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Chrysophyte stomatocysts from sediments in a man-made water reservoir in central Poland

Jolanta Piątek

Department of Phycology, W. Szafer Institute of Botany, Polish Academy of Sciences, Lubicz 46, PL-31-512 Kraków, Poland (e-mail: cabala@ib-pan.krakow.pl)

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Twelve chrysophyte stomatocysts are reported from sediments in a man-made water reservoir in the village of Wymysłów in central Poland. Three morphotypes are described as new to science: stomatocysts #40, #41 and #42. The descriptions of two other stomatocysts, 161 Zeeb & Smol 1993 *emend*. Piątek J. and 198 Duff & Smol 1994, forma A Pla 2001 *emend*. Piątek J., are emended to include some additional morphological characters, which had not been observed previously. The two morphotypes are also newly reported from Poland. Stomatocyst 171 Zeeb & Smol 1993 is recorded in Poland for the first time from extant material.

Key words: chrysophytes, new emendations, new morphotypes, stomatocysts, taxonomy

Introduction

Research on the diversity of chrysophyte stomatocysts in Poland has been carried out across various habitats, including high mountain peat bogs and lakes in the Tatra National Park (Cabała & Piątek 2004, Cabała 2005a, 2005b, Piątek 2005), lowland peat bogs (Cabała 2002, 2003a, 2003b) as well as a karstic sink-hole (Wołowski *et al*. 2004). The most interesting places in which the assemblages of stomatocysts were investigated are a soft-water bryophyte spring in the Tatra Mts. (Piątek 2005) and the sulphuric salt marsh in the Owczary Reserve (Piątek & Piątek 2005). Such unusual places have also been shown to be suitable for chrysophytes and their stomatocysts, often possessing unique morphology of cyst bodies. During continued examinations of chrysophyte stomatocysts in untypical places, the occurrence of stomatocysts was analysed in a small man-made water reservoir situated in the village of Wymysłów, central Poland. The water reservoir appeared to harbour several remarkable chrysophyte stomatocysts which are described, illustrated and discussed in the present paper. These data are needed to advance estimates of stomatocyst diversity (Hansen 2001, Piątek 2006), still poorly-known globally.

Material and methods

The material was collected on 10 July 2004 from a small water reservoir situated in the village of Wymysłów in the Wyżyna Małopolska upland in central Poland. The material comprised bottom sediments collected from the reservoir bank.

Water temperature (°C), conductivity (μS cm^{-1}) and pH were measured on one occasion, immediately after collection. Temperature and conductivity were measured using a CC-102 conductivity meter (Elmetron IP67), and pH was measured using a CP-103 waterproof pH-meter (Elmetron IP67).

In the laboratory, each sample was placed in a glass scintillation vial, covered with 10% HCl (to remove carbonates) and allowed to stand for 24 h, boiled for 15 min, and rinsed several times with distilled water. The samples were covered with 30% H_2O_2 and allowed to stand for 24 h, then boiled for 30 min with a small amounts of $KClO_3$ added at ca. 15-minute intervals, and rinsed several times with distilled water, with a settling time of 24 h between each aspiration. Finally the samples were slurred in glass vials and covered with 95% alcohol.

SEM preparation and studies proceeded as described by Cabała and Piątek (2004). SEM micrographs were taken in the Laboratory of Field Emission Scanning Electron Microscopy and Microanalysis at the Institute of Geological Sciences of the Jagiellonian University. Stomatocysts were measured and described from SEM micrographs according to International Statospore Working Group (ISWG) guidelines (Cronberg & Sandgren 1986).

New stomatocysts not published previously were assigned numbers beginning with stomatocyst #40, and are cited as 'this paper'. 'Number of specimens' refers to the number of SEM-micrographs used for the description of the respective stomatocyst.

