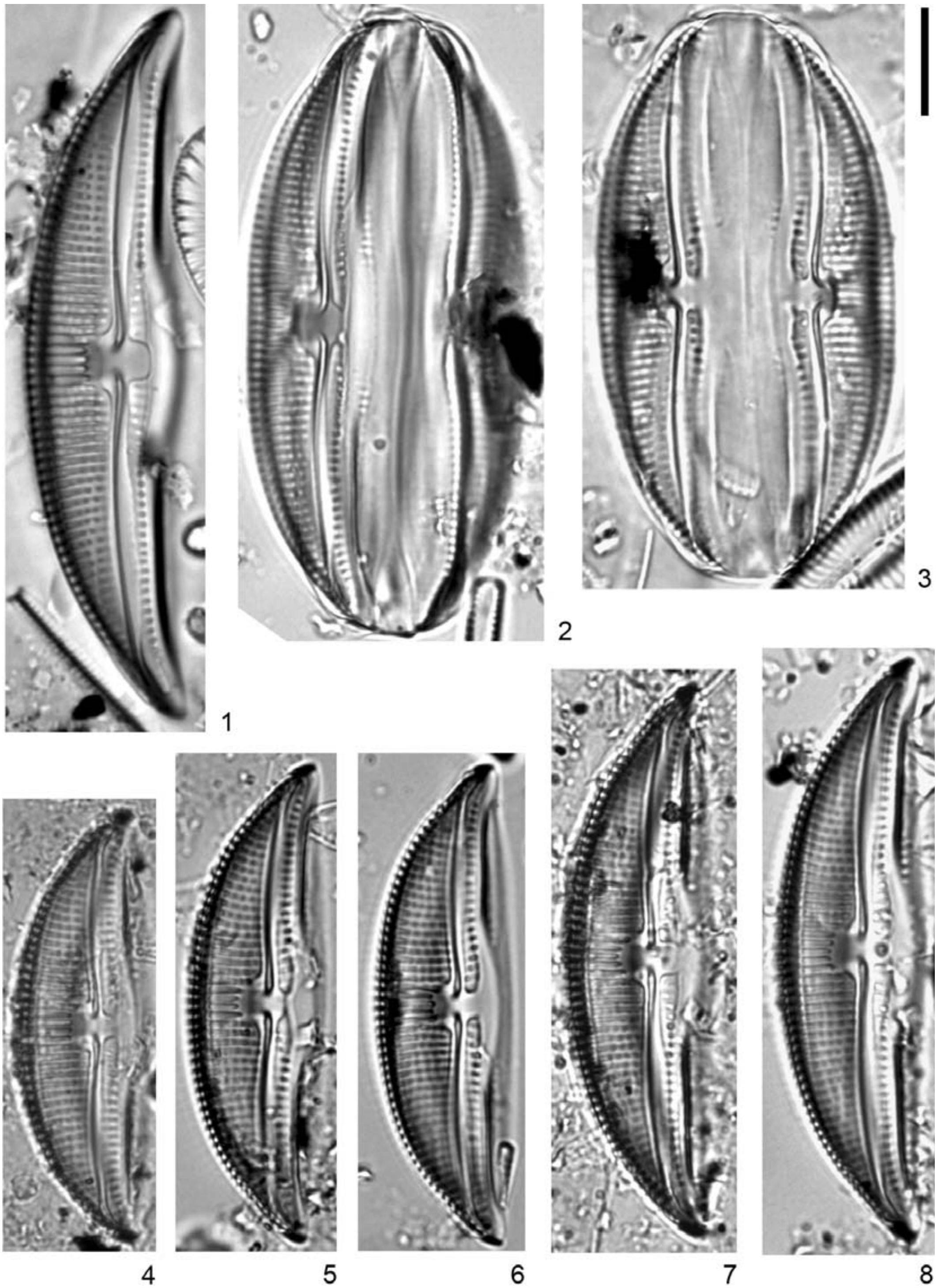

Fig 2. 1–8. *Amphora ohridana* Levkov from the Sokołówka River. Scale bar = 10 μm.

