ГОДИШНИК НА СОФИЙСКИЯ УНИВЕРСИТЕТ „СВ. КЛИМЕНТ ОХРИДСКИ“

БИОЛОГИЧЕСКИ ФАКУЛТЕТ
Книга 2 – Ботаника

Том 107, 2023

ANNUAL OF SOFIA UNIVERSITY “ST. KLIMENT OHRIDSKI”

FACULTY OF BIOLOGY
Book 2 – Botany

Volume 107, 2023

https://doi.org/10.60066/GSU.BIOFAC.Bot.107.5-16

SMALL WATER BODIES IN AGRICULTURAL AREAS AS IMPORTANT HABITATS FOR EUGLENOIDS IN POLAND

SOFIA CELEWICZ*

Department of Botany, Faculty of Agronomy, Horticulture, and Bioengineering, Poznań University of Life Sciences, Dąbrowskiego 159, 60-594 Poznań, Poland

Abstract. Temporary water bodies of glacial origin, known as kettle holes, are typical elements of the young moraine landscape in many countries. Unfortunately, they are very exposed to effects of anthropogenic changes, especially in agricultural areas. Due to their small area and depth, as well as to the great fluctuations in water level, they create specific conditions for organisms that inhabit them. Consequently, kettle holes are unique biodiversity hotspots in landscape, rich in some microalgal species, particularly euglenoids (euglenophytes). In this study, the taxonomic composition of euglenoids was studied in three temporary water bodies in an agricultural landscape of Wielkopolska Province (western Poland). In total, 65 euglenoid taxa were identified there during one year. Euglenoids in the investigated field ponds were the most species-rich group of microalgae. They accounted for 26% of the total number of phytoplankton taxa. According to the constancy (frequency) of occurrence most of the species were incidental. The most common taxa were: *Trachelomonas volvocina*, *Euglenaformis proxima*, *Trachelomonas intermedia*, *Lepocinclis tripteris*, and *Lepocinclis acus*. The high species richness of euglenoids in aquatic ecosystems of agricultural areas shows how valuable ponds are for preserving local biodiversity and for aquatic food webs. The small water bodies in farmlands should be protected against progressive anthropogenic eutrophication and degradation.

Keywords: field ponds, phytoplankton, species diversity, biodiversity conservation, eutrophication

* *corresponding author*: S. Celewicz - Department of Botany, Faculty of Agronomy, Horticulture, and Bioengineering, Poznań University of Life Sciences, Dąbrowskiego 159, 60-594 Poznań, Poland; sofiacelewiczgoldyn@gmail.com

INTRODUCTION

In intensively used farmlands in Poland small water bodies are particularly important elements of the heavily transformed landscape. Ponds in such areas are considered to be major hotspots of biodiversity, hosting populations of interesting and rare algae, higher plants, and animals (Boix et al. 2012; Goldyn et al. 2015 a, b). Most of the animal and plant species occurring in farmlands gather around and directly depend on functioning of small wetlands. Moreover, ponds play a crucial role in increasing connectivity between freshwater habitats, as stepping-stone ecosystems. They are important also because of their ecosystem services and high economic value because they play crucial roles in the rural landscape, such as flood control, groundwater recharge, toxicant removal, and recycling of nutrients (Koc et al. 2001; Waterkeyn et al. 2008). Moreover, species of animals connected with ponds play a significant role in pest control in surrounding agricultural areas (Williams 2006).

Climate change (increase in average temperatures, decrease in the amount or even long-term lack of regular snowfall or rainfall), together with the progressive anthropogenic transformations of landscape, lead to changes in species composition and to degradation of the sensitive small water bodies. Until recently, water management in Poland was focused on intensive drainage of agricultural land in order to increase the acreage of crops. Moreover, some activities indirectly affected their rapid degradation, *e.g.* drainage works in areas adjacent to ponds, which caused them to dry out, or intensive fertilization of agricultural fields, which led to overfertilization of water in the kettle holes and, consequently, to their shallowing and disappearance of the water bodies. Field ponds were treated as useless elements of landscape, so their area and number were reduced in an uncontrolled way (Juszczak & Arczyńska-Chudy 2003; Dudzińska et al. 2020). In recent decades, they have disappeared rapidly also in other parts of Europe and are known to be one of the most endangered ecosystems on this continent (Waldon 2012).

