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COPEPODA-CYCLOPOIDA OF WATER BODIES OF THE COAST OF GDAŃSK

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Summary. The study was aimed at determining the species composition of Copepoda-Cyclopoida living in 17 small water bodies: ponds, drainage ditches and canals located in the Tri-City, Otomin, Sobieszewo, Przejazdowo and Wiślinka. Selected bodies of water were natural or artificial. In addition, they differed in hydrologic conditions (electrolytic conductivity, mineralisation, pH, salinity, nitrate concentration, phosphate concentration). The analysis of the Cyclopoida cluster indicates a large variation in species composition of each water body. In the material collected 23 species were identified, where the greatest diversity (represented by a grouping of 7 species) was found in a pond in Gdańsk-Morena and a drainage ditch in Przejazdowo. Stations near a phosphogypsum heap near Wiślinka were poor in species, but the least favourable conditions for Cyclopoida were found at stations in the two ponds in the Park Oliwski (no representatives of this taxon were observed). The highest concentration was found for *Eucyclops serrulatus* (Fischer, 1851). In contrast, only 9 species were recorded on individual stations. There were found new species of fauna for the Coast of Gdańsk and Poland.

Key words: Copepoda-Cyclopoida, freshwater reservoirs, hydrologic condition, phosphogypsum heap, the Coast of Gdańsk

INTRODUCTION

The Coast of Gdańsk is situated on the Gulf of Gdańsk, on Żuławy Wiślane. The coastal part is located on the Vistula Spit. Diversity of hydrological conditions on the coast of Gdańsk is due to both physical and chemical diversity of the terrain (related to the neighbourhood of the Baltic Sea, Kashubian Seashore and Kashubian Lakeland) and the degree of urbanisation and industrialisation of the land [Cydzik *et al*. 1995, Kannen *et al*. 2004].

One of the most important links in the food chain in aquatic ecosystems (salt- and freshwater environments) are Copepoda [Kajak 2001, Piasecki *et al*. 2004] which are also an important producer of detritus [Kajak 2001, Rybak and Błędzki 2005]. Due to their ubiquitous nature, rapid increase and rapid rate of metabolism, they play an important role in the functioning of the ecosystem. The various species of Copepoda, despite a relatively large degree of tolerance to changes in the values of physical and chemical parameters, can be found in optimal environmental conditions for a species. Thus Copepoda species composition may reflect the overall condition of water bodies [Błędzki 2008].

The purpose of this study was to present, against of the background of physical and chemical parameters and the type of water body, the composition of Copepoda species belonging to the Cyclopoida order [Rybak and Błędzki 2005]. The occurrence of meiobenthos species (among which Copepoda is ranked) depends on the nature of water quality and land immediately adjacent to the water body [Damodaran 1973, Kuczyńska-Kippen *et al*. 2004].

MATERIAL AND METHODS

Study area

The area covered by the survey, was the Tri-City (Gdańsk–Sopot–Gdynia) metropolitan area, as well as Otomin, Przejazdowo, Wiślinka and Sobieszewo. Samples were collected from 17 freshwater bodies, consisting of 2 stations of artificial water bodies, created for decoration purposes in Oliwski Park, 6 residential ponds and 1 small reservoir in the area of Gdańsk, 1 residential pond in Gdynia, 1 residential pond in Otomin, 3 drainage ditches – two near the phosphogypsum heaps in Wiślinka and one in Przejazdowo, 1 canal in Wiślinka and 2 small water bodies on the Isle of Sobieszewo (Fig. 1).

Copepoda sampling and analytical methods

Sampling for quantitative assessments (collected by means of a pipe with a diameter of 2.5 cm from the surface layer of bottom sediment to the depth of 10 cm) and qualitative assessments (with a volume of about 0.5 l collected by means of a manual scoop with a trawl with mesh of 42 μm) was made in the years 2007 (autumn) and 2008 (winter, spring, summer). Together with the sampling, water physical and chemical properties were examined – electrolytic conductivity, mineralisation, pH, salinity, nitrate concentration and phosphate concentration.

Mature females were used for the evaluation of Copepoda-Cyclopida taxonomic content, the determination of which was carried out according to the following works: Rylov [1948], Dussart [1969], as well as Rybak and Błędzki [2005]. Nomenclature was given in accordance with the work of Rybak and Błędzki [2005].

