Teka Kom. Ochr. Kszt. Środ. Przyr. – OL PAN, 2013, 10, 23–35

SPATIAL CHANGES IN PHYTOPLANKTON, ZOOPLANKTON AND MACROBENTHOS COMMUNITIES IN DRAWA RIVER

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Co-financed by National Fund
for Environmental Protection
and Water Management

Summary. Drawa River basin is one of the most valuable natural areas of Pomeranian Lake District in Poland. However this river was rarely comprehensively studied. In terms of the size of the catchment area and the length the Drawa River is rather small. In the course of the river there are lakes, floodplains and reservoirs which directly affecting the qualitative and quantitative composition of phytoplankton, zooplankton and macrobenthos. The study of these taxonomical group were performed in Drawa River in 2010. The samples were collected at 12 sites, the first site was in upper, headwater section, while the last site was in downstream, in the mouth of Drawa into the Noteć River. The results obtained that taxonomical and quantitative composition of organism examined was typical for small rivers affected by limnetic basins. We observed some differences in composition plankton and macrobenthos between sites localized below limnetic basins outflows and sites localized far from these basins.

Key words: Drawa River, potamoplankton, zooplankton, phytoplankton, benthos, river ecology

INTRODUCTION

An attempt to describe the temporal occurrence of invertebrates in the river was the creation of the river continuum concept (RCC) [Vannote *et al*. 1980]. This concept describes mainly the dependence of the invertebrates occurrence on the organic energy supplied into stream from catchment. In the model of RCC plankton should be present in the greatest number of species and abundance in the lower course of the river. Also, density of macroinvertebrates should be the highest in the lower course of river, moreover along the river the communities of macroinvertebrates are divided on functional feeding groups (collectors, predators, shredders, filtrators, scrapers, grazers). In upper section significant domination of some functional feeding group is not observed, while in lower section the pronounced dominants are collectors. However RCC does not take into account some important environment variables. The concept considers a river that is not flowing through the limnetic basins. It is known that the flow lakes strongly influence on the typical pattern for river, especially below the lake outflow [Hillbricht-Ilkowska 1999] and from the point of view of RCC the limnetic basins destroy this pattern formed along river course, e.g. by reduction of typical river organisms, the appearance of large amounts of plankton and predators or rapid changes of physico-chemical variables [Minshall *et al*. 1985, Cummins *et al*. 1995].

A well area to study the changes of riverine invertebrates and plankton communities affected by limnetic basins is Drawa River. This river has in its course a few lakes, floodplains and reservoirs that change the model of RCC and affect the spatial changes of plankton and macroinvertebrates communities.

The aim of present study was to describe the spatial changes of phytoplankton, zooplankton and macrobenthos communities in relatively small Drawa River, in relation to RCC.

MATERIAL AND METHODS

The study was performed on the Drawa River, which is a 190 km long quaternary tributary of the Odra River. The springs of the Drawa River are at the altitude of 50 m a.s.l., and the mean slope of the river bed is 0.59 m km^{-1}. The catchment area of Drawa is 3198 km^2. The samples were collected in 2010 from at the sites shown in Figure 1 and characterised below.

Site 1 – This site is about 1 km below the outflow from the lakes in reserve „Valley of the Five Lakes". **Site 2** – Located 0.2 km below outflow from shallow, eutrophic lake Prosino Lake. **Site 3** – Located 0.5 km below outflow from mesotrophic lake Prosino. **Site 4** – Located far from lakes in Złocieniec town, above this site a many floodplains occurr. **Site 5** – Located far from lakes in Gudowo village. **Site 6** – This site is about 0,1 km below the outflow from the eutrophic lake Wielkie Dębno. **Site 7** – Located 2 km below reservoir of hydro power plant Prostynia and below many floodplains. **Site 8** – Located in Drawieński National Park, 0.5 km below outflow from eutrophic lake Adamowo. **Site 9** – Located in Drawieński National Park, far from lakes in Bogdanka village. **Site 10** – Located in Drawieński National Park, below outflow from reservoir of hydro power plant Kamienna. **Site 11** – Located far from lakes in Przeborowo. **Site 12** – Located far from lakes in, in mouth of Drawa.

