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Development of *Trachelomonas* species (Euglenophyta) during blooming of *Planktothrix agardhii* (Cyanoprokaryota)

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Abstract – This paper reports data on a community of *Trachelomonas* species (Euglenophyta) occurring during *Planktothrix agardhii* bloom formation in a shallow, highly eutrophic dam reservoir. The results come from a long-term study of Siemianówka Dam Reservoir, located on the upper Narew River (NE Poland). From April to October 2007, 132 alga taxa were identified, including 32 *Trachelomonas* taxa, 23 of which are new for the reservoir; of those, three are first records for Poland: *T. armata* (Ehrenberg) Stein var. *heterospina* Swirenko, *T. atomaria* Skvortzov var. *minor* Hortobagi and *T. minima* Dreżepolski. One variety, *T. curta* var. *pappilata* Wołowski, is described as new for science. The ultrastructural details of *Trachelomonas* species are illustrated. The highest number of *Trachelomonas* taxa was recorded in August in the shore zone of the reservoir. At the end of summer 2007, the conspicuous development of *P. agardhii* (Gomont) Anagnostidis et Komarek, caused a rapid decrease of *Trachelomonas* biomass due to lower water transparency and the oxygen concentration. In addition, a decline in the *Trachelomonas* taxa and biomass was associated with a decrease of water temperature. The negative impact of extracellular microcystin on the *Trachelomonas* development requires further study.

Key words: *Trachelomonas* / *Planktothrix agardhii* / taxonomy / cyanoprokaryota blooms / ultrastructure

Introduction

Summer domination of cyanoprokaryotes in Polish and other European inland waters has been observed in recent years (Wołowski *et al*., 1990; Rücker *et al*., 1997; Wetzel, 2001; Briand *et al*., 2002; Wojciechowska *et al*., 2004; Mbedi *et al*., 2005; Willame *et al*., 2005; Akcaalan *et al*., 2006; Pawlik-Skowrońska *et al*., 2008; Toporowska *et al*., 2010). Several cyanoprokaryote taxa cause blooming, with many damaging effects on the water environment such as reducing the vertical light penetration in water bodies and hampering the development of other groups of phytoplankton. Especially dangerous are cyanobacteria that produce toxins, which can harm many aquatic organisms. Most studies of cyanotoxins have concentrated on their effects on vertebrates and invertebrates, and possible health-related repercussions (Codd *et al*., 2005). Little is known about the inhibitory effects of cyanotoxins on algae (Bucka, 1989; Sedmak and Kosi, 1998; Camacho, 2008). Microalgae exposed to cyanotoxins have shown morphological and ultrastructural alterations. The most sensitive algae show disaggregation of colonies, discoloration, deformation, the formation of resistance cells and even cell death (Sedmak and Kosi, 1998; Valdor and Aboal, 2007). Even a low concentration of microcystins (MCs, 0.10 $\mu g.L^{-1}$) can affect microalgae, altering the composition and structure of communities (Valdor and Aboal, 2007). Motile algae such as *Chlamydomonas reinhardtii* are very sensitive to cyanotoxins of *Anabaena flos-aquae* (Camacho, 2008), but toxins can even stimulate the growth of some green algae, for example, *Scenedesmus quadricauda* (Bucka, 1989).

Euglenophytes of the genus *Trachelomonas* prefer fertile eutrophic warm waters with a high oxygen concentration (Starmach, 1983; Wołowski, 1998; Grabowska *et al*., 2003). In a long-term study (1993–2012) of the phytoplankton of the eutrophic Siemianówka Dam Reservoir (SDR, Poland), we observed periodic abundance of euglenophytes, especially those of the genus *Trachelomonas*, during blooming of potentially toxic cyanoprokaryotes (Grabowska *et al*., 2003; Wołowski and Grabowska, 2007).

The aim of the present study was to describe, in terms of taxonomy and ultrastructure, the variability of

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Trachelomonas species occurring in the SDR during toxic *Planktothrix agardhii* blooming. The study also attempted to verify the hypothesis that the blooms of *P. agardhii* inhibit the development of *Trachelomonas* community in the reservoir.

Study area

The SDR (52°55'N, 23°50'E) on the upper Narew River (NE Poland) is a shallow (mean depth 2.4 m, maximum depth 10 m),highly eutrophic reservoir constructed in 1990 as a multifunctional impoundment. It is a lowland reservoir, as reflected in its physical features: maximum area 32.5 km^2, maximum capacity 78.5 Mm^3 and mean retention time 4–6 months. High values of inorganic nitrogen (avg. 900 μg.L^{-1}) and the total phosphorous (avg. 370 μg.L^{-1}) indicate eutrophic character of reservoir waters already from the first years of its existence (Grabowska *et al.*, 2003). Since 1992 the development of potentially toxic cyanobacterial blooms has been a regular phenomenon in the reservoir (Grabowska, 2005). Cyanoprokaryotes present in the SDR produce toxic MCs (Grabowska and Pawlik-Skowrońska, 2008; Grabowska *et al.*, 2008; Kabziński *et al.*, 2008; Grabowska and Mazur-Marzec, 2011).

