

Review paper

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Future in the past: a review of phytoplankton studies conducted in southern Poland over the past fifty years

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Abstract

The data presented in the current paper address the analysis of phytoplankton with integrated species structure in aquatic ecosystems in southern Poland. The authors divided the studies into different investigation periods and based their review on changes in approaches and results over the past fifty years.

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INTRODUCTION

Phytoplankton studies developed in various directions over the course of a half a century. In the search for new subjects, that which has already been achieved is often overlooked. Thus, reviewing historical data to identify what is essential might be helpful in solving some current problems.

Generally speaking, studies conducted at the end of the 1950s dealt with the identification of numerous Euglenophyta taxa, especially species of *Euglena*, in post-regulation ponds on the banks of the Vistula River near Kraków. In the early 1960s, the subsequent study direction was phytoplankton dynamics and mosaic species composition in fish ponds with varied fish stocks, different applications, and the use (or lack thereof) of organic and inorganic fertilization (control ponds). In the 1970s through to the 1980s and into the 1990s, interest grew, due to their advancing eutrophication, in dam reservoirs of various trophic states. This, in turn, led to phytoplankton studies together with investigations of species composition (or diverse systematic groups) in response to abiotic physicochemical factors (Bucka et al. 1993). Another topic of interest is the influence of zooplankton as biotic factors on the dynamics of microflora communities, which is also known as phytoplankton-zooplankton mutual dependencies (Pociecha and Wilk-Woźniak 2005). One of the most current investigative issues is the implementation of the Water Framework Directive EU and the accompanying studies concerning the use of particular groups as bioindicators for the evaluation of water quality in a given ecosystem.

MATERIALS AND METHODS

The subject and methods presented are based on investigations conducted at the Ochaby Complex of the Experimental Fishery Farms in Silesia (in Gołysz and Landek), the Laboratory of Water Biology, Institute of Freshwater Biology and the Institute of Nature Conservation of the Polish Academy of Sciences.

The authors of the present article drew all the data collected from bibliographies including the *Polish Phycological Bibliography* (Siemińska 1990, Siemińska and Pająk 1992), *Half a Century of the Polish Academy of Sciences Fishery Center at Gołysz* (Szumiec 1998), *Bibliography of the Institute of Freshwater Biology Polish Academy of Sciences 1952-2002* (Amirowicz 2003). The latter contained *A monograph of cosmopolitan and ubiquitous species among pro- and eukaryotic algae from water bodies in southern Poland* (Bucka and Wilk-Woźniak 2002).

According to the preceding literature, it was evident that initially, the chosen phytoplankton algae cited in these studies were generally mentioned without reference to their new nomenclature. This means that species were

referred to by names that had been used by authors of papers published previously in the ‘olden days’. The present authors divided these first studies into several periods (approximately every decade). These investigations were conducted in different water bodies located in southern Poland on appropriate sectors of rivers (e.g., the Vistula and the River Dunajec; Sanecki and Bucka 1992).

Here it is worth emphasizing some observations and taxonomic concepts presented by, among others, Andrzej Witkowski, Horst Lange-Bertalot, and Kurt Krammer in their publications. The first one in *Diatom Monographs* (Vol. 5, 2005) mentioned (after various authors) the peculiar abilities of the colonial diatom *Bacillaria paradoxa* Gmelin (discovered by O.F. Müller 1783), which exhibited synchronous motility, apparent cell-cell communication, and worldwide geographical distribution. The complexity of this phenomenon remains to be explained as this species is able to adapt to various environments such as high salinity in the Vistula River (Bucka 2000).

RESULTS AND DISCUSSION

This section presents the different subjects addressed by phytoplankton investigations. Shallow post-regulation ponds on the banks of the Vistula River (near Kraków) were studied in 1955 (Bucka 1958). The following Euglenophyceae were the main subject of the study: *Euglena acus* Ehr. and *E. gaumei* Allorge and Lefèvre – both of which were very numerous in August and September; *Euglena proxima* Dang. and *E. spirogyra* Ehr. – both numerous in plankton during summer and very numerous in bottom deposits. Euglenophyceae were also studied in the phytoplankton of ponds, including rearing ponds supplemented with inorganic fertilizers (often N+P) and unfertilized or control ponds at Gołysz (Silesia), (Bucka 1998a, 2003). The following species were common and numerous:

- *Euglena oxyuris* Schmarda, *E. spirogyra*, *E. acus*, *E. tripteris* (Duj.) Klebs, *E. viridis* Ehr., and *E. proxima* – massive occurrence in waters polluted with wastes from the beet sugar factory in Chybie (Kyselowa 1973), as well as *E. geniculata* Duj. and *E. agilis* Carter (syn. *E. pisciformis*), which were very numerous in ponds with manure. *E. viridis* (typical of alpha-mesosaprobic waters) and *E. acus* and *E. spirogyra* (both typical of beta-mesosaprobic waters) (Turoboyski 1979, Starmach 1983, Wołowski 1998);
- *Phacus longicauda* (Ehr.) Duj., *P. pleuronectes* (O.F. Müller) Duj., and *P. triqueter* (Ehr.) Duj. were often encountered in control and inorganically fertilized ponds. Additionally, *P. wettsteinii* Drež. and *P. helicoides* Pochm. occurred very numerous in ponds treated with high concentration wastes from the nearby beet sugar factory in Chybie;

- *Trachelomonas armata* (Ehr.) Stein, *T. hispida* (Perty) Stein, *T. planctonica* and *T. volvocina* Ehr. in ponds with inorganic fertilization (P+N) more intense development was noted than in other ponds;
- *Lepocinclis ovum* (Ehr.) Minkiewicz was very common in the plankton of fish ponds, both control and inorganically fertilized ponds.

Today, studies of Euglenophytes are conducted by Wołowski (1998) at the Phycology Department, Institute of Botany (Kraków) and by Zakryś (Milanowski et al. 2006) at Warsaw University.

In general, it can be stated that, as shallow water bodies, various ponds types have very well-developed littoral zones. Due to this, they provide conditions that favor the formation of a certain mosaic within phytoplankton communities (Bucka et al. 2003). The term ‘various pond types’ refers to such experimental ponds as spawning ponds, transfer ponds (‘fingerling ponds’), and various experimental ponds where inorganic fertilizer, most often combined N+P, or different concentrations of wastes from the beet sugar factory in Chybie were applied.

The typical phytoplankton in these ponds is relatively poorly developed, which means that planktonic forms occur in small numbers contrary to the presence of benthic euglenophytes in the depth profiles (this is a consequence of their life cycle which begins on the bottom sediments).

In old spawning ponds (acidified) poor qualitative phytoplankton taxa were noted (ca. 100 taxa in net and nanoplankton samples and about 200 taxa in new ones) (Krzeczkowska-Wołoszyn 1967, 1973). A greater number of phytoplankton taxa were reported in fertilized transfer ponds than in control transfer ponds (Krzeczkowska-Wołoszyn 1966, 1973). Increased numbers of phytoplankton (Cyanoprokaryota and Cryptophyceae) were also noted along with increasingly intensive fish production (Urbaniec-Brózda 2001, Bucka et al. 2003).

It is worth noting here some of the species that preferred organically fertilized or control ponds. They are as follows: Chlorophyceae + Zygnemales (syn. Conjugales) – *Chlamydomonas* spp., *Eudorina elegans* Ehr., *Gonium pectorale* O.F. Müller, *Pandorina morum* (O.F. Müller) Bory, *Volvox aureus* Ehr., *Hydrodictyon reticulatum* (L.) Lagerh., *Cosmarium botrytis* Menegh., *C. granulatum* Bréb., *Micrasterias americana* (Ehr.) Ralfs, *M. mahabuleshwariensis* Hobson var. *wallichii* (Grun.) in: West and West 1904-1923; Cyanoprokaryota: *Anabaena flos-aquae* (Lyngb.) Bréb., *A. spiroides* Kléb., *Aphanizomenon flos-aquae* (L.) Ralfs.; Euglenophyceae: *Euglena acus*, *E. proxima*, *Trachelomonas hispida*.

Studies of dam reservoirs

Long-term investigations addressed various topics in Goczałkowice Dam Reservoir (Pająk 1986a, Żurek and Bucka 1994). Another interesting topic was phytoplankton dynamics in the Wisła-Czarne Dam Reservoir conducted by Pająk (1986b) in 1981-1983 on both net and sedimented phytoplankton samples collected in the Wisła-Czarne Dam Reservoir (station I) and its bays at Biała Wisielka (station II) and at Czarna Wisielka (station III) (Western Carpathians). Wróbel (1998) emphasized that the occurrence of 'water blooms' above the reservoir was observed periodically with the inflow of acidified water (mainly after snow melting and heavy rainfall; see also Maciaszek and Zwydak 1998). This indicated that acidification did not limit eutrophication. Its increase in the reservoir was associated with increased acidification, which caused a decrease in biodiversity (Pająk 1986b, Bucka 1998b, Bucka and Wilk-Woźniak 1998). In turn, acidification favors the intensive development of some algae more resistant to unfavorable environmental conditions including the green alga *Planctococcus sphaerocystiformis* Korschik. in summer 1993 and the dinoflagellate *Ceratium hirundinella* (O.F. Müll.) Bergh. and *Gymnodinium uberrimum* (Allman) Kofoid et Swezy in 1994. Their abundant development caused strong water alkalization (pH 9.4) that was a result of the intensive photosynthesis processes of these species and the low concentration of calcium hydrocarbonates.