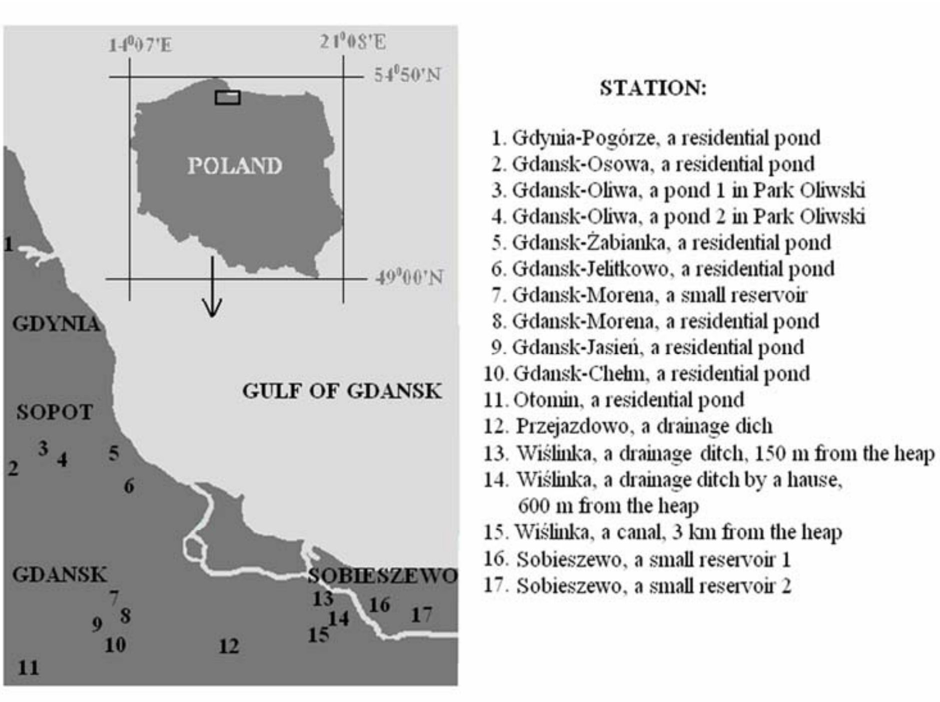

Fig. 1. Research area

The calculations covered the relative abundance (D), expressed as a percentage of the number of individuals of i-taxa to the number of all individuals in a given site, and the faunistic similarity coefficient of Bray-Curtis (present/absent), calculated using PRIMER v.5 software [Clarke and Gorley 2001] and presented in the form of cluster graph.

RESULTS

The tested water bodies had sandy and rocky ground (stations: 1, 2, 3, 4, 6, 10, 11, 15), sandy (stations: 7, 8, 16, 17), muddy (stations: 9, 12, 13, 14) and rocky (station 5), they were natural (stations: 2, 5, 7, 9, 10, 16) or artificial (stations: 1, 3, 4, 6, 8, 11, 12, 13, 14, 15, 17).

The performed analysis of hydrological parameters (electrolytic conductivity, mineralisation, pH, salinity, nitrate concentration, phosphate concentration) provided data on the diversity of environmental conditions of the tested water bodies (Tab. 1).

Table 1. Hydrological parameters of the tested water bodies

Station	Average annual values of physical and chemical parameters 2007 (autumn) – 2008 (winter, spring, summer)					
	pH	Conductivity, µS cm	TDS, mg dm^{-3}	Salinity, psu	NO_3, mg dm^{-3}	PO_4, mg dm^{-3}
1	7.98	248	117	0.0	-	-
2	8.24	411	192	0.0	-	-
3	8.42	446	234	0.0	-	-
4	8.44	439	205	0.0	-	-
5	8.12	361	209	0.0	-	-
6	7.44	502	267	0.0	-	-
7	7.63	524	281	0.0	-	-
8	8.16	600	276	0.0	-	-
9	8.32	534	271	0.0	-	-
10	8.27	537	258	0.0	-	-
11	8.33	582	264	0.0	-	-
12	7.95	582	523	0.4	5.0	> 0.5
13	6.82	4720	apart from range	2.6	10	10
14	8.18	1409	679	0.4	10	10
15	8.46	1365	676	0.5	10	10
16	8.15	1471	748	0.9	1.0	> 0.5
17	8.52	1881	885	0.8	1.0	> 0.5