Materials and methods

Surface water samples (0–0.5 m) were collected monthly from two stations in the SDR from April to October 2007. The stations were located at short (about 80 m) distances from each other; the first one was in the deeper part of the reservoir (maximum depth 8 m) and the second one in the shallower shore part (maximum depth 1.5 m).Water temperature, pH and conductivity were measured in the field with a Hydrolab DataSonde 4 (USA) kit. Transparency was determined with Secchi disc visibility. Chemical analyses followed the methods described by Hermanowicz *et al.* (1976).

Water samples (500 L) for phytoplankton studies were fixed with Utermöhl's solution. Species were determined using Nikon ECLIPSE 600 and Olympus BX-50 microscopes. Quantitative microscopy analyses were carried out in a Fuchs-Rosenthal chamber. In each sample, 200 individuals were counted. Single cells of the genera *Euglena*, *Monoraphidium*, *Trachelomonas* and also cenobia (*Coelastrum*, *Pediastrum*, *Scenedesmus*) were counted as individuals. Filamentous algae (*Aphanizomenon*, *Planktothrix*, *Pseudanabaena*) were considered individuals when they had 100 μm in length. The biovolume of the phytoplankton species was determined using a method of calculating the volume of cells based on the author's own measurements (Hillebrand *et al.*, 1999).

Trachelomonas species were also studied using a Hitachi scanning electron microscope. Samples were prepared according to Bozzola and Russell (1991). Material fixed with Utermöhl's solution was rinsed in distilled water several times to remove the buffer salts, after which the samples were dehydrated in a graded ethanol series. Then small drops of the material were transferred to the surface of the slides mounted on the SEM stubs and air-dried. The samples were sputter-coated with platinum–gold. Species identification follows Deflandre (1926), Tell and Conforti (1986), Wołowski and Walne (2007), Wołowski (1998) and Wołowski and Hindák (2004, 2005).

Table 1. Physico-chemical parameters of water in the SDR in 2007; MC-LR concentration were detected previously by Grabowska *et al.* (2008) and Kabziński *et al.* (2008).

Parameter	April–October	August
Temperature (°C)	4.1–25	21.9–22.0
pH	7.3–9.2	8.0–8.1
Conductivity (μS.cm^{-1})	242–294	273–275
Secchi disc visibility (m)	0.35–0.57	0.53–0.55
N-NH$_4$ (μg.L^{-1})	110–445	183–190
N-NO$_3$ (μg.L^{-1})	9–86	10–42
P-PO$_4$ (μg.L^{-1})	2–74	19–23
P$_{tot}$ (μg.L^{-1})	84–337	141–160
MC-LR (μg.L^{-1})	0–6.18	0–0.96

Results

In 2007, the reservoir's water temperature, pH and phosphates were highest in May and lowest in October (Table 1). In September, the highest concentration of total phosphorous (337 μg.L^{-1}) coincided with the maximum development of phytoplankton (Tables 1 and 2). With the exception of April, September and October, Secchi disc visibility exceeded 0.5 m. The oxygen concentration and saturation were highest from April to May and were lowest in September (Fig. 1). Physicochemical parameters are presented in Table 1.

From April to October, 132 algal taxa were identified. Species richnesswas greatest among chlorophytes (44), euglenophytes (37), cyanoprokaryotes (18) and diatoms (15). Desmids and dinophytes were represented by six taxa, cryptophytes by four, and golden algae by two. The number of taxa was the lowest in September (Fig. 2).

During the whole study period, cyanoprokaryotes were the main component of the phytoplankton community (Table 2). Representatives of Euglenophyta, Cryptophyta, Bacillariophyceae and Chlorophyceae were also noted, but their share in phytoplankton biomass was small, most often not exceeding 5%. Only diatoms reached higher biomass in April and euglenophytes in June (Table 2). Desmids, dinophytes and chrysophytes periodically occurred in the SDR, but with only a 2% share (Table 2). *P. agardhii* (Gomont) Anagnostidis et Komarek occurred during the whole period (Figs. 3A, 44). From April to May, different cyanoprokaryote taxa such as *Limnothrix redekei* (Van Goor) Meffert, *Pseudanabaena* spp. and *Aphanizomenon* spp. occurred in great biomass along with *P. agardhii*. *Aphanizomenon* spp. was dominant only in May, but *P. agardhii* was clearly dominant from June

Table 2. Total phytoplankton biomass with percentage shares of algal groups in the SDR in 2007.

Month	Total biomass of phytoplankton (mg.L^{-1})	Cyano.	Crypto.	Eugle.	Bacilla.	Chloro.	Other
		Percentage of total phytoplankton					
April	27.7	75.41	1.00	2.01	18.2	2.95	0.03
May	52.4	97.54	0.07	0.39	1.39	0.52	0.09
June	37.2	91.10	1.09	5.72	0.17	1.92	0.00
July	44.8	88.66	1.74	4.82	0.74	1.94	2.10
August	81.6	96.30	0.08	1.63	0.55	0.54	0.90
September	137.2	98.16	0.45	0.29	0.07	1.03	0.00
October	63.6	93.65	2.98	0.43	2.13	0.73	0.08

Cyano. - Cyanoprokaryota; Crypto. - Cryptophyta; Eugle. - Euglenophyta; Bacilla. - Bacillariophyceae; Chloro. - Chlorophyceae; other - Zygnematophyceae, Dinophyta and Chrysophyceae; average from 2 stations.