Results and discussion

Description of study area

The samples were collected from a small, man-made water reservoir situated in the village of Wymysłów in the Wyżyna Małopolska upland in central Poland. The water reservoir is a square with sides ca. 5 m × 5 m long and the maximum depth ca. 1 m. It is supplied with wastewater through a plastic pipe from farms upstream, covers soils with a high content of $CaCO_3$ and CaO, and is surrounded by meadow vegetation. The water surface is free from any vascular plant vegetation. Water pH was 7.7, electrolytic conductivity 440 μS cm^{-1}, and temperature 24 °C. The water reservoir lies within a large complex of alkaline mires covering several hectares, with unique vascular plant vegetation, represented, among others, by such remarkable communities as *Ctenidio molluscae–Seslerietum uliginosae* and *Lipario-Schoenetum ferruginei* (Głazek 1992).

Taxonomy

The recorded cysts are presented in groups based on their shared morphological characters, following Duff *et al*. (1995), Pla (2001) and Wilkinson *et al*. (2001).

Unornamented stomatocysts

Spherical, without collar

Stomatocyst 15, Duff & Smol 1988 *emend*. Zeeb & Smol 1993 (Fig. 1A)

Negative number: Wym/d-18.
Number of specimens: 1.

DESCRIPTION. Spherical, 11.3 μm in diameter. The pore is regular, 0.9 μm in diameter. The cyst body is unornamented.

DISTRIBUTION. **Poland**: karstic sink-hole in Staszów (Wołowski *et al*. 2004), Staw Toporowy Wyżni peat bog in the Tatra National Park (Cabała 2005a), Owczary Reserve (Piątek & Piątek 2005). **Other locations**: Canada, U.S.A., Greenland (Duff *et al*. 1995), Spanish Pyrenees (Pla 2001), high arctic Svalbard lakes (Betts-Piper *et al*. 2004), southwest Greenland (Pla & Anderson 2005).

Stomatocyst 22, Hansen 2001, Forma A (Fig. 1B)

Negative number: Wym/d-39.
Number of specimens: 9.

DESCRIPTION. Spherical, 7.6–9.5 μm in diameter. The pore is deep with planar pseudoannu-