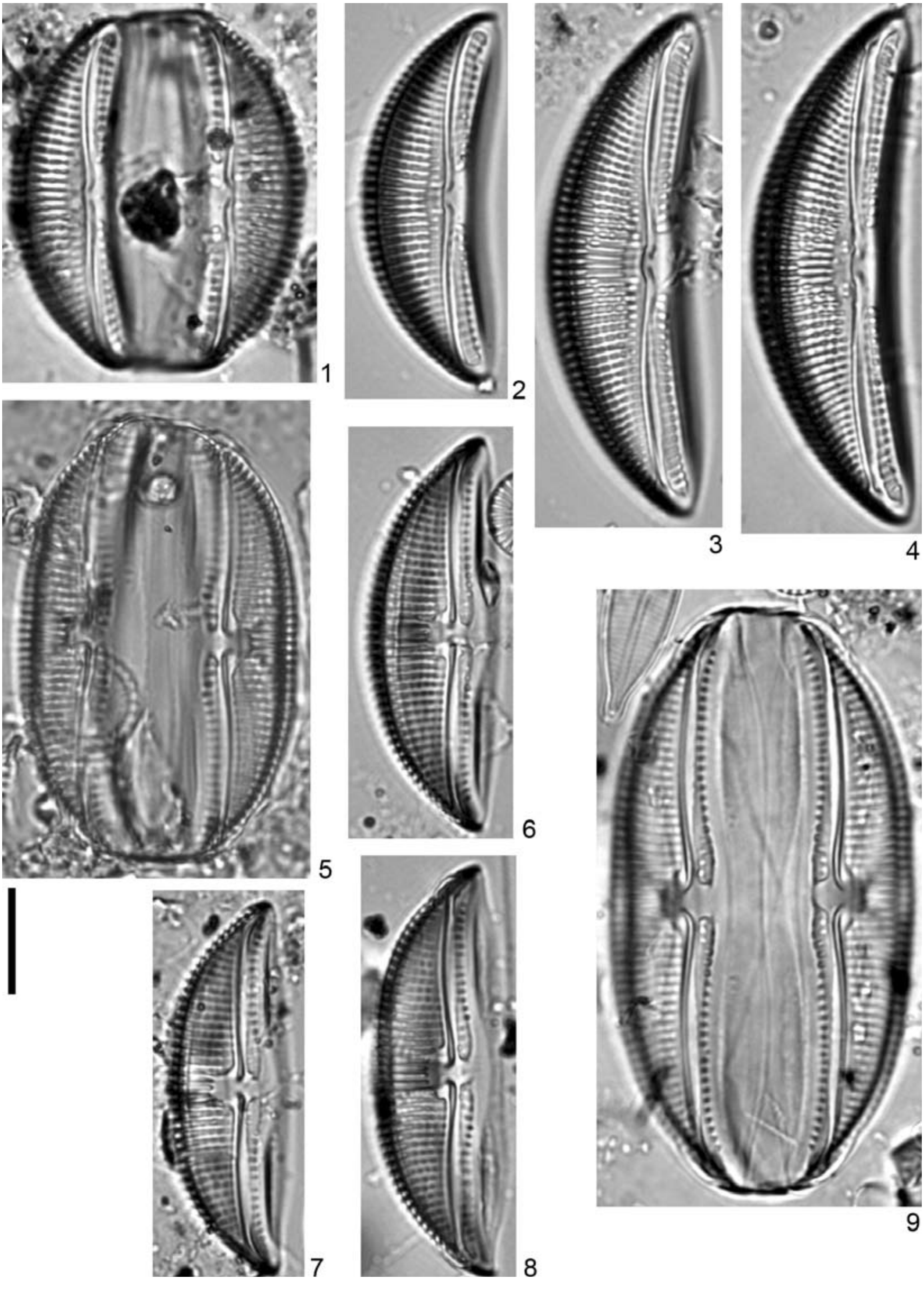

Fig. 3. 1–4. *Amphora ovalis* (Kützing) Kützing and 5–9. *Amphora ohridana* Levkov from the Sokołówka River. Scale bar = 10 μm.

Table 2. Comparison of the diagnostic characteristics of *Amphora ohridana* Levkov, *A. ovalis* (Kützing) Kützing and *A. hemicycla* Stoermer & Yang, according to Levkov (2009).

Features	*A. ohridana*	*A. ovalis*	*A. hemicycla*
Length, µm	41–62	40–90	36–72
Width, µm	10–13	11–17	8–14
Striae on dorsal side	11–14 in 10 µm; striae parallel in the middle portion, becoming radiate at the ends. Striae finely punctate	11–13 in 10 µm; striae coarsely punctuate, except striae in the middle of the valve which appears as transapical lines radiate throughout	11–13 in 10 µm; striae parallel in the middle, becoming radiate towards the ends. Striae finely punctuate
Striae on ventral side	11–13 in 10 µm; striae radiate in the middle, becoming convergent at the ends	9–11 in 10 µm; striae radiate in the middle, becoming convergent towards the valve ends comprise single areolae	10–11 in 10 µm; striae radiate, becoming convergent at the ends
Valve	Semi-elliptical-lanceolate with convex, arched dorsal margin. Slightly concave, tumid in the middle ventral margin	Semi-elliptical with smoothly arched dorsal margin and straight or slightly concave ventral margin. Valve ends obtusely rounded	Semi-elliptical to semi-lanceolate with arched dorsal margin and slightly concave with inflation in the middle ventral margin. Valve ends sharply attenuate and ventrally bent
Axial area	Very narrow	Moderately narrow, arched	Very narrow
Central area	On dorsal side small, rounded or rhombic. On ventral side narrow, semi-elliptical, usually closed by groove that interconnects areolae on ventral striae	On dorsal side absent, on ventral side broad fascia	On dorsal side small, orbicular or trapezoid, not reaching the valve margin. On ventral side narrower, surrounded by depressions that do not penetrate internally
Raphe	Proximal raphe ends dorsally deflected	Raphe branches biacurate, proximal and distal raphe endings dorsally bent	Proximal raphe ends dorsally bent

230 µS · cm^{-1}). The values for conductivity, nitrogen compounds and ion concentrations place Lake Ohrid in Class I (Janevski *et al.* 2008).

Monitoring of the chemical conditions of Lake Ohrid revealed progressive eutrophication. Most of the nutrient inputs come from underground inflows from eutrophic Lake Prespa, with smaller shares coming from runoff and direct precipitation (Matzinger *et al*. 2006).

The environmental conditions in the Sokołówka River differ significantly from those noted in Lake Ohrid. Presumably, *Amphora ohridana* is an alkaliphilic species with a wide ecological spectrum, tolerant to high conductivity and high concentrations of biogenic compounds.

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