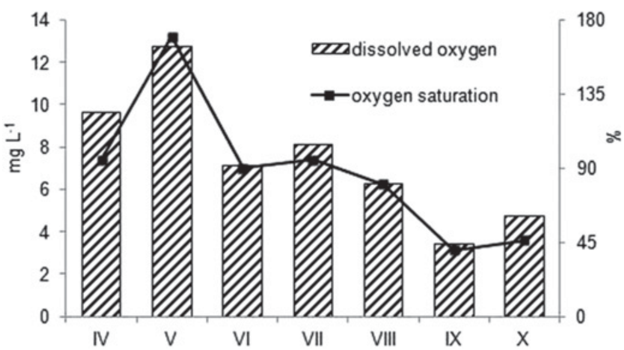


Fig. 1. Seasonal changes in the dissolved oxygen concentration and saturation in the surface layer of SDR in 2007.

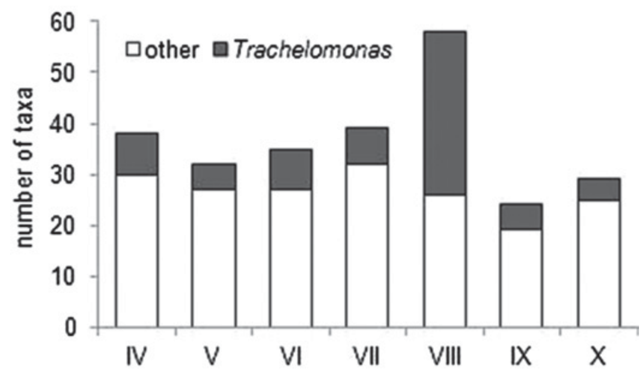


Fig. 2. Seasonal changes in number of taxa in SDR in 2007.

to October and was at peak biomass in September (Fig. 3A). During the period of *P. agardhii* dominance, among the euglenophytes *Trachelomonas* taxa (Figs. 4–43) were abundant, whereas *Phacus*, *Euglena*, *Monomorphina* and *Strombomonas* taxa were noted singly from April to June. The diversity of *Trachelomonas* species was highest (32 taxa) in August at shore station, when they represented 54% of the taxa in the reservoir (Fig. 2). At that time, 23 taxa new for the reservoir were identified, including three new for Poland (Figs. 4, 20, 31 and 36) and one variety new to science (Fig. 26). Table 3 summarizes the taxonomic and ecological data for each taxon. Only a few taxa (3–8) belonging to the *volvocineae* and *oblongae* groups were reported during the remaining months of the study. The most frequently noted ones were *T. oblonga* var. *oblonga* Lemmermann, *T. volvocina* Ehrenberg var. *volvocina*, *T. volvocina* var. *derephora* Conrad and Van Meel and *T. volvocinopsis* var. *volvocinopsis* Swirenko. Less frequently recorded were *T. armata* (Ehrenberg) Stein var. *armata*, *T. compacta* Middelhoek, *T. hispida* (Perty) Stein emend. Deflandre var. *hispida*, *T. mangini* Deflandre fo. *subpunctata* Safonova, *T. planctonica* var. *planctonica* fo. *longicollis* (Skvortzov) Popova and *T. planctonica* var. *planctonica* fo. *oblonga* (Dreżepolski) Popova. During the summer–autumn period the increase of *P. agardhii* biomass and the decrease of the *Trachelomonas* biomass were recorded (Fig. 3A, B, Table 4). At the time the most common taxa were green algae (*Monoraphidium contortum*