The pH value ranged from 6.82 in the drainage ditch in Wiślinka (near phosphogypsum heap) to 8.52 in a small water body located on the Isle of Sobieszewo. The lowest conductivity, amounting to 248 µS cm^{-1}, and the lowest mineralisation. amounting to 117, were recorded in the residential pond in Gdynia-Pogórze. The highest conductivity value, amounting to 4720 µS cm^{-1}, and the highest mineralisation, whose value goes beyond the scope of the measuring scale of the conductometer, were reported in the drainage ditch in Wiślinka, located 150 m from the toxic phosphogypsum heap. In this station there was also the highest salinity (inland, freshwater trench), amounting to 2.6 psu. In the remaining stations near the phosphogypsum heap, as well as in the water bodies located on the Isle of Sobieszewo and the drainage ditch in Przejazdowo there was also salinity, despite the freshwater type of the studied water bodies (Tab. 1).

In the analysed material there was found the occurrence of 23 Copepoda-Cyclopoida species (Tab. 2). However, the most common species was *Eucyclops serrulatus* (Fischer, 1851), found in 8 out of 17 tested stations. The most rare species recorded in the individual positions were *Acanthocyclops sensitivus* (Greater et Chappuis, 1914)*, Cyclops bohater* (Kożmiński, 1933), *Cyclops furcifer* (Claus, 1857), *Cyclops insignis* (Claus, 1857), *Cyclops vicinus* (Uljanin, 1875), *Diacyclops nanus* (Sars, 1863), *Megacyclops latipes* (Lowndes, 1927), *Microcyclops varicans* (Sars, 1863) and *Paracyclops affinis* (Sars, 1863).

Table 2. Species of Cyclopoida at sampling collection stations

Species of Cyclopoida	Station																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Acanthocyclops kieferi (Chappuis, 1925)								■				■					
Acanthocyclops robustus (Sars, 1863)		■			■					■				■			
Acanthocyclops sensitivus (Greater et Chappuis, 1914)								■									
Acanthocyclops venustus (Norman et. Scott, 1906)		■			■	■					■	■				■	
Acanthocyclops vernalis (Fischer, 1853)								■				■		■	■	■	
Cryptocyclops bicolor (Sars, 1863)							■		■								
Cyclops bohater (Koźmiński, 1933)										■							
Cyclops furcifer (Claus, 1857)						■											
Cyclops insignis (Claus, 1857)																	■
Cyclops vicinus (Uljanin, 1875)																■	
Diacyclops abyssicola (Lilljeborg, 1901)								■				■					
Diacyclops bicuspidatus (Claus, 1857)						■			■	■		■	■	■		■	
Diacyclops bisetosus (Rehberg, 1880)								■					■				
Diacyclops crassicaudis (Sars, 1863)					■				■		■		■			■	
Diacyclops languidoides (Lillijeborg, 1901)		■															■
Diacyclops languidus (Sars, 1863)		■						■									
Diacyclops nanus (Sars, 1863)												■					
Eucyclops macruroides (Lillijeborg, 1901)		■							■		■						■
Eucyclops serrulatus (Fischer, 1851)	■	■			■	■	■		■		■						■
Megacyclops latipes (Lowndes, 1927)										■							
Mesocyclops leuckarti (Claus, 1857)						■					■						
Microcyclops varicans (Sars, 1863)												■					
Paracyclops affinis (Sars, 1863)								■									

