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INVERTEBRATES OF THREE SMALL PONDS LOCATED IN STREAM-POND SYSTEM

Robert Czerniawski, Rafał Popko, Tomasz Krepski, Józef Domagała

Department of General Zoology, University of Szczecin
Z. Felczaka str. 3c, 71-415 Szczecin, czerniawski@univ.szczecin.pl

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Summary. The study was performed in three small connected ponds located in pond-stream-pond system, on the small stream in Ina river drainage. This study describes the pattern of invertebrates of these ponds in relation to the environmental conditions of landscape, with particular regard to pollution from agricultural areas. Samples of zooplankton and benthos were collected from each pond, once a month, from May to October in 2010. In macrozoobenthos samples, 35 families were observed. Density of Gastropoda differed significantly between sites. Among zooplankton, 51 taxa – 39 rotifers, 5 cladocerans and 7 copepods were noted. Statistical analysis revealed insignificant differences between sites in abundance of each zooplankton group.

Key words: macroinvertebrates, zooplankton, small ponds, stream ecology

INTRODUCTION

The concept of eutrophication means the increase of biological productivity in waters. This term also concern a environmental factors affecting the fertility of the water. Eutrophication depends on many factors, such as the amount of fertilizer getting into water from the cathment, the composition and abundance of flora and fauna, etc. Small water bodies are much faster eutrophicated than lake. The main nutrients accelerated eutrophication process are compound of nitrogen and phosphorus [Gołdyn *et al*. 2004]. Most often this process is related to the adverse impacts of anthropogenic and therefore much faster metabolism of ecosystem [Czerniawski and Piasecki 2004]. Consequently, there are a rapid changes in the quantity and quality of organisms inhabiting eutrophicated aquatic ecosystems. These changes concern especially aquatic invertebrates, zooplankton and benthic species that are highly susceptible to changes in physicochemical factors [Kudelska and Soszka 1996].

Small bodies of water, lying in a basin are under the strong influence of agricultural diffuse pollution. A notable object of study are small connected ponds that have different morphological and biological conditions, under the influence of the same factors of anthropogenic impact.

The aim of this study was to compare the taxonomic and quantitative composition of zooplankton and macrozoobenthos of three small connected ponds located in pond-stream-pond system in relation to their environmental conditions.

MATERIAL AND METHODS

The study was performed in three small connected ponds located in pond--stream-pond system, on the small stream in Ina river drainage, NW Poland (N 53° 24' 27.48”, E 15° 1' 42.24"). The beds of all ponds are slimy, covered with macrophytes. The riparian zone of ponds is covered with vegetation, there are mainly sedges and reeds. The surface of the water is covered by *Lemna* sp. At each pond set one sampling site, site 1 at the pond of no 1, site 2 at the pond of no 2, site 3 at the pond of no 3. The first pond has a surface ca. 0.05 ha, 80% of its bed is covered by slit, 20% is sand, the maximum depth of his pond is 1 m. The second pond has a surface ca. 0.1 ha, 100% of its bed is covered by slit, 80% of the bed is covered by makrophytes, the maximum depth of his pond is 1.3 m. The third pond has a surface ca. 0.07 ha, 100% of its bed is covered by slit, 80% of its water surface is covered by *Lemna* sp., the maximum depth of this pond is 0.3 m.

Measurements of temperature, pH, conductivity and dissolved oxygen were made using oxygen content meter and pH meter CX-401 produced by Elmetron (Poland). The contents of nitrites, as well as nitrates, orthophosphates and suspended solids were measured by a photometer DR-850 produced by Hach Lange (USA). The values of physico-chemical variables are showed in Table 1.

Table 1. Mean ± SD values of physico-chemical varaiables in sites examined

Variables	Site 1	Site 2	Site 3
Temperature, °C	15.67 ±1.97	16.32 ±1.76	16.78 ±2.05
Dissolved oxygen, $mg \cdot dm^{-1}$	7.70 ±2.17	7.80 ±2.27	4.93 ±1.57
pH	7.64 ±0.16	7.63 ±0.10	7.39 ±0.15
Conductivity, µS	1098.10 ±155.25	1186.42 ±137.57	1053.17 ±85.14
Nitrates, $mg \cdot dm^{-1}$	5.02 ±3.07	4.29 ±2.83	2.74 ±2.03
Nitrites, $mg \cdot dm^{-1}$	0.11 ±0.07	0.14 ±0.04	0.07 ±0.07
Orthophosphates, $mg \cdot dm^{-1}$	0.71 ±0.42	3.25 ±1.56	0.63 ±0.57