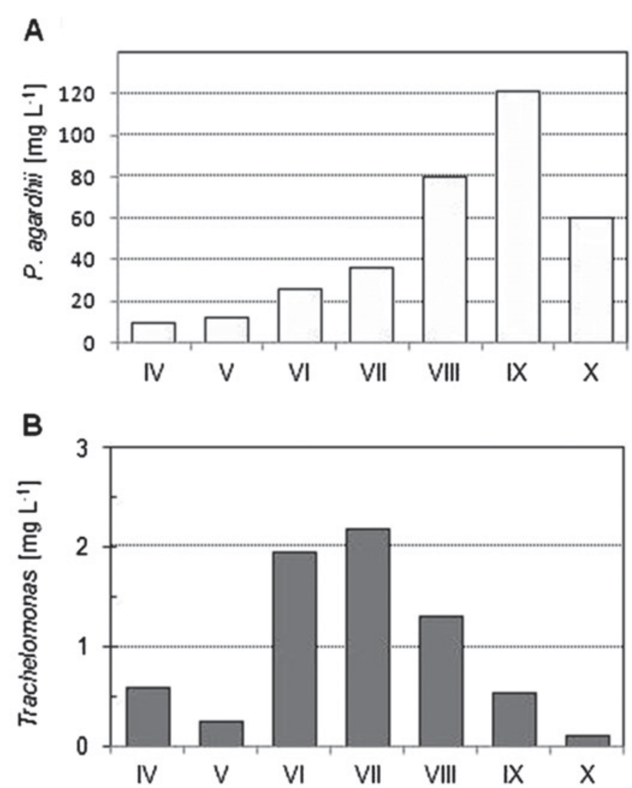
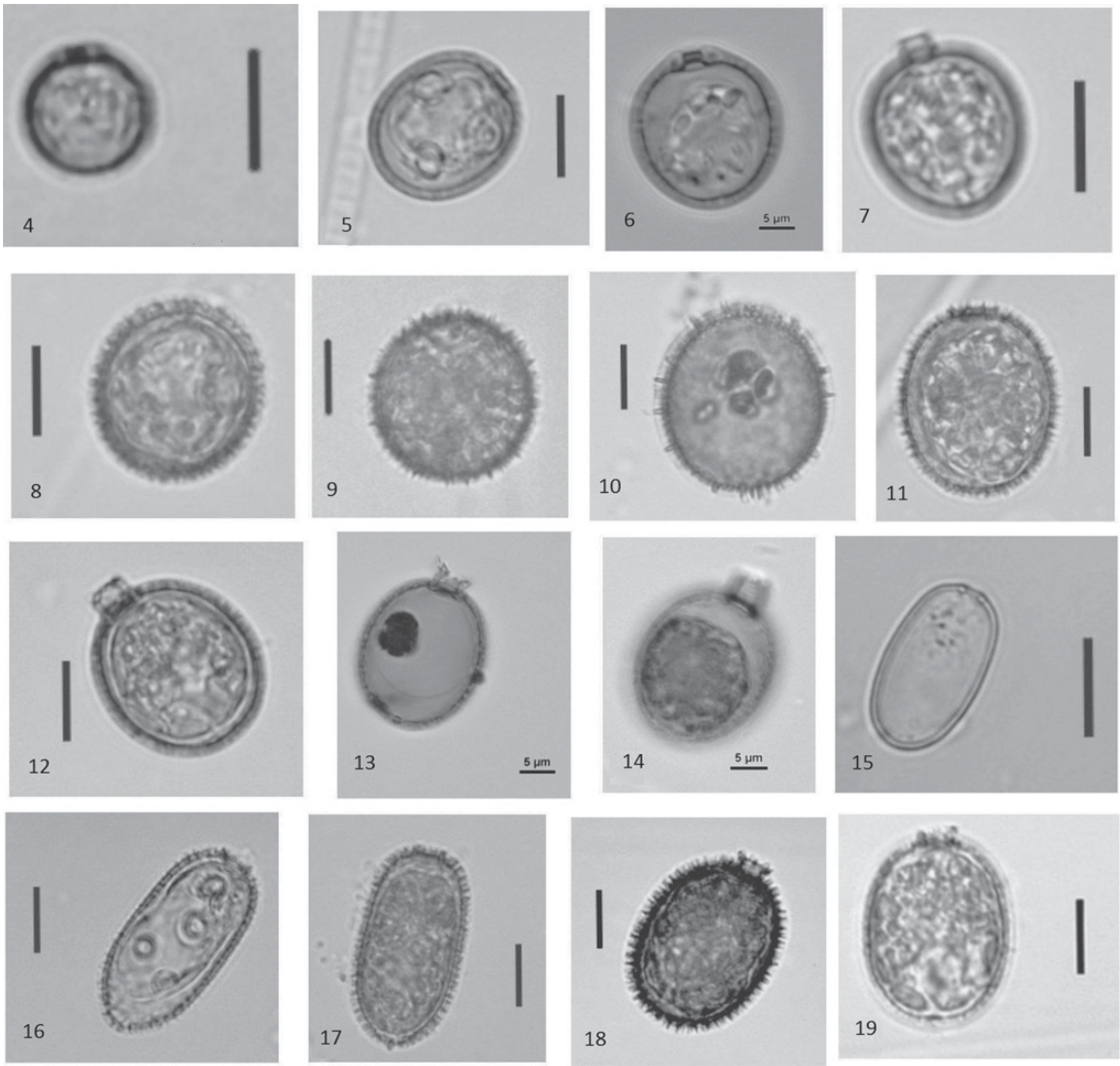


Fig. 3. Changes in biomass of *P. agardhii* (a), and *Trachelomonas* (b) in SDR from April to October 2007.