Small water bodies are typical elements of agricultural landscapes in the regions that were covered by the last glaciation. Many of them are of natural post-glacial origin. According to a Polish classification, they are up to 1 ha in area, usually have an oval shape, diameter up to 100 m, and depth not exceeding 2–3 m (Koc et al. 2001). They fill depressions left by the glaciers and are the most numerous type of aquatic ecosystems in Poland. These water bodies are often astatic, characterized by irregular, but usually very large fluctuations of water level, leading to periodic or even complete drying out, as opposed to permanent ponds (Goldyn & Kuczyńska-Kippen 2012). They create specific habitats for the species inhabiting them, because of the great fluctuations of physical-chemical parameters of water (*e.g.*, water temperature, pH, conductivity, and nutrient concentrations). Organisms in astatic ponds develop specific adaptations, which allow them to survive drought periods in habitats of this type. As a result of the instability of environmental conditions and the frequent drying out of small water bodies, they are usually devoid of fish. However, this allows their colonization by many other vertebrates (*e.g.*, specialized amphibians) or large aquatic invertebrates. Very important components of these habitats include planktonic algae, which are primary producers. Thus the structure and function of algal communities markedly influence the functioning of the whole aquatic ecosystem. The phytoplankton of small water bodies is highly specific (Całewicz & Gołdyn 2021). They are dominated by species that tolerate variable or even extreme environmental conditions, also by some rare species. After every drought period, phytoplankton communities in temporary water bodies are restored mainly thanks to resting stages preserved in bottom sediments. The colonization of the aquatic ecosystem by various algae after their filling with water is caused by secondary succession. The phytoplankton of astatic water bodies in rural areas is still poorly studied. Preliminary research shows that such ecosystems are rich in species that are rare in lakes (Całewicz, unpublished data).

Euglenoids (also known as euglenids or euglenophytes) are a characteristic group of pond phytoplankton and usually prefer shallow and freshwater habitats rich in dissolved organic matter, which are rapidly warming, even with poor light conditions (Messyasz 1996; Reynołds et ał. 2002; Wołowski & Grabowska 2007; Poniewozik & Wołowski 2017). According to Wołowski (2003), there are about 650 taxa of euglenoids in Poland. They are mixotrophic organisms, capable of both photosynthesis and using organic carbon from the environment as a source of energy. They are regarded as good indicators of organic pollution of water and used for trophic state assessment (Wołowski & Grabowska 2007; Czerwik-Marcinkowska 2019). Euglenoids are able to form resting stages (cysts) to survive unfavourable conditions in bottom sediments (Poniewozik & Juráň 2018). Species of this group are often present in broad belts of littoral vegetation of shallow water bodies (where intensive processes of decomposition of macrophytes take place), in inlets or in the whole permanent water bodies polluted by organic wastewater as well as in astatic water bodies (which dry out periodically), peatlands, and pools. Considering their specific habitat preferences, their species diversity is usually high also in astatic field ponds.

The aim of the study was to assess the species composition of euglenoids and their share compared to other phytoplankton groups in astatic water bodies, which could serve as a basis for future tracking of algal diversity in this type of aquatic ecosystems. Moreover, the acquired knowledge about the qualitative structure of microalgae will help us understand better the functioning of field ponds, but also will raise awareness of their ecological importance and of the need to protect them against drying out and degradation.