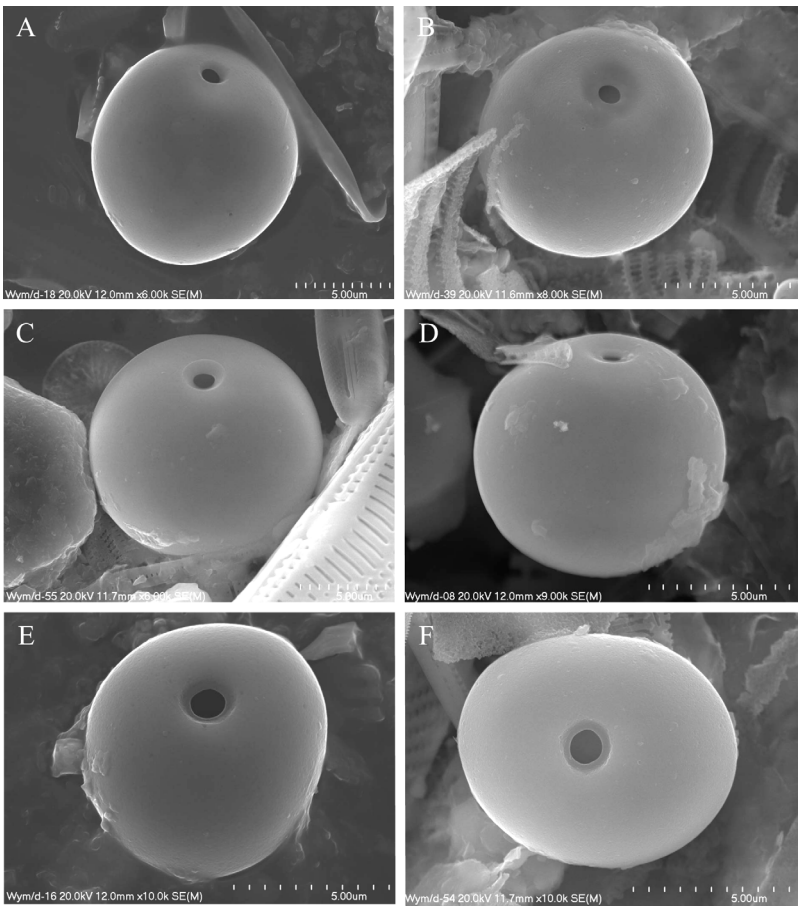

Fig. 1. — **A**: Stomatocyst 15. — **B**: Stomatocyst 22 forma A. — **C**: Stomatocyst 42. — **D**: Stomatocyst 49. — **E–F**: Stomatocyst #40.

lus, outer diameter 1.4–2.3 μm, inner diameter 0.6–0.9 μm.

DISTRIBUTION. **Poland**: Staw Toporowy Wyżni peat bog (Cabała 2005a) and Morskie Oko lake (Cabała 2005b) in the Tatra National Park. **Other locations**: Azores (Hansen 2001).

COMMENTS. Stomatocyst 22 was divided into two formae, A and B, by Cabała (2005b). They differ by the ornamentation of the cyst body. Forma A has a completely smooth surface while forma B is ornamented with verrucae.

Stomatocyst 42, Duff & Smol 1989 (Fig. 1C)

Negative: Wym/d-55.
Number of specimens: 4.

DESCRIPTION. Spherical, 11.8–12.3 μm in diameter (always > 10.0 μm). The pore is concave, outer diameter 2.1–2.3 μm, inner diameter 1.1–1.2 μm.

DISTRIBUTION. **Poland**: fossil chrysophyte cyst flora of Jezioro Racze on the island of Wolin (Rybak 1987), karstic sink-hole in Staszów (Wołowski *et al*. 2004), Owczary Reserve (Piątek & Piątek 2005). **Other locations**: Canada, U.S.A. (Duff *et al*. 1995), subantarctic island of South Georgia (van de Vijver & Beyens 1997), Spanish Pyrenees (Pla 2001), high arctic Svalbard lakes (Betts-Piper *et al*. 2004), southwest Greenland (Pla & Anderson 2005).

Stomatocyst 49, Duff & Smol 1991 *emend*. Zeeb & Smol 1993 (Fig. 1D)

Negative: Wym/d-08.
Number of specimens: 3.

DESCRIPTION. Spherical to slightly oblate, 8.4–10.4 μm in diameter. The pore is concave, outer

diameter 1.5–2.6 μm, inner diameter 0.6–1.0 μm, with a swollen pseudoannulus. No collar is present.

DISTRIBUTION. **Poland**: Jezioro Kortowskie (Rybak 1986), Budzyń peat bog (Cabała 2002), Owczary Reserve (Piątek & Piątek 2005), bryophyte spring on the western slope of the Mały Kościelec Mt. in the Tatra National Park (Piątek 2005). **Other locations**: Canada, U.S.A. (Duff *et al*. 1995), central Europe (Facher & Schmidt 1996), subantarctic island of South Georgia (van de Vijver & Beyens 1997, 2000), Spanish Pyrenees (Pla 2001), Austria (Kamenik *et al*. 2001), southwest Greenland (Pla & Anderson 2005).

Stomatocyst #40, Piątek J., this paper (Fig. 1E–F)

Negative: Wym/d-16, Fig. 1E.
Number of specimens: 12.

DESCRIPTION. Oblate, sometimes spherical, 7.3–8.8 μm in diameter. The pore is regular, outer diameter 1.4–1.8 μm, inner diameter 1.0–1.2 μm (always ≥ 1.0 μm), with a planar pseudoannulus.