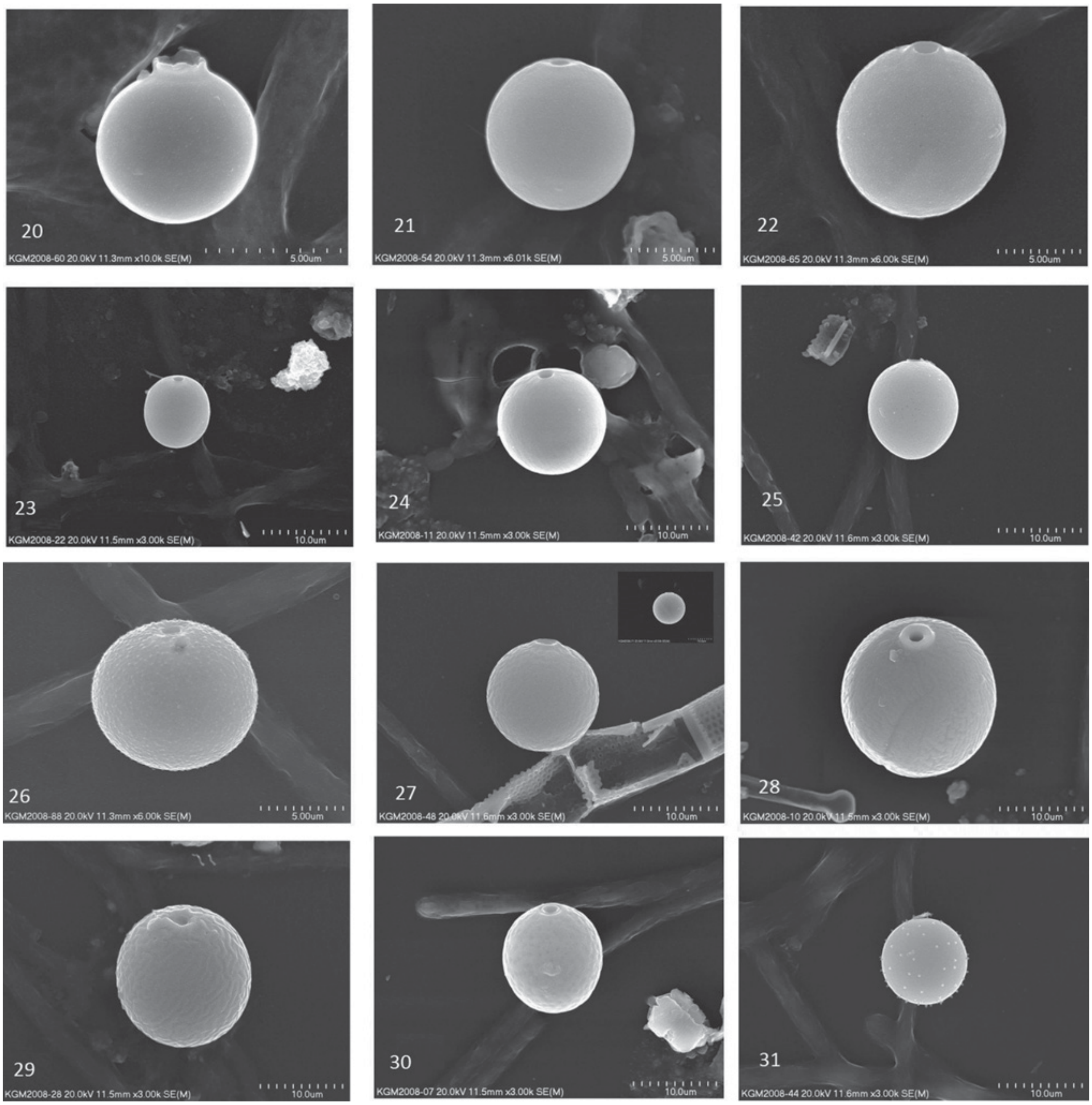
Figs. 4–19. 4. *Trachelomonas atomaria*, 5. *T. volvocina* var. *subglobosa*, 6. *T. volvocina* var. *compressa*, 7. *T. manginii*, 8. *T. bacillifera* var. *minima*, 9. *T. rotunda*, 10. *T. superba*, 11. *T. hispida*, 12. *T. planctonica* fo. *ornata*, 13. *T. planctonica* var. *planctonica*, 14. *T. planctonica* var. *hyalina*, 15. *T. oblonga* var. *pulcherrima*, 16. *T. klebsii*, 17. *T. obtusa*, 18. *T. sydnyensis*, 19. *Strombomonas scabra*.

(Thuret) Komárková-Legnerová, *M. minutum* (Nägeli) Komárková-Legnerová and *Scenedesmus* spp.

From June to October, during the most intensive development of *P. agardhii*, some opposite correlation between *P. agardhii* and *Trachelomonas* biomass and water parameters were recorded (Table 4).