MATERIAL AND METHODS

Euglenoids were studied in three small water bodies located at the outskirts of Poznań, within Wielkopolska Province, western Poland (52°27'N, 16°57'E). The ponds represented the post-glacial type and were located in an agricultural landscape. Their maximum depths and surface areas were as follows: 1.2 m and 1171 m^2; 1 m and 1100 m^2; 0,7 m and 371 m^2, respectively.

Samples for phycological analyses were taken from the surface layers of water (from the central part of each pond), by using a plankton net (mesh size: 25 μm) and then fixed with Lugol solution. Phytoplankton samples were collected every two weeks from 11.02.2008 to 02.03.2009, and 89 samples were taken in total. Algal taxa were determined with a light microscope (magnification 200x, 400x, and 1000x). Publications of the following authors were used for the taxonomic identification of euglenoids: STARMACH (1983), WOŁOWSKI (1998), and WOŁOWSKI & HINDAK (2005). Microalgal taxa names were given in accordance with classifications used in Algaebase (GUIRY & GUIRY 2021). Photographic documentation of algae was made using an Olympus BX43 microscope with an SC30 camera.

The constancy (frequency) of the phytoplankton taxa in the investigated ponds was estimated, and species were classified according to the Tichler scale (TROJAN 1975): incidental (1–25%), accessory (26–50%), permanent (51–75%), and absolutely permanent (76–100%).

RESULTS AND DISCUSSION

In the investigated ponds, 254 phytoplankton taxa have been identified, representing 8 systematic groups: Euglenophyta (65), Bacillariophyceae (64), Chlorophyta (54), Cyanoprokaryota/Cyanobacteria (36), Cryptophyta (21), Dinophyceae (9), Xanthophyceae (3), and Chrysophyceae (2).

Euglenoids had the largest share in the total number of taxa (26%), compared to the other phytoplankton groups (**Fig. 1**). Some of the species are illustrated in **Fig. 2**. Similar results were found in two temporary small water bodies in the farmlands of the southern edge of Wysoczyzna Świecka (PACZUSKA ET AŁ. 2002), where also euglenoids and diatoms dominated in the phytoplankton communities. The large share of diatom taxa in microalgae assemblages is probably connected with the fact that phytoplankton communities in ponds are enriched also by tychoplanktonic organisms (of epiphytic or benthic origin), due to their small area and depth. This was consistent with results of other studies concerning field ponds (PACZUSKA ET AŁ. 2002; KUCZYŃSKA-KIPPEN 2009; CEŁEWICZ-GOŁDYN & KUCZYŃSKA-KIPPEN 2017; CEŁEWICZ & GOŁDYN 2021).

The results of taxonomic identification of the euglenoids in all the studied ponds are summarized in **Table 1**. The listed taxa belong to 11 genera (*Astasia, Colacium, Discoplastis, Euglena, Euglenaformis, Euglenaria, Lepocinclis, Mono*