Lastly, it is useful to compare the phytoplankton species composition of fish ponds, lowland dam reservoirs such as the Goczałkowice (Pająk 1986a), and submontane dam reservoirs such as the Dobczyce and Rożnów (Bucka 1965, 1986, 1987, 1989, 1998c, Wilk-Woźniak and Bucka 2000). Initially in Goczałkowice Reservoir, Cyanoprokaryota occurred numerously with colonial *Microcystis aeruginosa* Kütz. or filamentous *Aphanizomenon flos-aquae* as the dominant species. In the submontane Dobczyce and Rożnów reservoirs, the massive occurrence of cyanophytes appeared in later periods of the reservoirs' existence. The colonial *Woronichinia naegeliana* (Unger) Elenkin was dominant causing water blooms in the Dobczyce Reservoir in fall (Wilk-Woźniak and Bucka 1998, Bucka and Wilk-Woźniak 1999, Wilk-Woźniak and Mazurkiewicz-Boroń 2003, Wilk-Woźniak et al. 2003), while the dominant in Rożnów Reservoir was *Aphanizomenon flos-aquae*. In general, the seasonal successions in the above reservoirs were as follows: spring – diatoms; summer – green algae; cyanobacteria (lowland reservoir) or green algae/cryptophytes/chrysophytes (submontane reservoir); fall - diatoms (lowland reservoir) or cyanobacteria/cryptophytes/dinophytes/diatoms (submontane reservoir) (Bucka et al. 2003).

The following species were common in all the aquatic ecosystem types discussed: Cyanoprokaryota – *Microcystis aeruginosa*, *Merismopedia tenuissima* Lemm., *Woronichinia naegeliana*; Chrysochyceae – *Dinobryon divergens* Imhof, *Mallomonas caudata* Iwanoff; Dinophyceae – *Ceratium hirundinella* (O.F. Müller) Bergh, *Peridinium cinctum* (O.F. Müller) Ehr.; Euglenophyceae – *Phacus longicauda*, *Trachelomonas volvocina*; Bacillariophyceae – *Asterionella formosa* Hass., *Cyclotella meneghiniana* Kütz., *Fragilaria ulna* var. *acus* (Kütz.) Lange-Bertalot (syn. *Synedra acus*), *F. crotonesis* Kitton, *Stephanodiscus hantzschii* Grun.; Chlorophyceae – *Botryococcus braunii* Kütz., *Coelastrum microporum* Naeg., *Crucigenia apiculata* (Lemm.) Schmidle, *Dictyosphaerium pulchellum* Wood, *Pediastrum biradiatum* Meyen, *P. boryanum* (Turp.) Menegh., *P. duplex* Meyen, *Scenedesmus quadricauda* (Turp.) Bréb., *S. ecornis* (Ralfs) Chod., *Sphaerocystis schroeteri* Chod., *Tetraedron minimum* (A. Braun) Hansg.; Desmidiaceae – *Cosmarium* spp., *Staurostrum gracile* Ralfs., *S. tetracerum* Ralfs (Bucka and Krzeczowska-Wołoszyn 1971). Many of the species mentioned as common in the above water bodies are recognized as cosmopolitans (Bucka and Wilk-Woźniak 2002). Studies addressing various dam reservoir issues are still being conducted, including topics from biodiversity (Wojtal et al. 2005), phytozooplankton relationships (Wilk-Woźniak et al. 2001, Żurek and Bucka 2004, Pocięcha and Wilk-Woźniak 2006), and the phenotypic plasticity of *Desmodesmus* (Shubert and Wilk-Woźniak 2003, Wilk-Woźniak et al. 2006a). Studies on dam reservoirs are also conducted in other parts of Poland by authors such as Dembowska and Napiórkowski (2000), Wiśniewska (2001), Kozak and Gołdyn (2004), Pawlik-Skowrońska et al. (2004), Gołdyn and Szelaż-Wasielewska (2005), and Grabowska (2005).

Bucka (2002) presents one of the more important aspects of phytoplankton investigations, namely the use of the formation of phytoplankton communities to evaluate water conditions. Many other articles detail the usage of algae as part of the implementation of the EU Water Framework Directive EU (Kelly et al. 1998, Kwandrans et al. 1998, Bucka 2002, Eloranta and Kwandrans 2000, 2004, 2005, Kwandrans 2002, Żelazowski et al. 2004, Kwandrans and Wojtal 2005).

New subjects within the study of phytoplankton include biodiversity and the functioning of oxbow lakes (Wilk-Woźniak and Bucka 2004, Wilk-Woźniak and Ligęza 2005, Wilk-Woźniak et al. 2006b).

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