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Cladocera and Copepoda of the Shallow Eutrophic Lake in Natura 2000 Area in Western Poland

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Abstract.- Scarcity of knowledge on the distribution of freshwater Cladocera and Copepoda is obvious due to small number of faunistic investigations. Especially copepods have been usually omitted during hydrobiological research. The aim of the study was to describe the species composition of Cladocera and Copepoda in the Kierskie Małe Lake which is a part of Natura 2000 system in western Poland. Using various sampling methods 32 species of both groups were collected. Moreover, two species of Copepoda new for Polish fauna and some other rare species were found, indicating high species richness of studied habitats. *Ceratophyllum* patch was the most diversified habitat, where crustaceans were the most abundant as well. However, the largest number of species was found in pelagic station. Valuable information about species distribution of planktonic crustaceans in lake Kierskie Małe – part of Natura 2000 net – were provided with this study.

Key words: Biodiversity, species richness, lake Kierskie Małe, zooplankton.

INTRODUCTION

The faunistic data with regard to Copepoda and Cladocera in Western Poland are scarce and limited to general information from lakes' ecological monitoring. The first data came from the '30 of the 20th century which reported 58 species of Cladocera (Brzęk, 1938). Tschuschke (1964) found 57 species of Cladocera. Both researchers focused on the waters of Wielkopolski National Park (WNP). Also the most recent species lists of Copepoda and Cladocera focussed mainly at the WNP (Kuczyńska-Kippen and Cerbin, 1998; Cerbin and Kuczyńska-Kippen, 2001; Kuczyńska-Kippen and Nagengast, 2002).

Only a few recent studies explore other lakes around city of Poznań and include more information on Copepoda. Investigations of several lakes and ponds have (Kuczyńska-Kippen *et al.*, 2004; Kuczyńska-Kippen and Świdnicki, 2008; Kuczyńska-Kippen *et al.*, 2009; Kuczyńska-Kippen, 2010a,b) resulted in some data, but since they were carried out for either ecological research or for monitoring lakes' degradation level, they were not aimed at sampling various microhabitats in order to check taxonomical composition of zooplankton. Nevertheless, there is no record of zooplankton composition in lake Kierskie Małe.

This scarcity of knowledge about planktonic crustaceans is conspicuous considering data given by Rybak and Błędzki (2010). There are about 1100 species of cyclopoids and 700 species of calanoids known in the world, and so far only 51 species of freshwater cyclopoids and 20 species of freshwater calanoids have been discovered in Poland. This might be due to poor representation of copepods in Polish lakes, but more believable reason is lack of research focusing on this subject as well as small amount of scientists investigating copepods, particularly in Western Poland. Possibilities of discovering new species of copepods were predicted for Poland by Rybak and Błędzki (2010) who suspected presence of 9 other species of cyclopoids. In fact, some of them were already found, *e.g., Acanthocyclops kieferi, A. sensitivus, A. venustus, Diacyclops abyssicola* (Mioduchowska and Wojtasik, 2009). Therefore, every new data expanding our knowledge is valuable.

Kierskie Małe lake is a part of the Natura 2000 system located on the Samica river (Natura 2000, 2006). In order to maintain biodiversity in such areas first we need to know the present composition of its inhabitants. It is important to estimate the species richness and level of

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degradation of such an environment. Therefore our aim was to investigate the taxonomic composition of zooplankton communities including various types of habitats within the lake. Moreover, we wanted to add new data on cladoceran and especially copepod distribution in Poland with special focus on rare and new species for Poland.