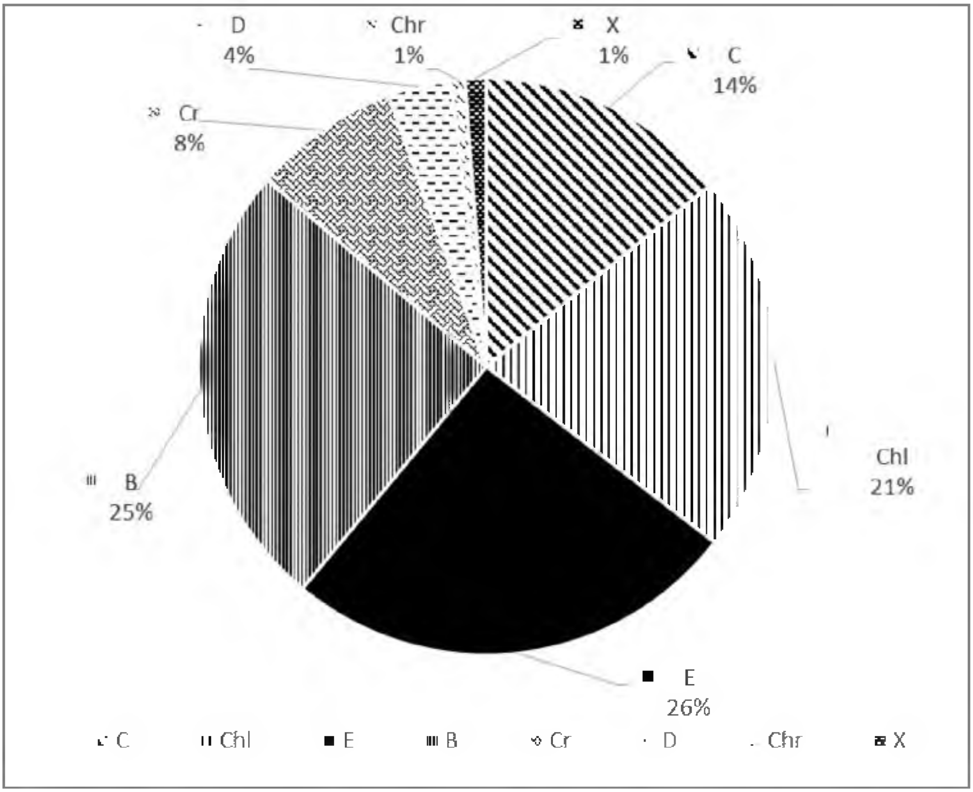

Fig. 1. Percentage contributions of major systematic groups – Cyanobacteria (C), Chl – Chlorophyta (Chl), Euglenophyta (E), Bacillariophyceae (B), Cryptophyta (Cr), D – Dinophyceae (D), Chrysophyceae (Chr), and Xanthophyceae (X) – to the total number of phytoplankton taxa in the investigated ponds.

morphina, Phacus, Strombomonas, and *Trachelomonas*). Among them, the most species-rich was the genus *Trachelomonas* (25 taxa). Many species of this genus are considered cosmopolitan, ubiquitous, and are often present in small water bodies polluted with mineral fertilizers, puddles, peatlands, lakes, and in slow-flowing waters (Czerwik-Marcinkowska 2019). Additionally, Grabowska & Wołowski (2014) stated that euglenoids of the genus *Trachelomonas* prefer eutrophic warm waters with a high oxygen content. According to Poniewozik & Juráň (2018), they are observed in waters with a very high concentration of ammonium nitrogen. Similarly, Stević et al. (2013) recorded a high diversity of *Trachelomonas* species in waters with large amounts of organic matter and, consequently, high concentrations of phosphorus and nitrogen.

In respect of constancy, most of the euglenoids (47 taxa) were classified as incidental in the investigated field ponds, because they were found in up to 25% of the analysed samples (**Table 1**). A large group of species (15) occurred in 26–50%