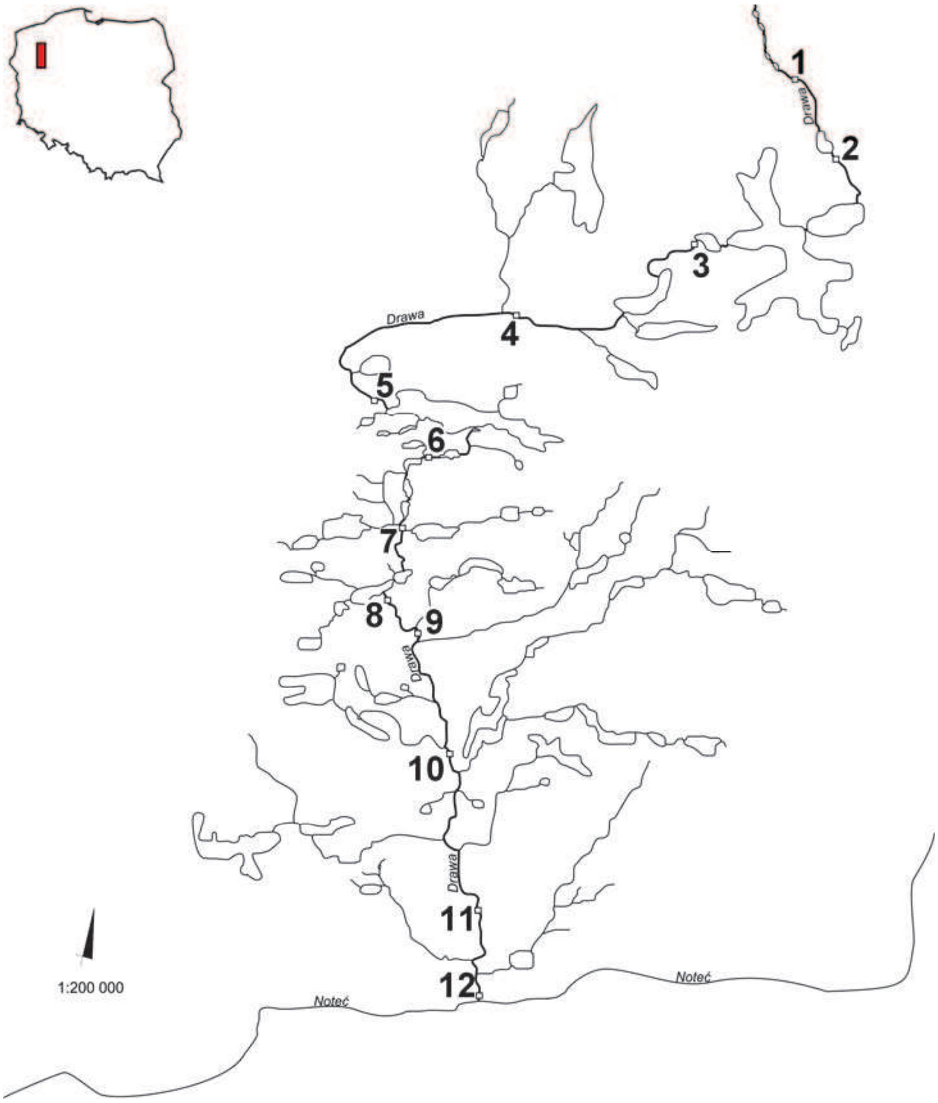

Fig. 1. Study area: 1–12 – explanations in the text

The samples of zooplankton to be studied were collected each month in 2010, at each site 50 l of water were collected from the river drift, the water was filtered through a 25 μm mesh net. The samples of phytoplankton to be studied were collected from April to December in 2010, at each site 1 l of water were collected from the river drift. The samples of macrobenthos to be studied were collected from April to December in 2010. 0.35 m^2 of the bottom with a bottom scraper was collected, the sample of macrobenthos was filtered through a 0.5 mm mesh net.

Phytoplankton identification was made using the key of Bucka and Wilk--Woźniak [2007]. Zooplankton identification was made using the keys of Wagler [1937], Kutikova [1970], Harding and Smith [1974]. Macrozoobenthos identification was made using the keys of Rozkosny [1980], Kołodziejczyk and Koperski [2000], Czachorowski and Pietrzak [2003]. The statistical significance of the differences in phytoplankton, zooplankton and macrobenthos density between sites was tested by non-parametric Mann-Wittney U test.