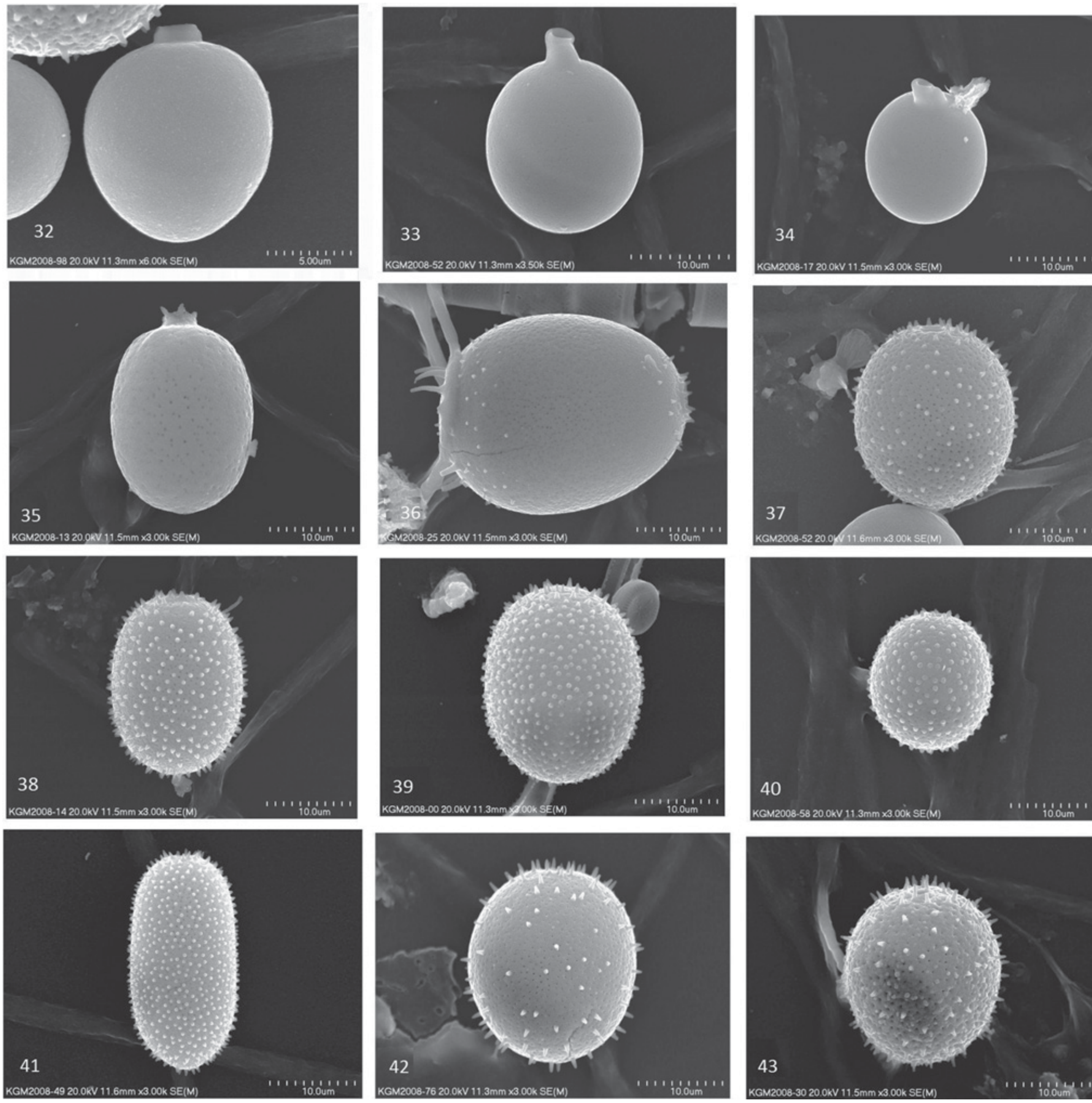
Discussion

The fertile eutrophic waters of reservoirs favor the development of cyanoprokaryote species, among which *P. agardhii* is often observed (Wojciechowska *et al*., 2004; Grabowska, 2005; Mbedi *et al*., 2005; Akcaalan *et al*., 2006; Toporowska *et al*., 2010). This species is a potential producer of hepatotoxins (Rücker *et al*., 1997; Briand *et al*., 2002; Willame *et al*., 2005; Wiśniewska *et al*., 2007; Pawlik-Skowrońska *et al*., 2008). Previous research at the SDR found that the MC concentration was highest when *P. agardhii* was dominant in late summer and autumn (Grabowska and Pawlik-Skowrońska, 2008; Grabowska and Mazur-Marzec, 2011). In our current study, *P. agardhii* was dominant in the reservoir during most of the vegetative season. From August to October, the period of the most abundant *P. agardhii* blooms, microcystin-LR (MC-LR) was detected in the reservoir water (Grabowska *et al*., 2008; Kabziński *et al*., 2008). In September the extracellular MC-LR concentrations in the reservoir (measurements taken several times in the diurnal cycle) were much higher (avg. 3.52 $\mu g.L^{-1}$, max. 6.18 $\mu g.L^{-1}$) than in August (avg. 0.26 $\mu g.L^{-1}$, max. 0.96 $\mu g.L^{-1}$) and October (avg. 0.22 $\mu g.L^{-1}$,



Figs. 20–31. 20. *Trachelomonas atomaria*, 21. *T. volvocina* var. *compressa*, 22. *T. volvocina* var. *derephora*, 23. *T. volvocina* var. *subglobosa*, 24. *T. volvocinopsis*, 25. *T. pusilla*, 26. *T. curta* var. *papillata*, 27. *T. rugulosa* var. *rugulosa*, 28. *T. stokesiana* fo. *inflexa* – lorica damaged, 29. *T. stokesiana* var. *conradii*, 30. *T. compacta*, 31. *T. minima*.

max. 0.26 μg.L^{-1}) (Grabowska *et al*., 2008; Kabziński *et al*., 2008). Although the correlation between extracellular MC-LR concentration and *Trachelomonas* biomass was not statistically significant; authors do not exclude the negative effects of the toxins on the euglenoids development. Further research in the reservoir (Grabowska and Mazur-Marzec, 2011) has shown that *P. agardhii* produces higher concentrations of other MCs (*e.g*., MC-RR, dmMC-RR) that have not been investigated in 2007. It is reasonable to infer that the MC could be one of the factors in the reduced species richness of algae, including euglenophytes, and in the decreased biomass of *Trachelomonas* spp. The total number of taxa fell to 24 in September when the MC-LR concentration was at maximum. Our observations are in accord with the results from Sedmak and Kosi (1998), who reported a decrease in plankton diversity under a high MC concentration. In the hypertrophic Borovci gravel pit during weak bloom formation by toxic *Microcystis* ($<$10 μg.MCs.L^{-1}), they recorded 21 taxa, including only a few diatoms, and the complete absence of chrysophyces and euglenophytes, while during heavy blooming of toxic *Microcystis* ($>$10 μg.MC-RR.L^{-1}) in the hypertrophic Savci Reservoir they noted only eight taxa and the complete disappearance of chrysophyces and diatoms. The drop in the number of phytoplankton species in the



Figs. 32–43. 32. *Trachelomonas manginii*, 33. *T. playfairii* var. *playfairii*, 34. *T. similis* var. *hyalina*, 35. *T. planctonica* var. *planctonica* fo. *oblonga*, 36. *T. armata* var. *heterospina*, 37. *T. intermedia* var. *papillato-spinifera*, 38. *T. hispida* var. *hispida*, 39. *T. bacillifera* var. *minima*, 40. *T. pulchella*, 41. *T. obtusa* var. *obtusa*, 42. *T. hirta* var. *duplex*, 43. *T. robusta*.

