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CHANGES IN MACROFAUNA COMMUNITY SETTLING ARTIFICIAL SUBSTRATES AFTER LONG-TERM EXPOSURE IN THE COLD CANAL (THE RIVER EASTERN ODRA, POLAND)

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artificial substrata,
succession

Synopsis

Artificial substrates colonized by macroinverterbrates were collected from freshwater-canal between February and June of 1997 (after several months of exposure), and once in April 2001 after they remained for 1760 days. Strong seasonal changes were observed in the qualitative composition, density, biomass and dominance structure of epifaunal communities in the first period of the research. The average density of invertebrates on the five year old substratum reached a similar level to the average density of the spring community of macroinvertebrates developing on the sheets installed for several months in the canal, however, the biomass of the macrofauna community after the long-term development was about 30 times higher. The population of *Dreissena polymorpha* composed the main part (96%) of the above biomass. Despite the similar number of taxa recorded on the substratum in April 2001 and between February and May 1997 the faunal similarity of these communities, calculated using the modified Jaccard formula, was relatively low reaching from 9% to 18.5%. The above observations can suggest that the investigated community of invertebrates was characterized by a low level of stability, modified by strong seasonal changes and long-term succession. The older community showed an increase in *k*-strategies importance in comparison with the one-year old macroinvertebrate aggregation.

INTRODUCTION

In a series of studies on the epifauna polyethylene sheets were used as permanent anthropogenic objects installed in an aquatic environment with the aim of offering conditions for the development of periphyton plant and animal aggregations on their surface.

The processes of formation and short-term functioning (in the scale of a few months, a year or two years) of invertebrate communities associated with natural and anthropogenic substrates are fairly well known (Soszka 1975; Cover & Harrel 1978, Gerrish & Bristow 1979; Niewiadomska 1981; Kornijow 1989; Piesik et al. 1991; B. Szlauer and L. Szlauer 1997, 1998; Schmude et al. 1998; Mihajlevic et al. 1998; Janicki 2000; Szlauer-Lukaszewska 2007; Zawal et al. 2003), however, changes occurring in epifauna communities developing for longer periods have been investigated insufficiently so far. Studies of his problem could not have been conducted on biotic substrates on account of their impermanence (Bownik 1970; L. Szlauer & B. Szlauer 1999) while the unknown time of exposure of hard abiotic surfaces found in waters and therefore of the “history” of periphyton developing on them impedes the proper interpretation of the conducted observations. The use of artificial substrates introduced in controlled conditions in the environment and resistant to its effects allowed studying long-term changes in the qualitative-quantitative structure of epifauna communities and also alterations occurring within individual populations. This type of studies was only sporadically undertaken: L. Szlauer & B. Szlauer (1999) observed changes in the structure of a periphyton community overgrowing polyethylene sheets after a few years of exposure in Lake Krąpsko. Szlauer- Lukaszewska (2000) compared the qualitative (size and age) structure of *Dreissena polymorpha* (Pall) population from natural habitats and of a population developing for five years on plastic sheets installed in the same lake.

The aim of the presented studies was to determine changes in the structure of a macrofauna community colonizing artificial plastic substrates after almost five years of exposure in one of the Odra canals and to analyze the mechanism of secondary succession in this environment.

STUDY AREA

The investigation was carried out in the Cold Canal feeding waters to the “Dolna Odra” Power Plant (at Gryfin, NW Poland) and fed by the main current of the eastern branch of the River Odra - the River Regalica. The canal was in 50 m in width, about 1 km in length and 3-4 m in depth. The quality of waters in the canal reflected the condition of the River Eastern Odra waters in this region. In the years 1996-1997 in the section between the localities of Widuchowa and Gryfino the River Regalica met the criteria of purity class II with respect to the content of organic and mineral compounds and saprobity while the concentration of biogenous compounds and the sanitary condition of the river were maintained at the level of purity class III, sporadically exceeding this limit. The amounts of suspension carried by the river classified it in purity classes II-III. The indices of water contamination with heavy metals, phenols, detergents; the salinity index; the content of dissolved oxygen and the water temperature were in purity class I of water quality (Landsberg-Uczciwek 1997, 1999). The quality of river waters was decreased by the high content of "chlorophyll a" whose level exceeded all the norms during the vegetation season. The disastrous flood in summer 1997 contributed to the temporary deterioration of water quality in the Regalica chiefly manifested by an increase in the content of nitrite nitrogen and a decrease in oxygen content in the water (Landsberg-Uczciwek 1999). In autumn all the controlled water parameters returned to the norm. In 2001 in the Regalica some water parameters improved compared with the years 1996-1997. This chiefly concerned indices which previously decreased the quality of waters in the River Eastern Odra: the level of chlorophyll a, content of ammonia nitrogen, total phosphorus and the sanitary condition of the water. Literature data concerning the physical and chemical parameters of the water were supplemented with the measurements of temperature, oxygen content, pH level and water turbidity carried out by the author in the Cold Canal in the period of macrofauna sampling (Table 1).