RESULTS

Changes in phytoplankton composition

Among density of main six group of phytoplankton not many significant differences between sites were observed (Tab. 1). The lowest density of phytoplankton groups was observed at site 1, in upper section of Drawa, far away from lakes. However, at last site, in lower section of Drawa, the density of phytoplankton was also relatively low. The highest density of phytoplankton was observed at site 4. Bacillariophyceae noted at this site were significantly more numerous than at the other sites ($P < 0.05$), except site 6. Dinoflagellata at site 4 characterized by significantly higher density than at other sites ($P < 0.05$). The third group that have significantly higher density between sites were Chryso-phyceae ($P < 0.05$). Their density at site 8 differed significantly from other sites, except site 6. Generally, the highest density of total phytoplankton and particular taxonomical groups was observed at sites localized below outflows of Drawa River from lakes, reservoirs or floodplains. Although, this density was many times not significantly higher ($P > 0.05$). The further from stagnant waters the smaller density of phytoplankton was noted.

Table 1. Mean density of phytoplankton at sites examined in Drawa River (ind. · l^{-1})

Site	Cyanobacteria	Bacillariophyceae	Chrysophyceae	Dinoflagellata	Chlorophyta	Euglenophyta
1	10000.0	27466.7	7200.0	400.0	5866.7	933.3
2	363373.3	71600.0	15866.7	266.7	40933.3	133.3
3	8266.7	49333.3	13600.0	4666.7	10933.3	65.0
4	146666.7	334266.7	9066.7	51466.7	91466.7	133.3
5	6666.7	137066.7	2400.0	1466.7	48666.7	666.7
6	117533.3	228800.0	47600.0	3733.3	34266.7	266.7
7	15693.3	88666.7	6266.7	1066.7	13800.0	666.7
8	39400.0	174933.3	83600.0	2800.0	38800.0	666.7
9	22133.3	119066.7	23066.7	2000.0	16266.7	133.3
10	8333.3	81733.3	4400.0	266.7	17466.7	533.3
11	40666.7	74800.0	933.3	133.3	19466.7	133.3
12	25133.3	101333.3	6933.3	1600.0	19866.7	133.3

Changes in zooplankton composition

The highest taxonomical similarity of zooplankton was observed between sites 9 and 12, the similarity index was 0.72 (Tab. 2). Also high similarity was noted between sites 5 and 10 and 5 and 12 (0.70). The lowest taxonomical similarity of zooplankton was noted between sites 1 and 11, and 2 and 11 (0.38 and 0.39 respectively).

Table 2. Taxonomic similarity of zooplankton between sites examined in Drawa River

Site	2	3	4	5	6	7	8	9	10	11	12
1	0.60	0.57	0.45	0.55	0.44	0.64	0.46	0.56	0.57	0.39	0.51
2		0.50	0.52	0.43	0.43	0.61	0.45	0.43	0.5	0.38	0.45
3			0.51	0.51	0.45	0.60	0.48	0.51	0.43	0.46	0.53
4				0.65	0.57	0.67	0.47	0.50	0.51	0.50	0.56
5					0.63	0.64	0.51	0.62	0.70	0.62	0.70
6						0.6	0.63	0.53	0.54	0.48	0.65
7							0.59	0.65	0.60	0.59	0.66
8								0.51	0.53	0.51	0.64
9									0.58	0.63	0.72
10										0.65	0.66
11											0.65

Table 3. Mean number of taxa and mean abundance of zooplankton (ind. · l^{-1}) at sites examined in Drawa River. Note: + mean number of taxa is lower than 1

Site	Taxa number			Abundance			
	Rotifera	Cladocera	Copepoda	Rotifera	Cladocera	Nauplii	Copepoda
1	4	+	1	27	0.1	2.1	0.7
2	5	1	1	117.2	2.1	9.6	0.4
3	5	1	2	71.6	2.2	3.7	3.8
4	5	+	2	19.9	0.3	1.6	2.6
5	5	+	1	38.5	0.1	1.6	0.5
6	5	1	2	80.3	7.7	12.6	8.2
7	6	+	2	21.2	0.9	1.8	0.5
8	7	1	2	55.7	0.9	3.2	0.8
9	4	+	1	30.9	0.1	1.7	1.0
10	5	+	1	27.2	0.1	1.5	0.1
11	6	-	1	28.8	-	1.8	0.8
12	5	+	1	32.6	0.1	0.9	0.3