SDR in the presence of toxic *P. agardhii* apparently can be the result of the inhibitory effect of extracellular MC-LR on algal growth. The most sensitive algae die and the less sensitive species can show different types of ultrastructural damages (Valdor and Aboal, 2007). The damaged loricas and smaller dimensions of *Trachelomonas* in the SDR may be associated with a presence of cyanotoxins. During LM and SEM studies, among the well-developed mature loricas we also observed several that were deformed, probably due to the high cyanotoxin concentration (see Figs. 45–47). The dimensions of several taxa such as *T. atomaria* var. *minor* and *T. rugulosa* var. *steinii* (see Table 3) and *T. mangini* fo. *subpunctata* were at the low end of the size range.

No doubt the drastic deterioration of oxygen levels in the SDR was the main factor in the rapid decrease of *Trachelomonas*. The reduced water transparency caused by blooming would be expected to depress production of oxygen through photosynthesis. *Trachelomonas* species prefer well-oxygenated water (Starmach, 1983; Wołowski, 1998). Additionally, the rapid decrease of water temperature from 22 °C in August to 15.6 °C in September and then to 4.3 °C in October was the next important factor in the inhibition of *Trachelomonas* development.

The constant presence of green algae such as *Scenedesmus* spp. in the SDR under higher levels of extracellular MC-LR in the water confirms their resistance to the cyanotoxin. Toxins can stimulate the growth of

Table 3. New taxa of *Trachelomonas* reported from SDR during *P. agardhii* blooming.

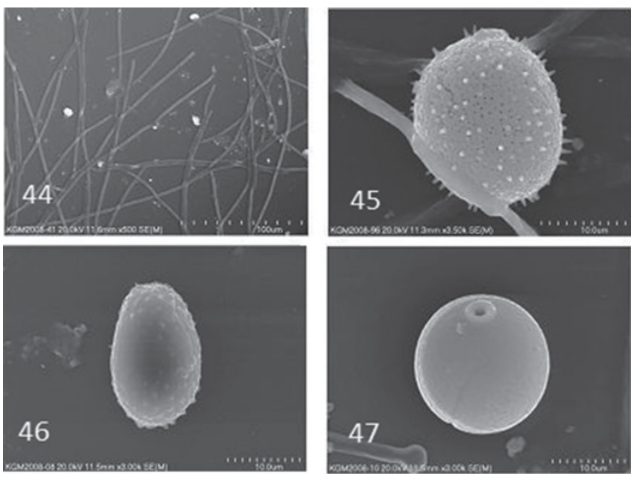
Taxon	Dimensions	Ecological data
T. armata (Ehrenberg) Stein var. *heterospina* Swirenko*	30.5–36.1 μm × 24.3–28.0 μm without spines, spines 3–5 μm long at the posterior part	Common; reported from ponds, lakes swamps; Europe, Asia, North and South America.
T. atomaria Skvortzov var. *minor* Hortobagi*	6.5 μm diam., collar low and 0.5 μm diam., slightly smaller than described by Hortobagy (9.0 μm diam., collar 2.5 μm diam.)	Rare; reported from Europe, first time from Poland
T. bacillifera Playfair var. *minima* Playfair	20.0–21.7 μm × 17–20.0 μm	Common; reported from puddles, swamps, lakes; Europe, Asia, Australia, America
T. curta Da Cuncha var. *papillata* Wołowski**	9.0–9.1 μm × 10.0–12.0 μm; differs from nominal variety because lorica covered by papillae	Variety new to science; reported from SDR, Poland
T. hirta Da Cuncha var. *duplex* Deflandre	21.0–24.0 μm × 18.0–20.0 μm, specimens broader than described by Deflandre	Not common; reported from stagnant water; Africa, Europe, America
T. intermedia Dangeard fo. *papillato-spinifera* Safonova	19.2–22 μm × 16.5–19.5 μm	Cosmopolitan
T. klebsii Deflandre	31.0–34.0 μm × 16.4–18.0 μm	Common; reported from lakes, ponds; Europe, Asia, Central America
T. minima Dreżepolski*	10.0–11.0 μm diam.	Rare; reported from stagnant water; Europe, Asia
T. oblonga Lemmermann var. *pulcherrima* (Playfair) Popova	18.1–19.0 μm × 10.0–11.0 μm	Common; reported from ponds, ditches; Europe, Asia, America, Australia
T. obtusa Palmer var. *obtusa*	27.3–35.0 μm × 13.3–18.0 μm	Common; reported from stagnant water bodies; Europe, South and North America
T. playfairii Deflandre var. *playfairii*	20.0–21.0 μm × 15.0–16.0 μm, collar 3.4 μm high ; similar to *T. similis* but the latter usually has toothed rim of collar	Not common; reported from swamps, ponds, peat-bogs; Europe, Asia, Australia, Africa, America
T. pulchella Dreżepolski	16.0–20.0 μm × 15.0–17.0 μm	Rare; reported from ponds, peat-bogs; Europe,
T. pusilla Playfair	12.3–9.0 μm × 7.6–9.5 μm	Common; reported from small water bodies; Europa, Asia, North and South America, Australia
T. robusta Swirenko	23.0–25.0 μm × 19.0–20.0 μm	Common; in various types of water bodies; Europe, Asia, America, Africa, Australia
T. rotunda Swirenko	22.7–23.3 μm diam.	Common; reported from ponds, ditches, swamps; Europe, Asia, North and South America
T. rugulosa Stein var. *steinii* Deflandre	13.6–15.0 μm diam. specimens were in lower range of dimensions	Common; reported from ponds, lakes, ditches; Europe, Asia
T. similis var. *hyalina* Skwortzow	18.7–19.3 μm × 15–17.5 μm	Not common; ditches; Asia, Europe
T. stokesiana Palmer fo. *inflexa* (Conrad) Huber-Pestalozzi	18.0–19.3 μm diam.	Not common
T. stokesiana Palmer var. *conradii* (Deflandre) Huber Pestalozzi	16.6–19.3 μm diam.	Cosmopolitan
T. superba Swirenko	30.0 × 28.0 μm; several varieties and forms known	Common; reported from ponds, ditches and peat-bogs; Europe, Asia, Africa, America
T. sydnyensis Playfair	33.0 μm × 25.0–26.0 μm, several varieties known	Cosmopolitan
T. volvocina var. *subglobosa* Lemmermann	9.0–18.0 μm × 10–22.0 μm	Cosmopolitan
Strombomonas scabra (Playfair) Tell and Conforti	25.4–27.0 μm × 19.2–21.0 μm	Cosmopolitan; earlier classified as *Trachelomonas*