COMMENTS. This stomatocyst is distinguished from stomatocyst 16 Hansen 2001 by the size of the cyst body and the pore. The latter cyst is larger (diameter 10.0–11.0 μm) with a smaller inner pore (diameter 0.7–0.8 μm). Stomatocyst #40 is also similar to stomatocyst 22 Hansen 2001, in which, however, the inner pore is smaller and the shape of the cyst body is always spherical. Hansen (2001) described this morphotype on the basis of 14 specimens, and the inner pore diameter of all ranges from 0.7 to 0.8 (always ≤ 1.0 μm). Stomatocysts #40 has a greater inner pore diameter ranging from 1.0 to 1.2 μm (always ≥ 1.0 μm). Moreover, the cyst body is oblate in most specimens. I believe that the two characters differentiating stomatocyst 22 and stomatocyst #40 are sufficient to describe the latter morphotype as new to science.

Stomatocyst #41, Piątek J., this paper (Fig. 2A–B)

Negative: Wym/d-65, Fig. 2A.
Number of specimens: 7.

DESCRIPTION. This stomatocyst is oblate, 6.9–7.9 μm long and 8.0–9.0 μm wide. The pore is conical to concave, outer diameter 1.6–1.9 μm, inner diameter 1.0–1.2 μm (always ≥ 1.0 μm).

COMMENTS. Stomatocyst #41 is distinguished from stomatocyst 3 Coradeghini & Vigna 2001 by the shape and size of the cyst body and the size of the outer pore. The latter cyst is spherical, 7.5 μm in diameter, and the outer pore diameter is 4.1 μm. Differences in the shape of the cyst body as well as in the size and morphology of the collar are important taxonomic characters in smooth stomatocysts. I therefore decided to describe stomatocyst #41 as a new morphotype on the basis of such differences.

Spherical, simple conical collar

Stomatocyst 181, Brown & Smol *in* Brown *et al*. 1994 (Fig. 2C)

Negative: Wym/d-63.
Number of specimens: 1.

DESCRIPTION. Spherical, 8.7 μm in diameter. The collar is conical, 4.1 μm in diameter and 1.3 μm high. The pore is regular, 0.5 μm in diameter.

DISTRIBUTION. **Poland**: Budzyń peat bog (Cabała 2002), Staw Toporowy Niżni peat bog (Cabała & Piątek 2004) and Zmarzły Staw Gąsienicowy lake (Piątek 2006) in the Tatra National Park. **Other locations**: Canada, U.S.A., Greenland (Duff *et al*. 1995), high arctic Svalbard lakes (Betts-Piper *et al*. 2004).

Spherical, simple obconical collar

Stomatocyst 161, Zeeb & Smol 1993 *emend*. Piątek J., this paper (Fig. 2D–E)

Negative: Wym/d-13, Fig. 2E.
Number of specimens: 7.

DESCRIPTION. Spherical to slightly oval, 9.8–11.1 μm in diameter. The collar is obconical, basal diameter 2.3–2.4 μm, apical diameter 2.5–3.0 μm, height 1.7–2.7 μm. The pore is regular, 0.9 μm in diameter.

DISTRIBUTION. **Poland**: Wymysłów, reported here for the first time from Poland. **Other loca-**