The Mann Wittney U test revealed significant differences between sites in number of zooplankton taxa (Tab. 3). Number of rotifers taxa differed significantly between sites 1 and 8, 1 and 11, 8 and 9 ($P < 0.05$). Number of cladocerans taxa differed significantly between sites: 2 and 5, 2 and 9, 2 and 10, 2 and 11, 2 and 12, 3 and 9, 3 and 10, 3 and 11, 3 and 12, 6 and 9, 6 and 10, 6 and 11, 6 and 12, 7 and 11, 8 and 9, 8 and 10, 8 and 11, 8 and 12 ($P < 0.05$). Number of copepods taxa differed significantly between sites:1 and 3, 2 and 3, 2 and 6, 3 and 9, 3 and 10, 3 and 11, 3 and 12, 5 and 6, 6 and 10, 6 and 11, 6 and 12, 8 and 10, 8 and 11, 8 and 12 ($P < 0.05$).

The Mann Wittney U test no revealed significant differences between sites in abundance of rotifers ($P < 0.05$) (Tab. 3). However the highest abundance of rotifers was observed at site below lakes outflows (site 2, 3, 6, 8). Abundance of cladocerans was significantly higher at site 6 than at other sites ($P < 0.05$), except sites 2 and 3 ($P > 0.05$). Abundance of naupliis at site 2 and 6 was significantly higher than at site 12. Site 4 and 5 had significantly lower abundance of naupliis than at site 8. Abundance of naupliis at site 8 was significantly higher tan at site 11 and 12. Adult Copepoda and copepodites obtained significantly higher abundance at site 6 than at other sites except sites 3 and 4 ($P > 0.05$). Additionally, site 3 has significantly higher abundance of Copepoda than sites 1, 2, 7, 10, 11, 12. Also, abundance of copepods at site 4 was significantly higher than at site 10.

Changes in macrobenthos composition

The higher number of macrobenthos taxa was observed at site 10 (Tab. 4). Another sites where number of taxa was also high were sites 3, 11 and 8. The lowest number of macrobenthos taxa was noted at site 6 and 1. The highest number of molluscs taxa was observed at sites localized below lakes or floodplains outflows (sites 3, 4, 8, 10), while the lowest number of taxa of this group was noted at river with regulated beds and characterized by high current velocity. Turbellaria and Nematoda were observed only at sites below lakes and floodplains. Hirudinea at sites densely covered by macrophytes were observed. Neuropterida, Plecoptera, Odonata and Acari were observed rather at last sites of Drawa characterized by high discharge and highest amount of niches. Other taxa occurred rather at all sites.

The highest density of macrobenthos was observed at site 8, it was significantly haigher than at other sites ($P < 0.05$), except sites 3 and 11 (Tab. 5). The macroinvertebrates at site 8 were represented mainly by Bivalvia and Diptera. These taxa obtained at this site significantly higher density than at other sites ($P < 0.05$). Moreover, gastropods at site 3 were significantly more numerous than at other sites ($P < 0.05$). The highest density of Hirudinea at site 2 not differed significantly only from sites 3, 4, 7, 8. The highest density of Malacostraca was observed at site 10, it was significantly higher than at sites 4, 6, 7, 9. Trichoptera occurred most numerous at site 8, and they density at his site not differed significantly only rom site 1 and 12.

Table 4. Number of taxa of macrobenthos at sites examined in Drawa River

Taxa	Site											
	1	2	3	4	5	6	7	8	9	10	11	12
Bivalvia	1	1	3	1	1	2	1	3	1	1	1	1
Mollusca	-	1	5	4	1	1	2	5	-	5	2	-
Oligochaeta	1	1	1	1	1	1	1	1	1	1	1	1
Nematoda	-	-	1	-	-	-	-	1	1	-	-	-
Turbellaria	-	-	1	-	-	-	-	1	-	1	-	-
Hirudinea	-	1	1	1	-	-	1	1	-	-	-	5
Malacostraca	1	2	2	2	1	-	1	1	1	2	1	2
Plecoptera	-	1	-	-	1	-	-	-	1	2	1	1
Odonata	-	-	3	-	-	-	-	-	2	2	3	1
Neuropterida	-	-	-	-	-	-	1	-	1	-	-	1
Ephemeroptera	1	2	2	3	3	2	1	1	3	5	4	2
Trichoptera	3	3	4	2	2	2	4	7	2	2	4	2
Coleoptera	-	-	-	2	2	-	1	-	-	-	1	-
Heteroptera	1	1	1	1	2		1	1	2	3	3	1
Diptera	3	4	6	3	6	1	3	4	6	6	6	5
Acari	-	-	-	1	-	-	1	-	1	1	1	1
Total	11	16	31	20	21	9	17	26	22	31	27	22