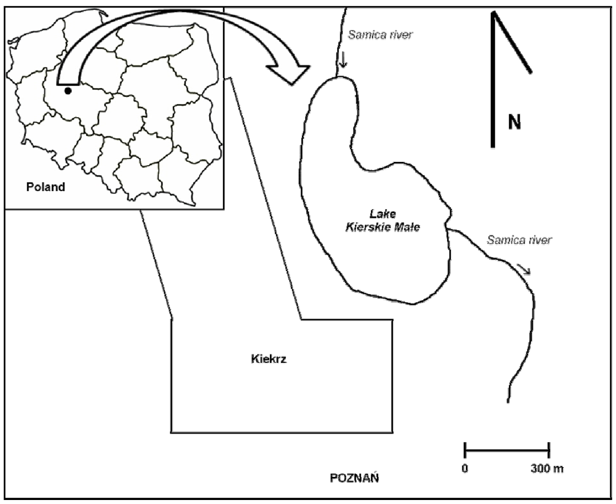

Fig. 1. Map of the Lake Kierskie Małe, Wielkopolska, Poland.

MATERIALS AND METHODS

Study area

Lake Kierskie Małe is a small (34 ha), eutrophic, flow-through body of water located in the valley of the Samica river near Poznań (Wielkopolska, Western Poland), which is protected area of Natura 2000 program (Natura 2000, 2006) (Fig. 1). The valley's surface is 2 391 ha, and it includes upper and middle course of the Samica river, which flows through the lake. The lake is shallow (average depth is 1.4 m; max. depth 3 m), surrounded by belt of reed *Phragmites australis*, and with many patches of hornworth *Ceratophyllum demersum*. The valley was included in the list of Special Protection Areas mainly for reasons of being a refuge for many rare species of birds. Moreover, it is one of the ten most important Poland's habitats for little bittern (*Ixobrychus minutus*), and for five other species of birds registered in Polish Red Book of Animals. It is used mostly for fishing by residents of Kiekrz – the village located near the lake. The areas around the lake and the river flowing trough it are used mainly for agriculture, but some parts of catchment area are covered with forests, meadows, moors and swamps.

The physico-chemical parameters of the lake were measured using YSI 556 MPS multiprobe. During sampling period, between stations and depths the temperature varied between 18.2 and 22.1°C. The dissolved oxygen oscillated between 1.27 mg/dm^3 at the bottom of pelagic zone and 8.71 mg/dm^3 near surface. In the littoral zone, the oxygen reached 8.3 mg/dm^3. Water conductivity was between 826 and 924 μS/cm and the pH varied from 7.37 near the sediments to 8.87 near the surface. Chlorophyll a concentration was the highest in *Ceratophyllum* patch – 52.6 μg/dm^3 and in the pelagic zone it reached 33.8 μg/dm^3.

Sampling

Present studies were conducted in May and August 2011. As cladocerans and copepods can live in various microhabitats, including open water, littoral and sediments, to catch maximal number of species samples were taken in 3 ways. First, 20 dm^3 of water from 3 pelagic stations were taken (5 replicates for each station) using 5 dm^3 Uwitec sampler. The sampling stations were located in the middle of the lake, halfway to the shore and close to a reed belt. Second, littoral samples were taken between reed belt and from *Ceratophyllum demersum* patches (also 5 replicates at each station) using plexiglass pipe 1.5 m long and 5 cm in diameter. Due to high amount of detritus and organisms the littoral samples contained material from 5 liters of water. All samples were condensed on a plankton net with 40 μm mesh sizes and preserved with ethanol (final concentration 95%). Thirdly, because crustacean zooplankton is known for its diurnal migrations (Burks *et al.*, 2002; Cerbin *et al.*, 2003), traps were also used to collect animals during the night when they are more active and easier to collect (Whiteside and Williams, 1975). The additional advantage of this method is the long sampling time allowing collection of more representatives of different species than compared to standard methods. In total, 48 traps were placed on a border of pelagic-littoral zone as well as near the bottom, half collecting specimens moving from open water zone to the vegetation (or sediments) and the other half catching crustaceans flowing in opposite direction. .