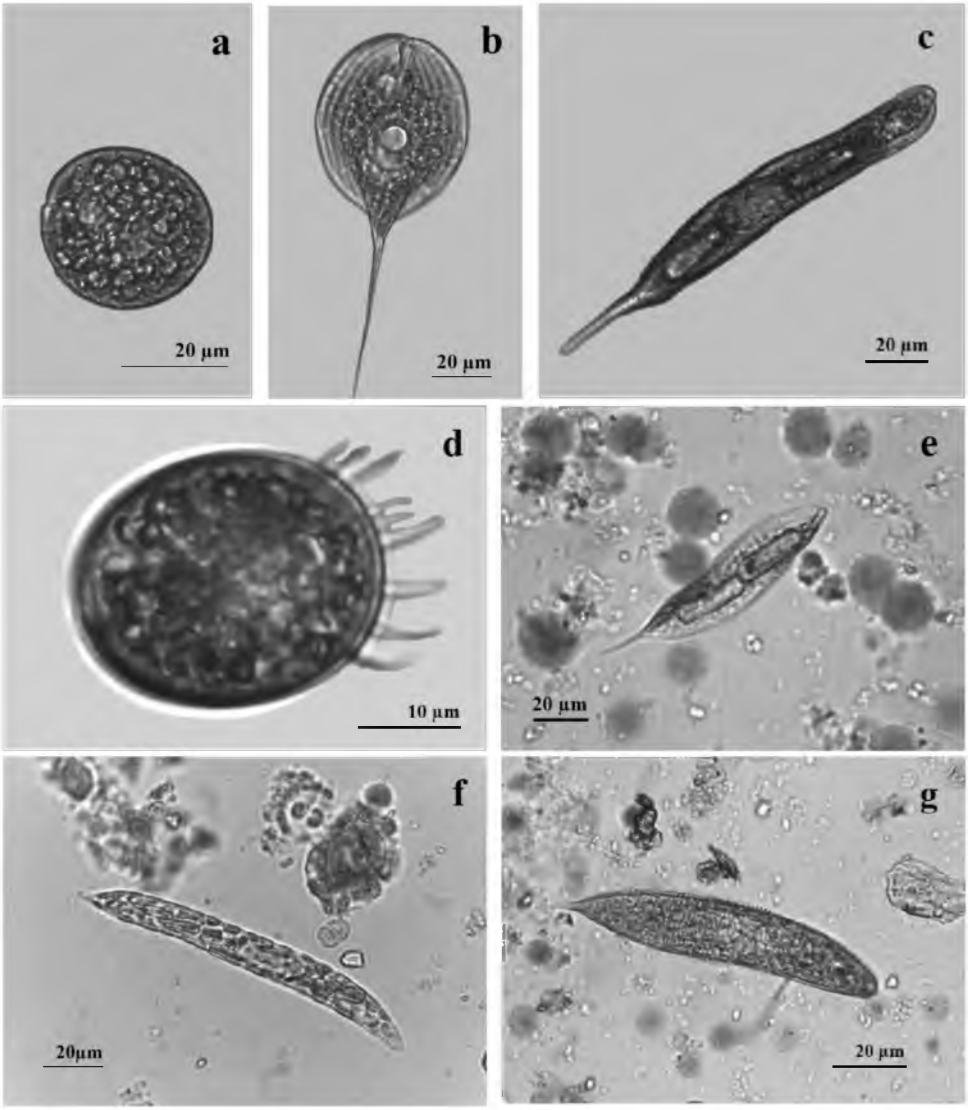

Fig. 2. Examples of euglenoids from the examined ponds: a - *Euglena texta*; b - *Phacus longicauda*; c - *Lepocinclis oxyuris*; d - *Trachelomonas armata*; e - *Lepocinclis tripteris*; f - *Euglena deses*; g - *Lepocinclis spirogyroides*.

of the analysed samples and most of them belong to the genera *Lepocinclis* and *Phacus*. The most frequently noted (absolutely permanent) species was *Trachelomonas volvocina*. According to Wołowski (1998), it is a very common species in Poland and can occur in various types of water bodies with various levels of saprobity. *T. volvocina* reached the highest frequency also in field ponds of the southern edge of Wysoczyzna Świecka in Poland (Paczuska et al. 2002). Permanent species included *Euglenaformis proxima* and *T. hispida*.

Most of the taxa recorded in the investigated ponds are cosmopolitan and widespread, usually inhabiting ponds and swamps. However, some interesting, rare species, such as *Trachelomonas sydneyensis*, were also observed. According to Poniewozik & Juráň (2018), this alga was found in nutrient-rich, temporary clay-pit ponds (especially rich in ammonium salts), located in eastern Poland near Lublin city.

Table 1. Taxonomic composition of euglenoids and type of constancy of species occurrence in the examined ponds.