Table 5. Mean abundance of macrobenthos at sites examined in Drawa River (ind. · m^{-2})

Taxa	Site											
	1	2	3	4	5	6	7	8	9	10	11	12
Bivalvia	40.7	31.8	64.4	17.2	1.3	9.9	9.6	298.6	35.0	4.6	45.7	1.3
Gastropoda	-	0.7	170.2	8.9	1.3	16.1	0.7	21.4	-	31.2	5.8	-
Oligochaeta	-	2.0	96.6	14.6	4.0	10.5	2.0	24.0	-	28.4	11.6	-
Hirudinea	-	6.4	3.9	0.7	-	-	0.7	1.2	-	-	-	-
Malacostraca	35.6	9.6	6.4	2.6	26.7	-	4.4	31.8	1.3	82.9	47.8	6.4
Plecoptera	-	1.2	-	-	1.9	-	-	-	1.3	5.7	1.9	3.2
Odonata	-	-	3.3	-	-	-	-	-	2.0	2.6	2.7	1.3
Ephemeroptera	15.2	8.9	6.4	7.1	11.3	6.1	13.0	3.8	5.7	29.9	14.8	6.3
Trichoptera	19.7	12.1	5.9	4.6	9.0	2.2	3.2	85.1	7.7	3.9	14.7	21.6
Coleoptera	-	-	-	2.0	5.1	-	1.3	-	-	-	0.7	-
Heteroptera	3.8	1.2	20.9	2.6	3.1	-	0.7	4.3	3.9	17.2	21.0	2.0
Diptera	20.9	56.4	42.0	58.7	91.1	59.6	119.9	273.3	75.7	42.2	169.4	40.7
Neuropterida	-	-	-	-	-	-	-	-	0.7	-	-	0.7
Other	-	-	2.6	0.7	-	-	3.2	5.7	3.8	1.9	2.7	1.2
Total	149.0	140.3	340.1	148.8	160.4	105.0	172.4	741.1	151.0	238.4	370.2	91.1

Density of Coleoptera was significantly higher at site 5 than at other sites ($P < 0.05$), except site 4. Density of Ditera was significantly higher at site 8 than at other sites ($P < 0.05$), except site 1.

DISCUSSION

Phytoplankton composition

Phytoplankton is a group of autotrophic photosynthetic microorganisms inhabiting the water column of limnetic and running waters. In the case of running waters, the general view is that the community of phytoplankton not develop in streams and small rivers due to high flow rates and low depth. Drifted phytoplankton assemblages in small rivers consists of organisms washed from the bottom, lakes, reservoirs or other small stagnant basins. The phytoplankton washed out from these water reservoirs into the rivers is often essential for development of the river phytoplankton, and below these basins the density of phytoplankton is the highest [Moss *et al*. 1989]. The same pattern was observed in the present study. The greatest amount of phytoplankton was noted at sites below lakes, reservoirs or floodplains. Such dam reservoirs, change the hydrological and ecological conditions in flowing water and are valuable sources of plankton in rivers [Lair 2006]. The results of phytoplankton density in the mouth of Drawa are opposed to the RCC. However, this concept applies to large rivers, where the retention time can be long enough for plankton colonisation and reproduction [Allan 1995]. In lower sections of large rivers the hydrological conditions, inorganic nutrients and temperature are important for growth of plankton communities) [Moss *et al*. 1989, Basu and Pick 1997]. At the last site of Drawa the retention time was not sufficient to phytoplankton reproduction). At this site, located far from stagnant water bodies a rather small density of phytoplankton was observed. Wetzel [2012] also stated that similarity values declined with increasing distance between sampling sites.

Additionally, higher density of the phytoplankton was observed in outflows from eutrophic lakes. Phytoplankton succession seems to turn increasingly autogenic with increasing eutrophication [Giorgio *et al*. 1991]. According to Dodds [2006], inorganic nutrients affected eutrophication process are the most important compounds regulating autotrophic state in flowing waters and their presence is positively correlated to gross primary production.