All cladocerans and copepods were identified and counted using light microscope (Zeiss ZE Axioskop 2 MOT). Literature used for species determination included key for crustaceans by Rybak and Błędzki (2010) and key for cladocerans by Amoros (1984). Samples are deposited in Department of Hydrobiology, Faculty of Biology, Adam Mickiewicz University in Poznań, Poland.

RESULTS

In total, 32 crustacean species were found, including 18 Cladocera and 14 Copepoda species. Moreover, two new species for Polish fauna were found. These were *Acanthocyclops trajani* Mirabdullayev et Defaye, 2002 and *Paracyclops imminutus* (Kiefer, 1929) (Table I).

Considering habitat preferences of crustacean species described by Rybak and Błędzki (2010) twelve species of Cladocera found in our samples are typical for littoral zone and four for pelagic one. *Chydorus sphaericus* and *Bosmina longirostris* are usually found in both littoral and pelagic zones. Furthermore, seven Copepoda species are characteristic for vegetation stands and only one is described as strictly pelagic (Table I). *Diacyclops abyssicola* and *Mesocyclops leuckarti* occur in littoral as well as in pelagial, *Thermocyclops crassus* and *T. oithonoides* are rather pelagic species but also found in the littoral. The knowledge about *Acanthocyclops trajani* and *Paracyclops imminutus* is rather scarce, thus the preferences of these species are not certain.

Twenty-four species (12 Copepoda and 12 Cladocera) were captured using traps and that was the highest number in comparison to other stations and methods (Fig. 2).

Among the other stations sampled, using water sampler and plexiglass tube, pelagic zone was the richest in number of species. The lowest number of species was present in midpelagic station (Fig. 2).

Generally, cladocerans preferred stations close to the littoral zone (pelagial-reeds and *Ceratophyllum*) where 12 and 10 species were found, respectively. Eight species were recorded among reeds. Copepoda species occurred in the highest number at the pelagic station (9 species), and only 3 were found at the midpelagic station. In general, the number of Cladocera species was higher or equal to number of Copepoda species in all sampling stations.

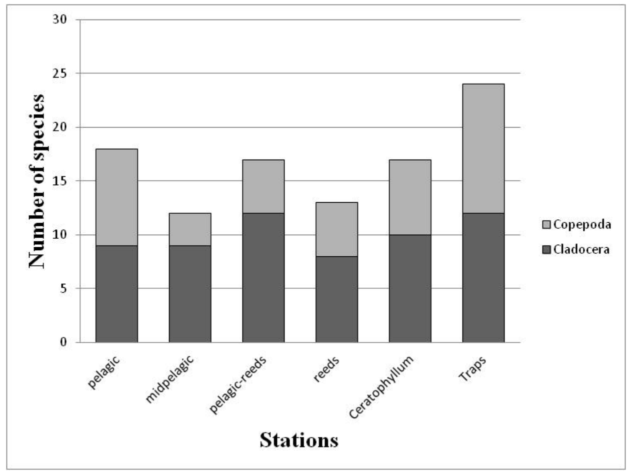

Fig. 2. Number of Copepoda and Cladocera species found at different stations.

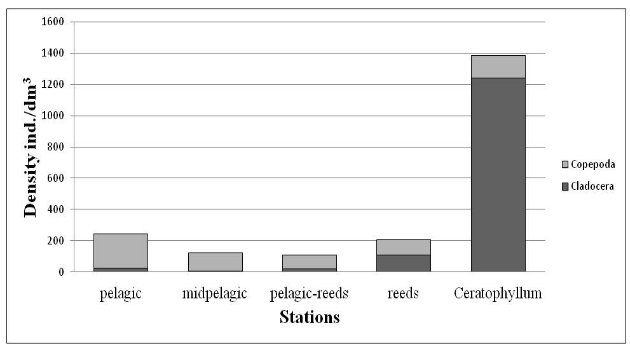

Fig. 3. Density of Cladocera and Copepoda (including larval forms) at different stations.