Samples of zooplankton and benthos were collected from each pond, once a month, from May to October in 2010. However, due to the low water level in the third pond, the zooplankton sample were collected only for the first two months of study. Macrozoobenthos was collected with a scraper of the bottom in the rectangular shape of the size 0.20 × 0.35 m, along the 1 m, which permitted performance of qualitative and quantitative analyses. Macroinvertebrates were filtered by mesh of the size 0,5 mm. The samples of zooplankton were collected from 50 l of water. The water was filtered through a 25 μm mesh net. The samples were concentrated to 250 ml. Statistical analysis was performed by the non-parametric Mann-Wittney test ($P < 0.05$). Zooplankton identification was made using the keys of Wagler [1937], Kutikova [1970], Harding and Smith [1974]. Macrozoobenthos identification was made using the keys of Kołodziejczyk and Koperski [2000], Widerholm [1989], Rozkosny [1980], Czachorowski and Pietrzak [2003].

RESULTS

Macroinvertebrates composition

In the macrozoobenthos samples we fund 7 phylum of invertebrates, among which were 35 families, including 19 families belonged to the Insecta. In all sites we observed occurrence of following taxa: Bivalvia (Sphaeriidae), Gastropoda (Hydrobiidae, Lymnaeidae, Physidae, Planorbidae, Valvatidae), Oligochaeta (Aelosomatidae, Enchytraeidae, Lumbricidae, Lumbriculidae, Tubificidae), Hirudinea (Erpobdellidae, Glossiphonidae, Hirudinidae), Crustacea (Gammaridae), Collembola (Isotomidae). Insecta: Megaloptera (Sialidae), Ephemeroptera (Baetidae, Caenidae), Plecoptera (Perlodidae), Trichoptera (Limnephilidae, Psychomyidae, Polycentropodidae), Heteroptera (Corixidae, Nepidae, Notonectidae), Coleoptera (Dytiscidae, Haliplidae, Hydrophilidae), Diptera (Ceratopogonidae, Chironomidae, Culicidae, Psychodidae, Simuliidae, Tipulidae). In all samples ostracods were observed.

At site 1 the highest frequency have Chironomidae and Gastropoda: Lymnaeidae, Planorbidae, Valvatidae and family of Hirudinea – Erpobdellidae. At site 2 the highest frequency received three families of gastropods: Hydrobiidae, Lymnaeidae, Planorbidae, family Sphaeriidae, family Lumbriculidae and Chironomidae. At site 1 the highest frequency have family Lymnaeidae, family Lumbriculidae z and family Erpobdellidae.

At each site insects were the dominants in the abundance of macroinvertebrates (Fig. 1). Among other dominants the taxa belonging to Mollusca and Oligochaeta may be considered. Insects in more than 80% were represented by Diptera. Other insect taxa were characterized by a similar percentage in the density at each site.

Statistical analysis not revealed significant differences between sites in density of macrozoobenthos, except Gastropoda (Tab. 2). Mann-Wittney U test reveled, taht mean density of gastropods at site 2 was significant greater tan at site 3 ($P = 0.0241$). Remarkable is also considerably lower abundance of

Oligochaeta at site 1 than at other sites. Additionally, at site 3 more than twice the mean number of Diptera than the at site 1 was observed.