■ present species □ absent species

Table 3. Species of Cyclopoida of selected water bodies of Poland

Species of Cyclopoida	Selected water bodies of Poland															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Acanthocyclops kieferi (Chappuis, 1925)	■															■
Acanthocyclops robustus (Sars, 1863)																■
Acanthocyclops vernalis (Fischer, 1853)		■	■	■	■		■	■	■		■		■		■	
Acanthocyclops venustus (Norman et. Scott, 1906)																
Cryptocyclops bicolor (Sars, 1863)	■	■		■		■		■			■		■		■	■
Cyclops abyssorum (Sars, 1863)	■									■			■			■
Cyclops bohater (Koźmiński, 1933)	■									■						■
Cyclops furcifer (Claus, 1857)		■	■				■						■			■
Cyclops insignis (Claus, 1857)	■	■	■							■	■		■			■
Cyclops kolensis (Liljjeborg, 1901)		■								■			■			
Cyclops scutifer (Sars, 1863)	■										■					
Cyclops strenuus (Fischer, 1851)		■			■				■		■		■			
Cyclops vicinus (Uljanin, 1875)				■			■	■	■	■	■		■			■
Diacyclops abyssicola (Lilljeborg, 1901)	■															■
Diacyclops bicuspidatus (Claus, 1857)		■	■				■	■	■			■	■		■	■
Diacyclops bisetosus (Rehberg, 1880)	■	■									■		■			■
Diacyclops crassicaudis (Sars, 1863)	■								■							■
Diacyclops languidus (Sars, 1863)	■						■		■		■		■			■
Diacyclops nanus (Sars, 1863)	■								■		■				■	■
Ectocyclops phaleratus (Koch, 1838)				■		■		■			■	■	■	■	■	
Eucyclops macrurus (Sars, 1863)			■	■		■			■		■	■	■		■	
Eucyclops macruroides (Lillijeborg, 1901)	■		■	■		■	■	■	■							■

cont. tab. 3

Eucyclops speratus (Lilljeborg, 1901)				■			■	■								
Eucyclops serrulatus (Fischer, 1851)	■	■	■	■	■	■	■	■	■		■	■	■		■	■
Macrocyclops albidus (Jurine, 1820)		■	■	■		■	■	■	■		■	■	■	■	■	
Macrocyclops distinctus (Richard, 1887)									■			■	■			
Macrocyclops fuscus (Jurine, 1820)			■	■		■	■	■			■	■	■	■	■	
Megacyclops gigas (Claus, 1857)			■	■			■		■				■			
Megacyclops latipes (Lowndes, 1927)									■							■
Megacyclops viridis (Jurine, 1820)	■	■	■	■		■	■	■	■	■	■	■	■		■	
Mesocyclops leuckarti (Claus, 1857)	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■
Metacyclops gracilis (Lilljeborg, 1853)						■		■			■	■	■		■	
Metacyclops minutus (Claus, 1863)											■	■		■	■	
Microcyclops varicans (Sars, 1863)		■		■		■		■			■	■	■			■
Paracyclops affinis (Sars, 1863)	■	■				■		■				■	■		■	■
Paracyclops fimbriatus (Fischer, 1853)	■	■							■		■	■	■	■	■	
Paracyclops poppei (Rehberg, 1880)	■			■		■							■			
Thermocyclops crassus (Fischer, 1853)				■		■	■	■	■	■		■	■			
Thermocyclops dybowskii (Lande, 1890)											■	■	■	■	■	
Thermocyclops oithonoides (Sars, 1863)			■	■			■	■		■	■		■	■	■	
Diacyclops languidus (Sars, 1863)																■
Acanthocyclops sensitivus (Graeter et Chappuis, 1914)																■

■ present species □ absent species

Explanations: 1 – lakes of the Upper Radunia [Kur and Wojtasik 2007], 2 – inland saline ponds [Latour *et al*. 1996], 3 – the ponds of Wrocław [Hajduk 1965], 4 – The Nowokuźnicki pond [Hajduk 1966a], 5 – Jamno Lake [Hajduk 1973a], 6 – nursery ponds in Izbick [Hajduk 1971], 7 – stone-pit ponds in Strzelbowo [Hajduk 1966b], 8 – nursey pond in Szczodre [Hajduk 1973b], 9 – the ponds of Łódź [Olszewski 1977], 10 – lakes of Pomorze [Kowalczyk 1957], 11 – ponds of vicinity of Warszawa-Gajl [Kowalczyk 1957], 12 – ponds of vicinity of Warszawa-Lande [Kowalczyk 1957], 13 – lakes of Poznań [Kowalczyk 1957], 14 – ponds of Janów [Kowalczyk 1957], 15 – lakes of vicinity of Kraków [Kowalczyk 1957], 16 – studies water bodies of the coast of Gdańsk