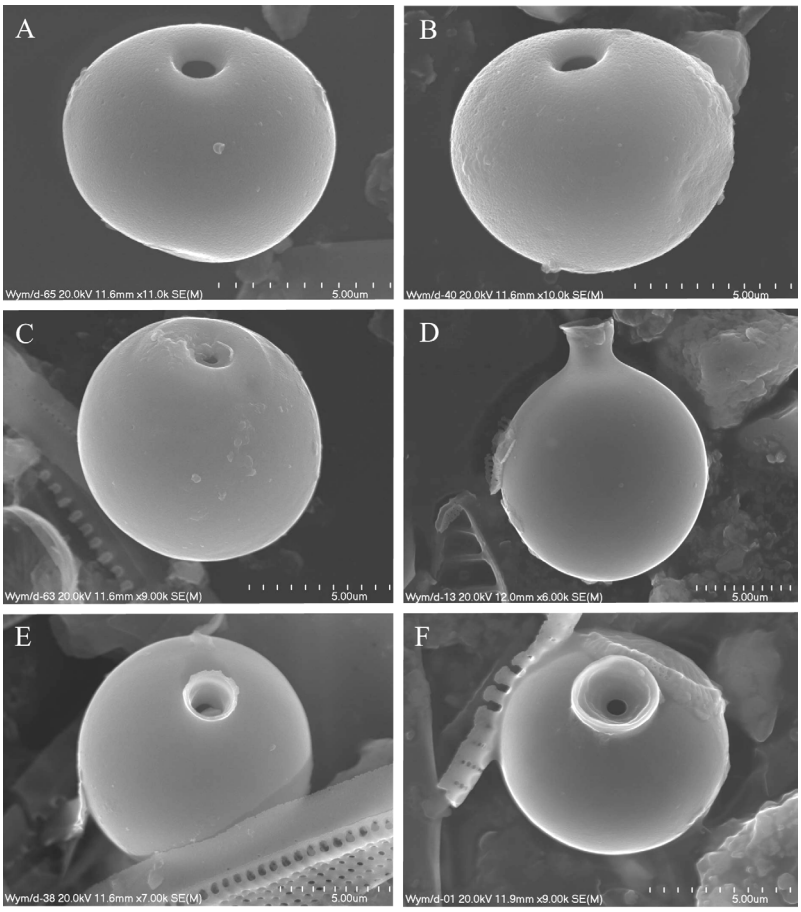

Fig. 2. — **A**–**B**: Stomatocyst #41. — **C**: Stomatocyst 181. — **D**–**E**: Stomatocyst 161. — **F**: Stomatocyst 198 forma A.

tions: Canada, U.S.A. (Duff *et al*. 1995), central Europe (Facher & Schmidt 1996), Spanish Pyrenees (Pla 2001), high arctic Svalbard lakes (Betts-Piper *et al*. 2004), southwest Greenland (Pla & Anderson 2005).

Comments. Stomatocyst 161 Zeeb & Smol 1993 is emended in the present paper to include the characters of the pore not observed either by Zeeb and Smol (1993) or by Pla (2001). The specimens found in Wymysłów are similar to the specimen described by Pla (2001) as the collar is obconical. Conversely, according to Zeeb and Smol (1993) the collar is cylindrical.

Stomatocyst 198, Duff & Smol 1994, Forma A Pla 2001 *emend*. Piątek J., this paper (Fig. 2F)

Negative: Wym/d-01, Fig. 2F.
Number of specimens: 2.

Description. Spherical, 7.7–8.0 μm in diameter. The collar is obconical, 2.9–3.1 μm in diameter, with a flat planar annulus. The pore is 0.6–0.7 μm in diameter.

Distribution. **Poland**: Wymysłów, reported here for the first time from Poland. **Other locations**: Canada, U.S.A. (Duff *et al*. 1995), Spanish Pyrenees (Pla 2001), high arctic Svalbard lakes (Betts-Piper *et al*. 2004), southwest Greenland (Pla & Anderson 2005).

Comments. Stomatocyst 198 forma A is distinguished from stomatocyst 53 Duff & Smol 1991 by collar morphology. The latter has a cylindrical to slightly obconical collar with a planar annulus that always has some evidence of radial annular rings. Pla (2001) found only one specimen of this morphotype, describing it as a new form and giving the measurements of the cyst body and the collar for this specimen only. The specimens found in Wymysłów certainly belong to the same morphotype but are slightly larger. The difference probably results from a greater number of speci-