Zooplankton composition

The RCC shows that the farther from the watercourse headwater, the more the amount of suspended solids in water increases [Vanotte *et al*. 1980]. This phenomenon concerns both inorganic and organic matter, among which drift zooplankton plays an important role. However, communities of zooplankton in running waters often exhibit low species numbers, and low abundance in comparison to stagnant waters [Philips 1995]. The reason is because water currents, turbidity, and lack of food provide an unfavorable environment [Ejsmont-Karabin and Kruk 1998] and because of the short water residence time [Allan 1995].

Although the zooplankton samples were collected in one river basin, many differences in the composition of zooplankton between sections of the river were observed. Many authors who studied spatial pattern of zooplankton communities in rivers have reported that zooplankton composition in rivers depend on many environmental variables [Pourriot 1997, Czerniawski and Domagała 2010a, Czerniawski and Pilecka-Rapacz 2011]. The highest number of taxa and the highest abundance of zooplankton were observed below the outflow from limnetic basins. However, according to the RCC and some studies in large rivers the highest values of this variables should be noted in the lower section of river [Czerniawski *et al*. 2013]. Main sources of zooplankton reproduction in riverine ecosystems are lakes, floodplains, wetlands or slackwaters from which zooplankton is flushed to the main channel [Lair 2004, Nielsen *et al*. 2005, Humphries *et al*. 2006]. Thus, in the present study the highest densities of zooplankton were noted in sections below outlets from stagnant waters. We observed also, higher densities of zooplankton, especially crustaceans in sections covered by macrophytes. The watercourses with the bottom grown with macrophytes permit proliferation of zooplankton, so in such watercourses the zooplankton density is much higher, especially the Cladocera [Davidson *et al*. 2000, Czerniawski and Pilecka-Rapacz 2011]. This pattern particularly refers to limnetic basins, as according to Estlander *et al*., [2009] and Kuczyńska-Kippen and Nagengast [2006] the abundance of Cladocera increases with increasing vegetation. Only small density of zooplankton in upper headwater section of Drawa agree with the RCC. In headwater sections of small rivers very small densities are observed [Czerniawski 2013].

According to the RCC in lower section of river the highest density of zooplankton should be observed. It is associated with high amount of phytoplankton in this zone as food for zooplankton. In the present study in lower section of Drawa (located far from lakes), small abundance and number of taxa in zooplankton composition was observed. Also at other sites located far from lakes, floodplains and reservoirs a reduction of zooplankton communities was observed, especially adult crustaceans. The reasons for zooplankton reduction in rivers can be first of all biological conditions – predation by fish or invertebrates [Walks and Cyr 2004, Chang *et al*. 2008, Czerniawski and Domagała 2010b] and hydrological conditions, because river zooplankton is correlated with the physical parameters, mainly with the river regime [Pace *et al*. 1992, Basu and Pick 1996, Ejsmont-Karabin and Węgleńska 1996, Chang *et al*. 2008, Czerniawski 2008], which can affect its composition. For example, the width and depth of the river affect the rate of zooplankton reduction by fish predation. Campbell [2002] and Czerniawski and Domagała [2012, 2013] claims that high water flow and current speed favour the abundance of zooplankton as in such conditions it is more difficult for the fish to catch zooplankton. Density of the zooplankton in rivers depends mainly on the biotic factors, and physical factors, in particular on the hydrological conditions [Basu and Pick 1996, Thorp and Casper 2003, Lair 2006]. In streams with low value of current velocity (< 3 cm s^{-1}) zooplankton could reproduce [Czerniawski 2012]. However, main variable affect the drift of zooplankton is predation by fish. According to Lair [2006] and Czerniawski and Domagała [2013] the distance over which zooplankton is transported depends mainly on the biotic conditions in a watercourse and first of all on the number of predatory fish. Lair [2006] practically disregards the effect of the water flow character, however, we want to emphasise that the type of water flow can significantly influence to effectiveness of zooplankton catching by fish. The plankters which are observed in rivers in relatively equal quantities are rotifers. However, it seems that these small organisms were ignored by fish. So, in regard to the RCC, zooplankton communities along the small river depend rather on biological and morphological conditions occurred in particular section of river, independent from distance from headwaters.