The highest total number of individuals of crustaceans in the open water zone occurred at the pelagic station and the lowest number was found in pelagial-reeds station. The mean density of crustacean individuals calculated for all stations in the lake reached 413 ind./dm^3 (278 ind./dm^3 of cladocerans and 135 ind./dm^3 of copepods). Quantitative data show higher number of copepods (in comparison to Cladocera) collected on each pelagic station (Fig. 3). Opposite trend was

Table I.- List of species and stations of their occurrence. p, pelagic; mp, midpelagic; pr, pelagic-reeds; r, reeds; c, *Ceratophyllum*; t, traps; +, species found.

Species	p	mp	pr	r	c	t
Copepoda						
Acanthocyclops einslei Mirabdullayev and Defaye, 2004[L]	+		+			+
Acanthocyclops trajani A. trajani Mirabdullayev and Defaye, 2002[!]	+			+	+	+
Cryptocyclops bicolor (Sars, 1863)[L]					+	
Diacyclops abyssicola (Lilljeborg, 1901)[$]						+
Eucyclops macruroides (Lilljeborg, 1901)[L]						+
Eucyclops serrulatus (Fischer, 1851)[L]	+		+		+	+
Eudiaptomus gracilis (Sars, 1863)[P]	+					
Macrocyclops albidus (Jurine, 1820)[L]				+		+
Megacyclops viridis (Jurine, 1820)[L]						+
Mesocyclops leuckarti (Claus, 1857)[$]	+	+	+	+	+	+
Paracyclops affinis (Sars, 1863)[L]				+		+
Paracyclops imminutus (Kiefer, 1929)[!].	+					
Thermocyclops crassus (Fischer, 1853)[#]	+	+	+		+	+
Thermocyclops oithonoides (Sars, 1863)[#]	+	+	+	+	+	+
Cladocera						
Acroperus harpae (Baird,1835)[L]			+	+	+	+
Alona costata Sars, 1862[L]						+
Alona guttata Sars, 1862[L]					+	
Alona rectangula Sars, 1862[L]	+	+	+	+	+	+
Anchistropus emarginatus Sars, 1862[L]						+
Bosmina longirostris (Müller, 1785)[$]	+	+	+	+		+
Ceriodaphnia quadrangula (Müller, 1785)[L]						+
Ceriodaphnia pulchella Sars, 1862[L]	+	+	+	+	+	+
Chydorus sphaericus (Müller, 1776)[$]	+	+	+	+	+	+
Daphnia cucullata Sars, 1862[P]	+	+	+	+		+
Diaphanosoma brachyurum (Liévin, 1848)[P]	+	+	+			
Eubosmina coregoni (Baird, 1857)[P]	+					
Graptoleberis testudinaria (Fischer, 1848)[L]			+		+	
Leptodora kintdii (Focke, 1844)[P]	+	+	+			
Scapholeberis mucronata (Müller, 1776) [L]			+		+	+
Simocephalus vetulus(Müller, 1776)[L]		+	+	+	+	+
Pleuroxus aduncus (Jurine, 1820)[L]	+	+	+	+	+	+
Pseudochydorus globosus (Baird, 1843)[L]					+	
Total species number	18	12	17	13	17	24
Copepoda	9	3	5	5	7	12
Cladocera	9	9	12	8	10	12

[$] Species occurring in pelagic zone as well as in littoral
[#] Species common for pelagial, sometimes inhabiting littoral
[L] Species typical for littoral zone
[P] Species typical for pelagic zone
[!] Species new for Polish fauna

observed in *Ceratophyllum demersum* stand where cladocerans were dominating, mainly due to two very abundant species: *Ceriodaphnia pulchella* and *Chydorus sphaericus*. Cladocerans outnumbered copepods only at this station. Moreover, they were less abundant in all open water stations with lowest numbers in midpelagial.