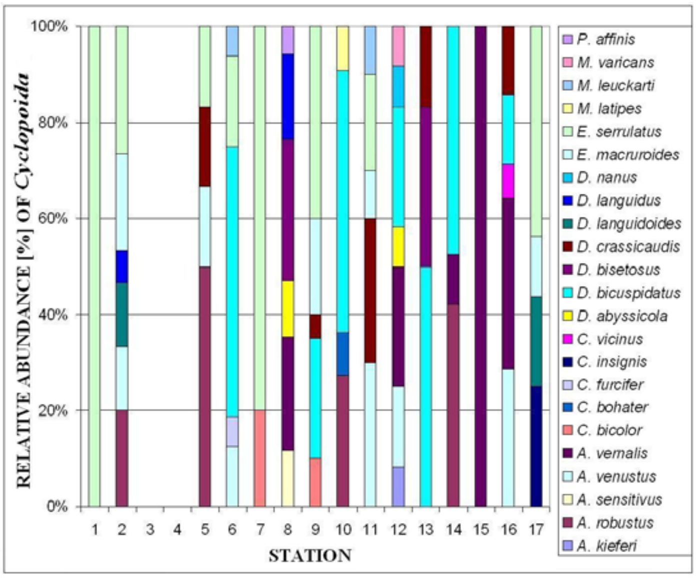

Fig. 2. Relative abundance of Cyclopoida at sampling collection stations

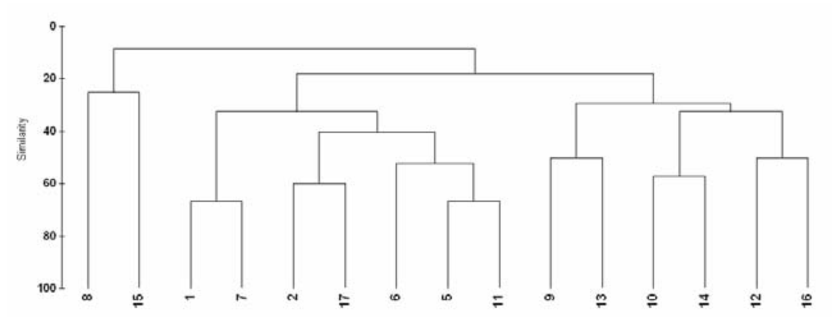

Fig. 3. Cyclopodia of water bodies of the coast of Gdańsk (at sampling collection stations): similarity dendrogram

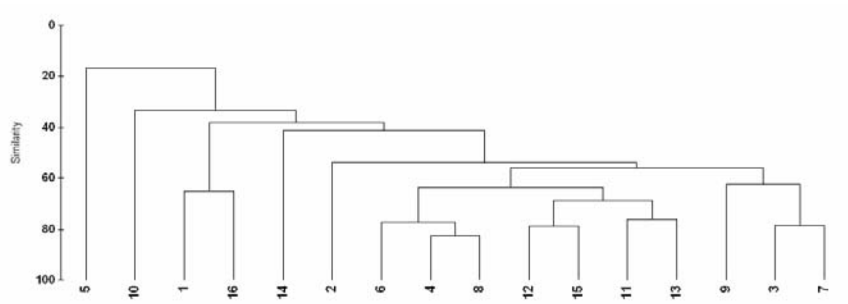

Fig. 4. Cyclopoida of water bodies of Poland: similarity dendrogram

Most species were found in the pond in Gdańsk-Morena and the drainage ditch in Przejazdowo. A low number of Copepoda-Cyclopoida species was found in the ditches near the phosphogypsum heap in Wiślinka. In two ponds located in Oliwski Park no Copepoda-Cyclopoida were found (Tab. 2, Fig. 2). Species of Cyclopoida of water bodies of Poland are presented in Tab. 3. The analyses of similarity Cyclopoida for the Coast of Gdańsk and Poland are presented in Figures 3 and 4.

DISCUSSION

Aquatic ecosystems are among the components of the natural environment that are particularly sensitive to anthropopressure factors [Kuczynska-Kippen *et al*. 2004, Czerniawski 2008]. According to the chemical analysis of water, it follows that the tested water bodies are under the influence of anthropopressure, which is showed by the parameter values (Tab. 1), that differ from those attributable to natural, pure water bodies. The processes of urbanisation (urban agglomerations and deposition of phosphogypsum) affect the loss of sustainable character by aquatic ecosystems [Czerniawski 2008].