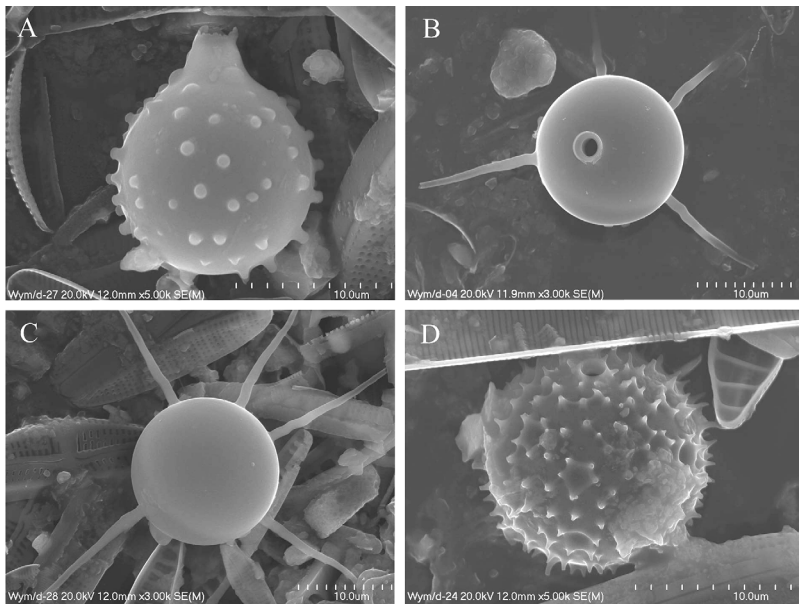

Fig. 3. — **A**: Stomatocyst 10. — **B–C**: Stomatocyst #42. — **D**: Stomatocyst 171.

mens recorded in the present study. Consequently, stomatocyst 198 forma A is emended.

Ornamented stomatocysts

With conula

Stomatocyst 10, Cabała J. *in* Wołowski *et al.* 2004 (Fig. 3A)

Negative: Wym/d-27.
Number of specimens: 12.

DESCRIPTION. Spherical, 11.3–13.5 μm in diameter. The surface is ornamented with conula, 0.4–0.9 μm in diameter and height 0.4–0.9 μm. The collar is conical, basal diameter 3.0–4.9 μm, apical diameter 1.8–2.5 μm, height 1.4–2.7 μm.

DISTRIBUTION. **Poland**: karstic sink-hole in Staszów (Wołowski *et al.* 2004). **Other locations**: it has so far been found only in Poland (Wołowski *et al.* 2004, and this study).

With spines

Stomatocyst #42, Piątek J., this paper (Fig. 3B–C)

Negative: Wym/d-04, Fig. 3B.
Number of specimens: 19.

DESCRIPTION. Spherical, 14.1–15.7 μm in diameter (always $\geq$ 14.0 μm). The surface is ornamented with 3–5, long spines (basal diameter 1.2 μm, apical diameter 0.4–0.7 μm, and 12.1–15.1 μm long), scattered over the whole area of the cyst wall. The collar is obconical, 2.8–3.0 μm in diameter (usually diameter 3.0 μm) and 0.2–0.6 μm high (usually 0.4 μm high). The pore is regular, 1.5–1.8 μm in diameter (usually diameter 1.8 μm).

COMMENTS. Stomatocyst #42 is morphologically comparable with several stomatocysts known previously, including stomatocyst 114 Zeeb *et al.* 1990, stomatocyst 115 Zeeb *et al.* 1990, stomatocyst 218 Duff & Smol 1994, stomatocyst 64 Duff & Smol 1991, stomatocyst 262 Zeeb & Smol *in* Zeeb *et al.* 1996, stomatocyst 80 Hansen 2001, stomatocyst 41 van de Vijver & Beyens 1997 and stomatocyst 12 Vilaclara, Cuna & Zeeb 2005. However, all of them are smaller and also differ by other morphological characters.