Taxa	**Type of constancy**			
	absolutely permanent	**permanent**	**accessory**	**incidental**
Astasia sp.				+
Colacium mucronatum Bourrelly & Chadefaud				+
Colacium sp.				+
Colacium vesiculosum Ehrenberg				+
Discoplastis angusta (C. Bernard) Zakryś & Łukomska				+
Euglena clara Skuja				+
Euglena deses (O. F. Müller) Ehrenberg			+	
Euglena hemichromata Skuja				+
Euglena texta (Dujardin) Hübner			+	
Euglena truncata L. B. Walton				+
Euglena viridis (O. F. Müller) Ehrenberg				+
Euglenaformis proxima (P. A. Dangeard) M. S. Bennett & Triemer		+		
Euglenaria caudata (E. F. W. Hübner) Karnkowska -Ishikawa & E. W. Linton				+
Euglenaria clavata (Skuja) Karnkowska & E. W. Linton				+
Lepocinclis acicularis France				+
Lepocinclis acus (O. F. Müller) B. Marin & Melkonian			+	
Lepocinclis fusiformis (H. J. Carter) Lemmermann			+	
Lepocinclis globulus Perty				+
Lepocinclis hispidula (Eichwald) Daday				+

Taxa	Type of constancy			
	absolutely permanent	**permanent**	**accessory**	**incidental**
Lepocinclis ovum (Ehrenberg) Lemmermann				+
Lepocinclis oxyuris (Schmarda) B. Marin & Melkonian				+
Lepocinclis spirogyroides B. Marin & Melkonian			+	
Lepocinclis steinii (Lemmermann) Lemmermann			+	
Lepocinclis tripteris (Dujardin) B. Marin & M. Melkonian			+	
Lepocinclis sp.				+
Monomorphina pyrum (Ehrenberg) Mereschkowsky				+
Phacus acuminatus A. Stokes			+	
Phacus alatus G. A. Klebs			+	
Phacus caudatus Hübner			+	
Phacus clavatus P. A. Dangeard				+
Phacus curvicauda Svirenko				+
Phacus limnophilus (Lemmermann) E. W. Linton & Karnkowska				+
Phacus longicauda (Ehrenberg) Dujardin			+	
Phacus onyx Pochmann				+
Phacus orbicularis Hübner			+	
Phacus parvulus G. A. Klebs				+
Phacus pusillus Lemmermann				+
Phacus sp.				+
Strombomonas acuminata (Schmarda) Deflandre				+
Strombomonas sp.				+
Trachelomonas armata (Ehrenberg) F. Stein				+
Trachelomonas caudata (Ehrenberg) F. Stein			+	
Trachelomonas cylindrica Ehrenberg				+
Trachelomonas dubia Svirenko				+
Trachelomonas duplex (Deflandre) Couté & Tell				+

Taxa	Type of constancy			
	absolutely permanent	**permanent**	**accessory**	**incidental**
Trachelomonas globularis (Averintsev) Lemmermann				+
Trachelomonas globularis f. *crenulato-collis* (Szabados) T. G. Popova				+
Trachelomonas hispida (Perty) F. Stein		+		
Trachelomonas hispida var. *coronata* Lemmermann				+
Trachelomonas hispida var. *crenulato-collis* (Maskell) Lemmermann				+
Trachelomonas hispida var. *volicensis* Drežepolski				+
Trachelomonas intermedia P. A. Dangeard			+	
Trachelomonas manginii Deflandre				+
Trachelomonas oblonga Lemmermann			+	
Trachelomonas oblonga var. *pulcher-rima* (Playfair) T. G. Popova				+
Trachelomonas pseudobulla Svirenko				+
Trachelomonas pusilla Playfair				+
Trachelomonas rugulosa F. Stein				+
Trachelomonas sp.				+
Trachelomonas sydneyensis Playfair				+
Trachelomonas verrucosa A. Stokes				+
Trachelomonas volvocina (Ehrenberg) Ehrenberg	+			
Trachelomonas volvocina var. *dere-phora* W. Conrad				+
Trachelomonas volvocinopsis Svirenko				+
Trachelomonas woycickii Koczwara				+