Considering the dominant structure, *Chydorus sphaericus* and *Ceriodaphnia pulchella* were the most numerous (49% and 34% of total lake zooplankton, respectively) (Fig. 4). Among adult copepods, highest densities were revealed by

Thermocyclops oithonoides and *Mesocyclops leuckarti* (mean from all stations: 7.49 and 5.53 ind./dm^3, respectively) (Fig. 4). Copepods (especially *T. oithonoides* and juvenile forms) reached much higher participation among crustaceans in open water zone (Fig. 3).

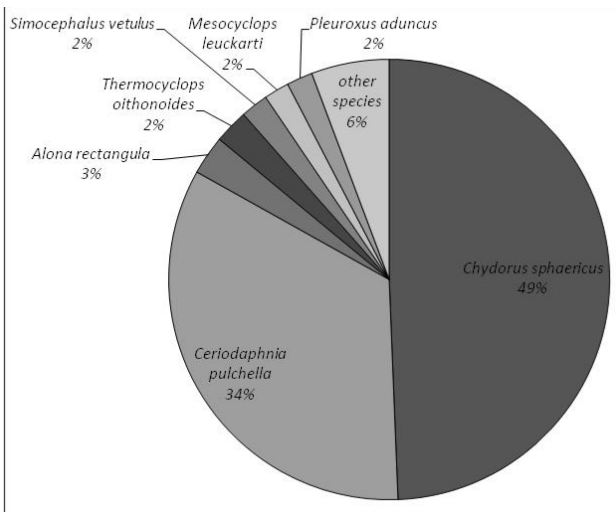

Fig. 4. Mean percentage participation of particular species in zooplankton in lake Kierskie Małe.

Shannon-Wiener biodiversity index calculated for the whole lake gives a value of 1,45 (Fig. 5). Comparing particular stations, the highest biodiversity was found on station “reeds” (H=2.04) and the lowest in *Ceratophyllum* patch (H=1.1). All pelagic stations reached similar biodiversity index value - about 1.7.

DISCUSSION

Most of the species present in the lake Kierskie Małe are common for Wielkopolska region, and were reported also by other researchers (Brzęk, 1938; Tschuschke, 1964; Kuczyńska-Kippen and Cerbin, 1998; Cerbin and Kuczyńska-Kippen 2001; Kuczyńska-Kippen and Nagengast, 2002). Nevertheless, some of the species are rare for Wielkopolska region: *Anchistropus emarginatus*, *Acanthocyclops einslei* and *Paracyclops affinis*. Moreover, two new for Poland species were noted

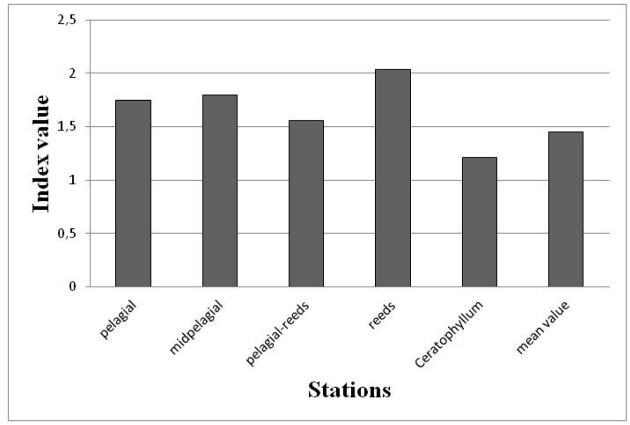

Fig. 5. Shannon-Wiener biodiversity index calculated for each station and for the whole lake (mean value).

during this study: *Acanthocyclops trajani* and *Paracyclops imminutus*. The only known till now localities of another copepod *Diacyclops abyssicola* (Table I) were found recently in the Radunia river (Kur and Wojtasik, 2007) and some residential ponds and drainage ditches (Mioduchowska and Wojtasik, 2009) in Pomorskie voivodeship. Variety of habitats, in which this cyclopoid was found gives a reason to conclude, that this species is not necessarily rare in Poland, but due to lack of research and specialists, it could have been simply omitted until now. Because of the high trophy state and shallowness the lake Kierskie Małe offers microhabitats similar to drainage ditches or ponds. This can explain the occurrence of *D. abyssicola* in the investigated lake. Interestingly, this species was also found in oligotrophic lakes (Rybak and Błędzki, 2010), which suggests wide range of its tolerance to habitat parameters.