Macrobenthos composition

The largest number of taxa in sites 12 and 6 was due to environmental conditions of these river sections. Bottom of above sections was covered with sand and gravel, some places were covered by macrophytes, values of current velocity were relatively high. These different conditions in one site favored occurrence of many families of macroinvertebrates [Beisel *et al*. 2000, Korte 2010]. The lowest number of macroinvertebrates taxa was observed at site 1, where the bottom was only muddy, without macrophytes and at site 6 in lake outflow where the bottom was not differed and pressure of fish could be high. In lake outflows rather small taxa number and density of macroinvertebrates is observed. Winkelmann *et al*. [2011] explain this pattern by occurrence large mount of preying fish reduced communities of macroinvertebrates. The highest number of moluscs taxa observed in outflows from lakes or floodplains can be caused by rapid increase of temperature in these limnetic basins. Between values of temperature and number of taxa or density of Mollusca is positive correlation [Sahin 2012]. Therefore, we can assume that also the ecotone zone between the lake and the river is a suitable environment for the existence of these taxa. The highest density of macroinvertebrates at site 8 was caused by abundant occurrence of Bivalvia: Sphaeriidae, Trichoptera: Hydropsychidae and Diptera: Simuliidae). Site 3 also characterized by large density, mainly because of abundant snail *Potamopyrgus antipodarum* (Hydrobiidae). We observed a high density of macrocrustaceans at site 10, which may be related to good food base for this group and high content of dissolved oxygen [González and Graca 2005]. The highest diversity and high density were observed in sections among forest area and located far from agricultural areas and urban zones. Similar pattern was observed by other authors who studied communities of riverine macroinver-tebrates [Pavlin 2011, Li *et al*. 2012]. So, according to RCC at site 1, in upper section of Drawa a high number of taxa should be observed. However, it seems that in this section, rather conditions of the bottom determined taxonomical composition of macroinvertebrates but no organic matter supplied from catchment zone. In last site taxonomical and quantitative composition of macro-benthos can refer to RCC, but only according to density. However, the relatively high number of taxa at last site of Drawa not refer to model of RCC. Thus, the most important factor determining composition of macroinvertebrates could be thickness of bottom substrate.

CONCLUSION

The results of the present study revealed that pattern of plankton and macrobenthos composition in Drawa River is different from model presented in RCC. Phytoplankton and zooplankton communities along the river depended rather on biological and morphological conditions occurred in particular section of river, independent from distance from headwaters. In the case of macroinvertebrates it seems that most important factor determining its composition is kind of the bottom substrate. Although the authors are aware of the assumptions of RCC (without lakes and reservoirs along the river) it seemed that test the validity of this concept in the context of a small river has its justification. However, this problem was previously featured [Ward *et al*. 2002].

Acknowledgment. Research are financed by the European Union under the Operational Programme „Sustainable Development of Fisheries Sector and Coastal Fishing Areas 2007–2013". Agreement number: 00001-61724-OR1600004/10

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ZMIANY PRZESTRZENNE FITOPLANKTONU, ZOOPLANKTONU I MAKROBENTOSU W RZECE DRAWIE

Streszczenie. Zlewnia rzeki Drawy należy do najcenniejszych obszarów przyrodniczych Pomorza Zachodniego. Pomimo to, rzadko była poddawana kompleksowym badaniom. Pod względem wielkości obszaru zlewni i długości Drawa należy do rzek małych. Przepływa przez wiele form krajobrazu. W jej biegu występują różnej wielkości jeziora, rozlewiska i zbiorniki zaporowe, wpływające bezpośrednio na skład jakościowy i ilościowy makrobentosu oraz fitoplanktonu i zooplanktonu dryfującego z prądem rzeki. Badania tych trzech grup ekologicznych prowadzono w 2010 roku. Próby pobierane były z 12 stanowisk w biegu rzeki Drawy, poczynając od odcinka źródłowego, kończąc na ujściu Drawy do Noteci. Wyniki badań wskazały, że kompozycja jakościowa i ilościowa analizowanych grup ekologicznych jest typowa dla odcinków małych rzek, znajdujących się pod wpływem większych i mniejszych zbiorników limnetycznych. Zaobserwowano różnice w kompozycji fitoplanktonu, zooplanktonu i makrobentosu pomiędzy odcinkami rzeki poddanymi wpływowi zbiorników stojących a odcinkami znajdującymi się w dalszej odległości od jezior, rozlewisk i zbiorników zaporowych.

Słowa kluczowe: Drawa, potamoplankton, zooplankton, fitoplankton, bentos, ekologia rzek