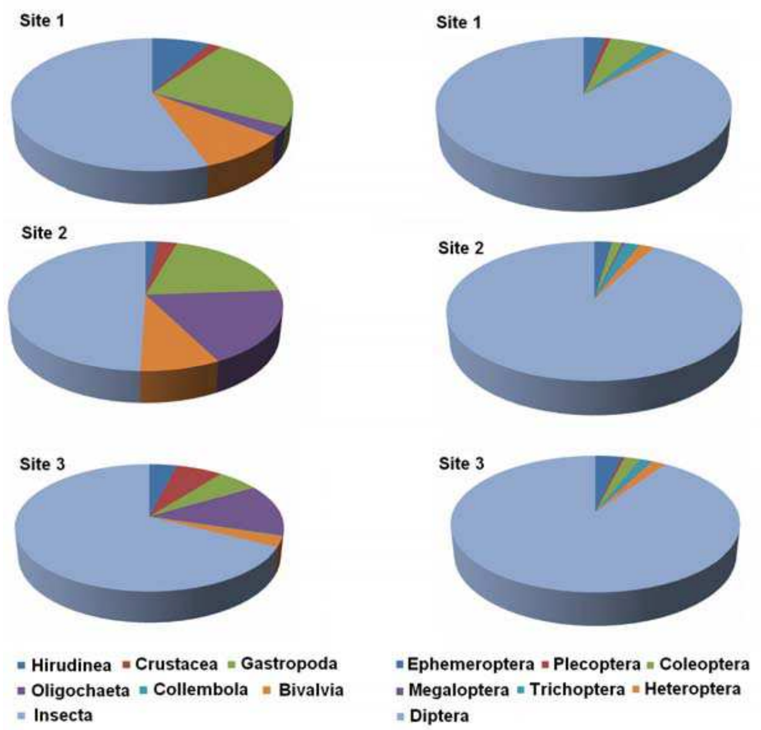

Fig. 1. Percentage contribution of main groups in the total macroinvertebrates abundance (left) and insect taxa (right) in insect abundance

Table 2. Mean ± SD abundance (ind. · m^{-2}) of macroinvertebrates at sites examined

Taxon	Site 1	Site 2	Site 3
Bivalvia	35.17 ±56.60	53.83 ±67.59	20.17 ±29.03
Gastropoda	91.17 ±56.25	131.00 ±71.17	44.83 ±38.40
Oligochaeta	9.67 ±12.45	125.67 ±162.44	99.67 ±111.61
Hirudinea	30.50 ±24.22	12.00 ±13.83	30.17 ±25.96
Crustacea	7.17 ±12.07	17.67 ±36.84	49.50 ±76.83
Collembola	0.50 ±1.22	-	1.50 ±3.67
Megaloptera	-	1.00 ±2.45	-
Ephemeroptera	6.17 ±9.97	7.67 ±7.94	18.00 ±26.43
Plecoptera	1.50 ±3.67	-	1.83 ±4.49
Trichoptera	5.16 ±9.00	6.67 ±9.67	8.50 ±20.82
Hetoroptera	2.00 ±3.63	6.33 ±10.25	9.17 ±11.00
Coleoptera	11.33 ±17.96	4.33 ±5.57	10.83 ±8.54
Diptera	191.00 ±218.14	307.33 ±170.30	460 ±534.62

Zooplankton composition

At all sites 48 species of zooplankton were observed: 38 species of rotifers, 8 species of cladocerans and 2 species of copepods (Tab. 3). Among rotifers the dominants in abundance were *Anuraeopsis fissa* and *Polyarthra longiremis*. *Coronatella rectangula* dominated among cladocerans while copepods were represented mainly by nauplii.

Table 3. Taxonomic composition and mean abundance of zooplankton species at sites examined

Taxon	Site 1	Site 2	Site 3	Taxon	Site 1	Site 2	Site 3
Anuraeopsis fissa	537.7	241.2	6.0	*Mytilina crassipes*	7.5	2.5	19.5
Ascomorpha saltans	0.5	-	-	*Mytylina ventralis*	-	1.5	4.0
Bdelloidea	32.0	30.7	11.0	*Polyarthra dolichoptera*	-	1.3	-
Brachionus angularis	8.2	14.0	19.0	*Platyias quadricornis*	-	0.2	-
Brachionus budapestinensis	1.5	2.0	-	*Polyarthra longiremis*	150.8	47.3	-
Brachionus calyciflorus	2.7	2.2	4.0	*Polyartha minor*	20.5	2.5	-
Brachionus quadridentatus	0.5	0.5	-	*Polyarthra vulgaris*	27.0	14.7	-
Brachionus rubens	1.8	2.0	-	*Pompholyx sulcata*	1.2	1.5	-
Conochilus unicornis	-	0.5	-	*Synchaeta kitina*	30.7	12.8	14.0
Colurella adriatica	-	1.7	12.0	*Synchaeta pectinata*	4.7	4.0	-
Colurella unticata	8.7	9.8	4.0	*Synchaeta tremula*	2.2	6.0	12.0
Elosa worallii	-	-	2.0	*Trichocerca capucina*	-	0.5	4.0
Euchlaris dilatata	0.2	-	0.5	*Trichocerca pusilla*	-	0.7	1.5
Filinia longiseta	22.0	15.0	48.0	*Alona afilis*	-	-	2.0
Gastropus stylifer	-	0.2	-	*Coronatella rectangula*	1.0	4.2	2.0
Keratella coch. cochlearis	5.5	2.0	-	*Alona guttata*	0.3	0.2	-
Keratella coch. tecta	5.2	1.0	-	*Alonella nana*	-	0.5	-
Keratella testudo	16.3	5.0	12.0	*Bosmina coregoni*	0.3	-	0.5
Keratella ticinensis	22.7	9.3	-	*Chydorus gibbus*	0.2	-	-
Keratella quadrata	3.5	1.5	-	*Chydorus sphaericus*	1.3	-	0.5
Lecane closterocerca	16.7	19.2	37.0	*Peracantha trumcata*	0.3	0.3	-
Lecane curvicornis	2.0	2.8	1.0	Nauplii Cyclopoida	84.2	114.0	60.5
Lecane hamata	4.0	3.7	0.5	Kopepodit Cyclopoida	-	6.5	1.0
Lecane scutata	4.2	-	-	*Eucyclops serrulatus*	-	-	0.5
Lepadella acuminata	0.3	-	2.0	*Thermocyclops oithonoides*	1.2	0.7	-
Lepadella ovalis	1.3	3.8	21.5				