The number of 32 species discovered in lake Kierskie Małe is rather high in comparison to other lakes examined in Wielkopolska region, especially considering that study was undertaken during only one season - summer. Cerbin and Kuczyńska-Kippen (2001) investigated 17 lakes, 12 ponds and 3 streams in Wielkopolski National Park and found 47 species of Cladocera and 13 species of Copepoda in all of these water-bodies together. Only one lake Skrzynka showed higher number of zooplankton species than lake Kierskie Małe. However, large number of 39 species occurring in this dystrophic lake was given including rotifers. With this in mind, such poor and degraded habitat as lake Kierskie Małe showed surprisingly great variety of species. Nevertheless, the species richness in examined lake could be even higher if sampling was undertaken throughout all four seasons. However, various methods that have been used gave an important contribution to efficiency of species collecting. Especially the Whiteside traps proved to be efficient when number of species caught by them is compared to the water sampler/plexiglas core - much more species were collected using traps. This might be due to much longer sampling time when using traps (about 6 hours) as well as to location of sampling by traps. Placing them in ecotonal zone – border of pelagic zone and elodeids patch enables collecting pelagic and littoral species (if they migrate horizontally) and ecotonal species of this habitat. Using traps appeared to be very efficient way to collect crustaceans, at least in this kind of study site.

Quantitative data showed dominance of *Ceriodaphnia pulchella* and *Chydorus sphaericus* among Cladocera as well as crustaceans in general, and copepods were dominated by *Thermocyclops oithonoides* and *Mesocyclops leuckarti*. All four species were present on each station. All of them are considered either as ubiquistic or migratory, not avoiding littoral habitats (Cerbin *et al.*, 2003; Rybak and Błędzki, 2010). Refuge provided by plants, predation from fish as well as invertebrate predators and better quality of food in open water zone gives profits for migratory species (*C. pulchella, T. oithonoides* and *M. leuckarti*) or for small, hard to detect species (*C. sphaericus*). High trophy, no hypolimnetic zone, small pelagic zone and lots of reeds and hornworth stands characterise this lake and have an important impact on results since majority of detected species were ubiqustic or littoral.

Biodiversity measured with Shannon-Wiener index was rather comparable to other previously examined lakes of this region (Kuczyńska-Kippen *et al.*, 2004; Kuczyńska-Kippen *et al.*, 2010a,b), but again it might be considered as high when poor quality of the lake is taken into account. Among sampling stations the highest biodiversity, equal to 2.04 was calculated for reeds stand, where no high dominance of any species was marked. The lowest biodiversity index value of 1.21 for crustaceans inhabiting hornworth patch was caused by great dominance of two species (*C. pulchella* and *C. sphaericus*), as the index is sensitive to high dominance.

The study undertaken on lake Kierskie Małe proves that there is still much to discover in Polish freshwater fauna. Further investigations are necessary to fill gaps in knowledge on freshwater ecosystems of Poland. It is even more important when the subject of interest is protected area such as lake Kierskie Małe included in Natura 2000 net. Lack of information on zooplankton and particularly on Copepoda in Poland is obvious, and any new data is valuable, especially considering indicative function of planktonic fauna (Karabin, 1985). Data on changes in geographical distribution of planktonic invertebrates can be used in detecting influence of global climate changes on ecosystems, but first the distribution ranges has to be established, which is why gaps in such data should be filled.

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