Stomatocyst 114 Zeeb *et al.* 1990 is 5.0–6.3 μm in diameter, has a smaller and conical pore, 0.4–0.5 μm in diameter, a conical primary and cylindrical secondary collar and up to four echi-

nate spines which are located approximately equatorially and approximately equally. Stomatocyst 115 Zeeb *et al*. 1990 is 5.4–6.5 μm in diameter, has a smaller and conical pore, 0.3–0.8 μm in diameter, a cylindrical collar and up to four spines which are located equatorially and approximately equidistantly. Stomatocyst 218 Duff & Smol 1994 is 4.9–5.6 μm in diameter, has a conical pore, 0.3–0.5 μm in diameter, and three or four approximately equatorial spines. Stomatocyst 64 Duff & Smol 1991 is 5.1–8.8 μm in diameter, may be smooth or scabrate and has 2–4 spines located approximately equidistantly in the equatorial region or in the posterior hemisphere. Stomatocyst 262 Zeeb & Smol in Zeeb *et al*. 1996 is 6.1–6.6 μm in diameter and has four or five spines which are located in the subequatorial region. Stomatocyst 80 Hansen 2001 is about 10.0 μm in diameter and has ornamentation with spines trifurcating at the top, located mainly in the posterior hemisphere. Stomatocyst 41 van de Vijver & Beyens 1997 is 6.3–7.9 μm in diameter, has a smaller pore, 0.6–0.69 μm in diameter, and cylindrical collar. Stomatocyst 12 Vilaclara, Cuna & Zeeb 2005 is 9.5–13.6 μm in diameter, has a regular pore, 0.6 μm in diameter, a low cylindrical collar and ornamentation with four approximately equatorial spines.

With compound ornamentation

Stomatocyst 171, Zeeb & Smol 1993 (Fig. 3D)

Negative: Wym/d-24.
Number of specimens: 9.

DESCRIPTION. Spherical, 12.7–14.1 μm in diameter. The surface is ornamented with conula, 0.1–0.3 μm in diameter, and spines, 0.1–0.4 μm in diameter and 0.6–1.1 μm high, scattered randomly or arranged in a ring around shallow circular depressions (1.2–1.5 μm in diameter) in the cyst wall. The collar is cylindrical to conical, 1.8 μm in diameter and 0.5 μm high. The pore is regular, 0.7 μm in diameter.

DISTRIBUTION. **Poland**: as a *cysta polygonata* in the paleocyst flora of bottom sediments in Jezioro Kortowskie (Rybak 1986); reported in Poland for the first time from extant material. **Other locations**: Canada, U.S.A., Denmark (Duff *et al*. 1995), Spanish Pyrenees (Pla 2001).

Summary

A total of 12 different stomatocysts were recorded from sediments in a man-made water reservoir in the village of Wymysłów. In the stomatocyst assemblage, nine morphotypes were unornamented stomatocysts and three morphotypes were ornamented stomatocysts. Some of the former may be produced by more than one chrysophyte species. The majority of stomatocysts found in the water reservoir occurred abundantly and only three morphotypes, stomatocyst 15 Duff & Smol 1988 *emend*. Zeeb & Smol 1993, stomatocyst 181 Brown & Smol *in* Brown *et al*. 1994, and stomatocyst 198 Duff & Smol 1994, forma A Pla 2001 *emend*. Piątek J., were represented by one or two specimens.

Three morphotypes appeared to be new to science: stomatocysts #40, #41 and #42. They were described on the basis of 12, 7 and 19 specimens, respectively. It was therefore possible to define the variability of the new morphotypes and to establish that typical features of these cysts are constant in different specimens. Two other stomatocysts are new to Poland: stomatocyst 161 Zeeb & Smol 1993 *emend*. Piątek J. and stomatocyst 198 Duff & Smol 1994, forma A Pla 2001 *emend*. Piątek J. These stomatocysts have been found in various places across Europe and North America, and are most probably produced by cosmopolitan chrysophytes. Unfortunately, their biological affinities are unknown. The descriptions of these two stomatocysts are emended in the present study to include some additional morphological characters which had not been observed previously. Furthermore, stomatocyst 171 Zeeb & Smol 1993 was found for the first time in Poland in extant material. It had been observed previously only in the paleocyst flora of the bottom sediments in Jezioro Kortowskie lake (Rybak 1986).

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