Table 4. Mean ± SD abundance of zooplankton at sites examined

Taxon	Site 1	Site 2	Site 3
Rotifera	941.83 ±1320.10	464.00 ±609.00	235.50 ±181.73
Cladocera	1.67 ±2.73	4.83 ±8.54	4.50 ±4.95
Copepoda	87.50 ±110.41	121.50 ±198.30	62.50 ±81.32

In all ponds the highest frequency (over 80%) have *Anuraeopsis fissa* and nauplii Cyclopoida. Slightly lower frequency have *Lecane closterocerca*, Bdelloidea and *Polyarthra longiremis*.

Statistical analysis not revealed significant differences between three sites in density of any group of zooplankton. Rotifers obtained the highest abundance at site 1, while the lowest at site 3 (Tab. 4). The highest abundance of cladocerans was observed at site 2, while the lowest at site 1. Copepods obtained the highest abundance at site 2, while the lowest at site 3.

DISCUSSION

Composition of benthic fauna, noted in the ponds was similar to other observed in such ecosystems [Kownacki 2000b, Kudelska and Soszka 2001, Czerniawski *et al*. 2008]. According to the statistical analysis, only the number of gastropods differed between the ponds. In the second pond, their density was the highest, due to the conditions of the basin in which the highest concentration of nutrients was found (especially phosphorus), which have a positive effect on the vegetation development. The significantly higher abundance of gastropods in the second pond can be explained by a very good environmental conditions in this site, especially large surface of makrophytes. Additionally, Gastropoda make a rapid decomposition of high amount of organic matter, in the ponds system.

In third pond a large number of Chironomidae was observed, probably due to the respective environmental conditions and migrating juvenile from other ponds [Kołodziejczak and Koperski 2000]. *Chironomidae* characterized by small differences in abundance between pure and contaminated waters [Kownacki 2000a], therefore their number was very high in all sites. Additionally, the lack of significance may also be explained by the statistical test, using the whole Diptera but not families. Because the examined system of ponds is a flow system, it is likely that many organisms have drifted with flow current from other ponds (e.g. *Chironomidae*) [Czerniawski and Domagała 2010a].

Noteworthy is the case of density of three Insecta families: Plecoptera, Trichoptera and Ephemeroptera. Soszka *et al*. [2001] and Kownacki [2002b] have recorded that larvae of Ephemeroptera, Plecoptera and Trichoptera are typical for unpolluted and slightly polluted streams and rivers. Occurrence of Ephemeroptera and Plecotera (the most vulnerable to pollution), also depends on the structure of the substrate. However, the basic variable determining their presence is water quality and flow rate. The most abundance of Ephemeroptera occurs on the substrate covered by moss, while their lowest abundance on the substrate with large stones is observed [Soszka *et al*. 2001]. Largest number of listed three groups at site 3 was observed, where smallest content of inorganic nutrients and large amount of organic matter were observed.