CONCLUSIONS

The results showed that small water bodies in the agricultural landscape in Wielkopolska Province in Poland are important habitats of interesting and often unique euglenoids. Their high contribution to the qualitative structure of phyto-plankton is probably associated with a high organic matter content and high con-centrations of nutrients in ponds (CELEWICZ, unpublished data) as well as with the fast changes in water temperature. These observations are confirmed by results of phycological studies of other authors, cited in this article. Research on algae living in these interesting ecosystems should be continued, contributing to their better understanding.

Aquatic ecosystems fulfil numerous functions in the usually monotonous agricultural landscapes (simplified structurally) but are subject to strong human impact, which threatens their existence. Thus, it is necessary to study their flora and fauna, and to assess their environmental value, in order to optimize protection measures. Protection of such ponds aims to preserve many rare and valuable species of algae, higher plants, and animals linked with aquatic habitats, and thus to maintain or increase biodiversity.

CONFLICT OF INTERESTS

The author declare that there is no conflict of interests regarding the publication of this article.

References

Boix D., Biggs J., Céréghino R., Hull A. P., Kalettka T. & Oertli B. 2012. Pond research and management in Europe: "Small is Beautiful". - Hydrobiologia 689: 1-9.

Celewicz-Goldyn S. & Kuczyńska-Kippen N. 2017. Ecological value of macrophyte cover in creating habitat for microalgae (diatoms) and zooplankton (rotifers and crustaceans) in small field and forest water bodies. - PLoS One 12(5): e0177317.

Celewicz S. & Goldyn B. 2021. Phytoplankton communities in temporary ponds under different climate scenarios. - Scientific Reports 11: 17969.

Czerwik-Marcinkowska J. 2019. Algologia. Praktyczny przewodnik. Wydawnictwo Naukowe PWN, Warszawa, 140 pp. (In Polish)

Dudzińska A., Szpakowska B. & Pajchrowska M. 2020. Influence of land development on the ecological status of smallwater bodies. - Oceanological and Hydrobiological Studies 49: 345-353.

Goldyn B., Chudzińska M., Baralkiewicz D. & Celewicz-Goldyn S. 2015a. Heavy metal contents in the sediments of astatic ponds: Influence of geomorphology, hydroperiod, water chemistry and vegetation. - Ecotoxicology and Environmental Safety 118: 103-111.

Goldyn B., Kowalczewska-Madura K. & Celewicz-Goldyn S. 2015b. Drought and deluge: Influence of environmental factors on water quality of kettle holes in two subsequent years with different precipitation. - Limnologica 54: 14-22.

Goldyn R. & Kuczyńska-Kippen N. (Ed.) 2012. Rola zbiorników wodnych w krajobrazie rolniczym. Fundacja Biblioteka Ekologiczna w Poznaniu,