* Taxa new for Poland.
** Variety new to science.

Table 4. Spearman correlations between phytoplankton biomass and water parameters in SDR in June–October 2007.

	P. agardhii	*Trachelomonas*
SD	– 0.590	**0.681**
Temp.	– 0.305	**0.639**
O_2	**–0.673**	**0.663**
MCs	0.370	– 0.390
P. agardhii		– 0.340

Significance level at 0.05* **in bold**.



Figs. 44–47. 44. *P. agardhii* filaments; 45–47. Examples of damage loriceae of *Trachelomonas*.

some green algae such as *Scenedesmus quadricauda* (now *S. communis*) (Bucka, 1989), *M. contortum* and *Coelastrum microporum* (Sedmak and Kosi, 1998). *M. contortum* was also recorded in Syczyńskie Reservoir during the summer when toxic *P. agardhii* was dominant (Pawlik-Skowrońska *et al.*, 2008; Toporowska *et al.*, 2010).

In the eutrophic SDR, the high level of nutrients favors the development of cyanoprokaryotes but also euglenophytes, especially *Trachelomonas* species (Starmach, 1983; Wołowski, 1998). Such a heightened concentration of inorganic nitrogen (avg. 210 μg.L^{-1}) and total phosphorous (avg. 131 μg.L^{-1}) compounds in the reservoir (see Table 1) corresponds to eutrophy (Wetzel, 2001). Previous work disclosed a positive correlation between euglenophyte biomass and ammonium and total phosphorous concentrations (Grabowska *et al.*, 2003). Our current and previous results (Wołowski and Grabowska, 2007) confirm that *Trachelomonas* species are the main component of the euglenophyte summer communities in the SDR, together with various taxa of cyanobacteria (*e.g.*, *Aphanizomenon* spp., *P. agardhii*). With 23 taxa reported as new for the SDR, the number of *Trachelomonas* taxa reported from the reservoir is now 56. Assemblages of *Trachelomonas* species behave as Wołowski (1998) described in small ephemeral communities: they lack stability and show high biodiversity. The reservoir such as other polymictic lowland reservoirs shows little stability, especially in the shallowest shore zone. Wind resuspension of bottom sediments in shallow reservoirs causes short but significant increase of nutrients in water (Kristensen *et al.*, 1992). The representants of *Trachelomonas* species quickly react to the increase of mineral form of nitrogen and phosphorous (Starmach, 1983). The highest diversity of *Trachelomonas* species in the reservoir in August could be the result a combination of several favorable environmental factors, such as high concentration of nutrients (mainly nitrates – 42 μg.L^{-1}), high temperature of water, very good oxygen condition and low concentration of MC-LR.

During the long-term study we found only ten mutual species of *Trachelomonas* present when both *Aphanizomenon* spp. (mainly *A. flos-aquae*) (Wołowski and Grabowska, 2007 and current study) and *P. agardhii* cyanobacteria were dominant: *T. armata* var. *armata*, *T. compacta*, *T. hispida* var. *hispida*, *T. mangini* fo. *subpunctata*, *T. oblonga* var. *oblonga*, *T. planctonica* var. *planctonica* fo. *longicollis*, *T. planctonica* var. *planctonica* fo. *oblonga*, *T. volvocina* var. *volvocina*, *T. volvocina* var. *derephora* and *T. volvocinopsis* var. *volvocinopsis*. Most of them belong to the group with smooth lorica, without ornamentation. We suppose that these very common taxa, known worldwide, tolerate MC at lower concentrations (<1 μg.L^{-1}). We attribute the sharp decline in *Trachelomonas* species richness and biomass to water transparency and oxygen deficiency in the reservoir water when *P. agardhii* peaked in biomass. An equally important factor in *Trachelomonas* development was water temperature. The negative impact of extracellular MC on the *Trachelomonas* development requires further study.

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