The study performed shows that the meiobenthos response to the degree of pollution of water bodies as a result of anthropopressure involves changes in Copepoda-Cyclopoida species composition. However, there is a tendency to reduce species diversity together with increased human intervention in the aquatic environment [Błędzki 2008].

The most common species in the analysed stations, *Eucyclops serrulatus* (Fischer, 1851), is a cosmopolitan species and is counted among the most common copepods [Hajduk 1965, Rybak and Błędzki 2005]. *Eucyclops serrulatus* (Fischer, 1851) was recorded as the only species that occurs at the station in Gdynia-Pogórze, where the large urban agglomeration affected destructively the number of Copepoda-Cyclopoida species.

No Copepoda-Cyclopoida were found in the two artificial water bodies in Oliwski Park. The stations were dominated by another type of Copepoda, namely Harpaticoida. There were few Copepoda-Cyclopoida species near the phosphogypsum heap as a result of penetration of toxic compounds into aquatic ecosystems [Hupka *et al*. 2006]. Thus, inland freshwater water bodies showed salinity. Moreover, in these stations there was a significant concentration of nitrates and phosphates, high mineralisation and electrolytic conductivity. High values of abovementioned physical and chemical parameters are an evidence of contamination of the water bodies, resulting in a disorder of homeostasis of aquatic ecosystems. It results in depletion of biodiversity, including species composition of the Copepoda-Cyclopoida.

Acanthocyclops kieferi (Chappuis, 1925) and *Acanthocyclops sensitivus* (Greater et Chappuis, 1914) are species typical to groundwater and wells [Rybak and Błędzki 2005]. They were found in an artificially created residential pond in

Gdansk-Morena. It is possible that in this area there were wells, because the stand is located close to houses. *Cyclops vicinus* (Uljanin, 1875), found in a small water body on the Isle of Sobieszewo, occurs in brackish waters [Rybak and Błędzki 2005]. Despite the freshwater nature of that inland water body, as a result of penetration of toxic pollutants from phosphogypsum, the body showed salinity. Other found species, in accordance with the literature data, widely occur in various types of water bodies [Rybak and Błędzki 2005, Kur and Wojtasik 2007].

There were found new species of fauna of Poland – *A. venustus* and *A. sensitivus* (Tab. 3) [Błędzki 2008].

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COPEPODA-CYCLOPOIDA ZBIORNIKÓW WODNYCH WYBRZEŻA GDAŃSKIEGO

Streszczenie. Przeprowadzone badania miały na celu określenie składu gatunkowego Copepoda-Cyclopoida zasiedlających 17 niewielkich zbiorników wodnych: stawy, sadzawki, rowy melioracyjne i kanały, położone na terenie Trójmiasta, Sobieszewa, Przejazdowa i Wiślinki. Wybrane zbiorniki wodne były naturalne bądź sztuczne. Ponadto różniły się warunkami hydrologicznymi (przewodnictwo elektrolityczne, mineralizacja, pH, zasolenie, azotany, fosforany). Analiza zgrupowania Cyclopoida wskazuje na duże zróżnicowanie składu gatunkowego poszczególnych zbiorników. W całym materiale oznaczono 23 gatunki, przy czym największą różnorodność (zgrupowanie reprezentowane przez 7 gatunków) stwierdzono w stawie w Gdańsku-Morenie i w rowie melioracyjnym w Przejazdowie. Stanowiska w pobliżu hałdy fosfogipsów w Wiślince były ubogie gatunkowo, jednak najmniej sprzyjające warunki dla Cyclopoida stwierdzono na stanowiskach w dwóch stawach w Parku Oliwskim (nie zaobserwowano w ogóle przedstawicieli tego taksonu). Najwyższą frekwencję stwierdzono dla *Eucyclops serrulatus* (Fischer, 1851). Natomiast 9 gatunków odnotowano tylko na pojedynczych stanowiskach. Znaleziono nowe gatunki fauny Wybrzeża Gdańskiego oraz fauny Polski.

Słowa kluczowe: Copepoda-Cyclopoida, zbiorniki słodkowodne, warunki hydrologiczne, hałda fosfogipsów, Wybrzeże Gdańskie