„Bonami" Wydawnictwo-Drukarnia, 176 pp. (In Polish)
Grabowska M. & Wolowski K. 2014. Development of *Trachelomonas* species (Euglenophyta) during blooming of *Planktothrix agardhii* (Cyanoprokaryota). - Annales de Limnologie-International Journal of Limnology 50: 49–57.
Guiry M. D. & Guiry G. M. 2023. AlgaeBase. Retrieved from http://www.algaebase.org/ on 26 October 2023.
Juszczak R. & Arczyńska-Chudy E. 2003. Ecological and land reclamation valorization of small ponds in agricultural landscape of Wielkopolska. - Postępy Nauk Rolniczych 1: 145-160 (In Polish).
Koc J., Cymes I., Skwierawski A. & Szyperek U. 2001. Role of protecting small water reservoirs in rural landscape. - Zeszyty Problemowe Postępów Nauk Rolniczych 476: 397-407 (In Polish).
Kuczyńska-Kippen N. (Ed.) 2009. Funkcjonowanie zbiorowisk planktonu w zróżnicowanych siedliskowo drobnych zbiornikach wodnych Wielkopolski. Bonami Wydawnictwo-Drukarnia, 504 pp. (In Polish)
Messyasz B. 1996. Phytoplankton of the ponds in the „Meteoryt Morasko" nature reserve. - Roczniki naukowe Polskiego Towarzystwa Ochrony Przyrody „Salamandra" 1: 19 – 23.
Paczuska B., Paczuski R. & Krasicka-Korczyńska E. 2002. Midforest and field ponds of the southern Edge of Wysoczyzna Świecka (The Krajeńskie Lakes). Microflora, Macrophytes and the environment. - Wydawnictwa Uczelniane Akademii Techniczno-Rolniczej w Bydgoszczy, 91 pp. (In Polish)
Poniewozik M. & Wolowski K. 2017. Eugleniny (Euglenophyta) siedlisk wodno-torfowiskowych Tatr. - Fragmenta Floristica et Geobotanica Polonica 24 (2): 283–294 (In Polish).
Poniewozik M. & Juráň J. 2018. Extremely high diversity of euglenophytes in a small pond in eastern Poland. - Plant Ecology and Evolution 151 (1): 18–34.
Reynolds C. S., Huszar V., Kruk C., Naselli-Flores L. & Melo S. 2002. Towards a functional classification of the freshwater phytoplankton. - Journal of Plankton Research 24: 417–428.
Starmach K. 1983. Euglenophyta – Eugleniny. - In: Starmach K. & J. Siemińska (Ed.) Flora słodkowodna Polski, t. 3. PWN, Warszawa – Kraków, 594 pp. (in Polish)
Stević F., Mihaljević M. & Špoljarić D. 2013. Changes of phytoplankton functional groups in a floodplain lake associated with hydrological perturbations. - Hydrobiologia 709: 143–158.
Trojan P. 1975. General ecology. PWN, Warszawa, 419 pp. (in Polish).Waldon B. 2012. The conservation of small water reservoirs in the Krajeńskie Lakeland (North-West Poland). - Limnologica 42: 320-327.
Waterkeyn A., Grillas P., Vanschoenwinkel B. & Brendonck L. 2008. Invertebrate community patterns in Mediterranean temporary wetlands along hydroperiod and salinity gradients. - Freshwater Biology 53 (9): 1808-1822.

WIŁŁIAMS D. D. 2006. The biology of temporary waters. Oxford University Press, 348 pp.
WOŁOWSKI K. 1998. Taxonomic and environmental studies on Euglenophytes of the Kraków-Częstochowa Upland (Southern Poland). - Fragmenta Floristica et Geobotanica. Supplementum 6: 3-192.
WOŁOWSKI K. 2003. Różnorodność gatunkowa – glony. - In: ANDRZEJEWSKI R. & A. WEJGŁE (Ed.), Różnorodność biologiczna Polski. Narodowa Fundacja Ochrony Środowiska, Warszawa, 37-48 (In Polish).
WOŁOWSKI K. & HINDÁK F. 2005. Atlas of Euglenophytes. VEDA Publishing House of the Slovak Academy of Science, Bratislava, 136 pp.
WOŁOWSKI K. & GRABOWSKA M. 2007. *Trachelomonas* species as the main component of the euglenophyte community in the Siemianówka Reservoir (Narew River, Poland). - Annales de Limnologie-International Journal of Limnology 43 (3): 207-218.
WOŁOWSKI K. & KOWAŁSKA J. 2009. Autumnal flora of euglenophytes and other algae in the pond of the Botanical Garden in Kraków. - Fragmenta Floristica et Geobotanica Polonica 16 (1): 145 – 154 (In Polish).

Received 30th September 2023
Accepted 17th November 2023