The taxonomic composition of zooplankton was typical for waters in Pomeranian Lake District [Szlauer 1977, Czerniawski 2004, 2008]. In ponds examined a much larger number of rotifers taxa than cladocerans and copepods was noted. Besides, more species were listed in the warm season, which is typical, but their abundance was highest in October, especially for species *Anuraeopsis fissa*. High density of this species shows the high degree of status trophy [Karabin 1985]. In addition, the high proportion of copepods larvae, especially nauplii Cyclopoida demonstrates the rapid and progressive eutrophication of ponds water. This pattern is tipical for high trophy status of water. In the polluted waters or highly eutrophic nauplius Cyclopoida often reach very large numbers [Wolska and Czerniawski 2006, Estlander *et al*. 2009, Czerniawski and Domagała, 2010a, b]. High trophic status of ponds is also shown by the small percentage of Cladocera in abundance and biomass of total zooplankton. Cladocerans are much higher density in unpolutted waters, characterized by low trophic status [Karabin 1985, Dodson *et al*. 2009, Estlander *et al*. 2009].

Statistical analysis revealed insignificant differences between ponds in abundance of zooplankton groups. However, comparing these ponds, the highst abundnace of zooplankton (especially pelagic rotifers) in first pond was observed. The bottom of this pond is covered in lowest extent by macrophytes, so pelagic rotifers had better conditions to reproduction than littoral species. Cladocerans and copepods were the most abundant in the second pond, the deepest and the most covered by macrophytes. Sites densely covered by makrophytes are good habitat for crustaceans, especially for cladocerans [Kuczyńska-Kippen and Nagengast 1996]. In addition, macrophytes inhibited water current in the ponds and increased water retention time, which in running waters and reservoirs is crucial factor for the development of zooplankton [Czerniawski 2010b]. While in lakes relationships between zooplankton communities and chemical parameters are most important, in streams correlations are rather associated with physical variables, mainly stream regime [Basu and Pick 1996]. The results of presented ponds show the combined limnetic-lotic-system effect, in which both hydrological and chemical factors participate. Thus, abundance of zooplankton was impacted not only by inorganic nutrients from sediments, but also from agricultural catchment area.

Fry and less macroinvertebrates are the most important factors that reduced density of zooplankton, both in running and limnetic waters [Szlauer 1977, Hanazato 1990, Chang *et al*. 2008]. In ponds examined no fish were observed, so only macroinvertebrates could reduced the zooplankton density. The bivalves occurred in ponds, could reduced zooplankton, by selective filtration.

CONCLUSION

Although few significant differences in the composition of zooplankton and macrobenthos were observed, some divergences in both qualitative and quantitative composition of the two ecological groups of animals were noted. The environmental conditions of ponds had the impact on zooplankton and macroinvertebrates communities. The most important factors were retention water time and macrophytes. Retention time of water determined content of nutrients, alike inorganic and organic. So, despite the closely situated and interconnected ponds, the qualitative and quantitative composition of macrobenthos and zooplankton depend mostly on the morphology of examined ponds.

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FAUNA BEZKRĘGOWA TRZECH MAŁYCH STAWÓW POŁOŻONYCH W SYSTEMIE KASKADOWYM

Streszczenie. Badania dotyczyły charakterystyki zooplanktonu i makrobentosu trzech przepływowych, kaskadowych, małych stawów, leżących na terenie Zespołu Pałacowo-Parkowego Uniwersytetu Szczecińskiego w Małkocinie. W pracy został opisany stan hydrobiologiczny tych stawów w odniesieniu do warunków środowiskowych terenu, ze szczególnym uwzględnieniem spływu zanieczyszczeń z obszarów rolniczych. Próby pobierano z każdego stawu raz w miesiącu, od maja do października w 2010 roku. W pobranych próbach makrobentosu wyróżniono 35 rodzin, z czego 19 rodzin należało do gromady Insecta. W odniesieniu do makrobentosu analiza statystyczna wykazała istotną różnicę pomiędzy stawami tylko w liczebności Gastropoda. Spośród zooplanktonu stwierdzono obecność 51 taksonów – 39 taksonów Rotifera, 5 taksonów Cladocera i 7 taksonów Copepoda. Analiza statystyczna nie wykazała istotnych różnic w liczebności i biomasie zooplanktonu pomiędzy trzema badanymi stawami.

Słowa kluczowe: makrobezkręgowce, zooplankton, małe zbiorniki wodne, ekologia cieków