SUBJECT AND METHOD OF RESEARCH

Early in July 1996 polyethylene substrates in the form of square sheets of 1000 cm^2 each were installed in the canal at a depth of 1 m and at a distance of 1.5 from the bottom. Owing to the current the plastic sheets did not fall vertically but were maintained horizontally in relation to the water current. In the first year of the experiment the substrates were sampled from the canal every month, each time three random substrates overgrown with periphyton being obtained. In April 2001 four substrates were taken at one time. The sheets overgrown with periphyton were preserved with a 4% formalin solution. The largest specimens of the macrofauna, e.g., bivalves *D. polymorpha* Pall., some taxa of insects, snails and also random samples of *Cordylophora caspia* Pall. colonies were selected in the laboratory. Then the periphyton was removed from both sides of the sheet and subjected to sedimentation in a cylinder up to the precipitation of all the suspension. In the case of large Bryozoa colonies occurring on the sheets they were selected from the scratched periphyton, washed, dried on filter paper and weighed. The sediment left in the cylinders was decanted, diluted to a determined volume of 1.5 of the sediment volume and carefully mixed to obtain a homogenous suspension; then depending of the amount of the suspension 3-4 sub-samples of 5.6 ml each were taken. In further procedures the sub-samples were used as a whole. The remaining macrofauna representatives were selected from them and classed as to taxa using a binocular. The wet biomass of the taxa was also measured. Before weighing the animals were dried on filter paper to remove water not bound in the organisms. The obtained numbers and biomass of the taxa in samples were referred to the standard surface of 1 m^2 of the substrate. The biomass of *C. caspia* was determined by weighing the previously taken samples free of detritus and bigger epibionts in which the number of zooides was determined. Then the obtained data were used in estimating the biomass of *Cordylophpora caspia* per 1 m^2 of the substrate on the basis of the recorded density of these coelenterates on the plastic sheets. This procedure allowed determining the real biomass of zooides together with stolons which were strongly fragmented in the process of removing periphyton from the substrates. In determining the density of *Plumatella* sp. on the substrates 10-12 fragments of colonies were randomly taken, the number of individuals and the wet weight of the colony being measured. On the basis of the total biomass of *Plumatella* sp. colonies, the density of zooides per 1 m^2 of the substrate was estimated. The age structure of *D. polymorpha* population colonizing the substrates taken from the canal in April 2001 was also determined.

The similarly of the macrofauna communities inhabiting one-year and five-year old substrates was calculated using the Jaccard formula valorized by the numbers of species (Biesiadka 1977):

$$Pxy = \frac{\sum_{i=1}^{s} \frac{ai}{bi}}{n} \quad 100\%$$

where Pxy – faunal similarity between the x and y systems,

a – the lower numbers of i-species in comparable systems

b – the higher numbers of i-species in comparable systems

n - total number of recorded species.

date	temperature of water [^{0}C]	[mgO_2dm^{-3}]	pH	turbidity [SiO_2dm^{-3}]
27.02.97	4	11,7	7,6	-
06.03.97	6	10,5	7,9	15,0
13.03.97	7	-	-	-
24.03.97	5	12,2	7,8	-
03.04.97	8	13,2	8,2	25,0
18.04.97	7	-	-	-
24.04.97	8	-	-	-
30.04.97	12	13,6	8,9	-
08.05.97	15	12,5	8,6	38,0
23.05.97	18	-	-	-
26.05.97	19	-	-	-
31.05.97	18	9,5	8,2	-
06.06.97	20	10,5	8,6	-
09.06.97	19	-	-	-
16.06.97	19	-	-	-
19.06.97	20	9,3	8,4	33,4
26.04.01	10	10,7	8,1	19,3

Tab. 1.Basic physical and chemical properties of the canal's water in 1997 and in 2001

RESULTS

The conducted investigation allowed comparing a few-year old community of epiphytic macrofauna with the epifauna developing on substrates exposed in the canal for eight to 12 months. Environmental parameters described at the time of sampling the five-year old substrates (April 26, 2001) were comparable with conditions of early April 1997, presenting a typical pattern of this month (Table 1). The results of measurements of physical and chemical factors confirm a fairly good condition of waters in the Cold Canal and are characterized with the dynamics of seasonal changes typical of large lowland rivers. The increased alkalinity of water in the late spring and summer periods was probably brought about by the intensified photosynthetic processes in phytoplankton whose development also contributed to seasonal increases in water turbidity.

date of sampling	27.02.97	03.04.97	08.05.97	19.06.97	26.04.01
density of macrofauana [ind.m^{-2}]	14809,2	13367,0	9783,4	221481,9	14002,0
biomass of makrofauna [$mg_{w.w.}m^{-2}$]	23,902	20,779	18,093	110,601	655,162

Tab. 2. Density and biomass (wet weight) of macrofauna on substrata exposed in Cold Canal

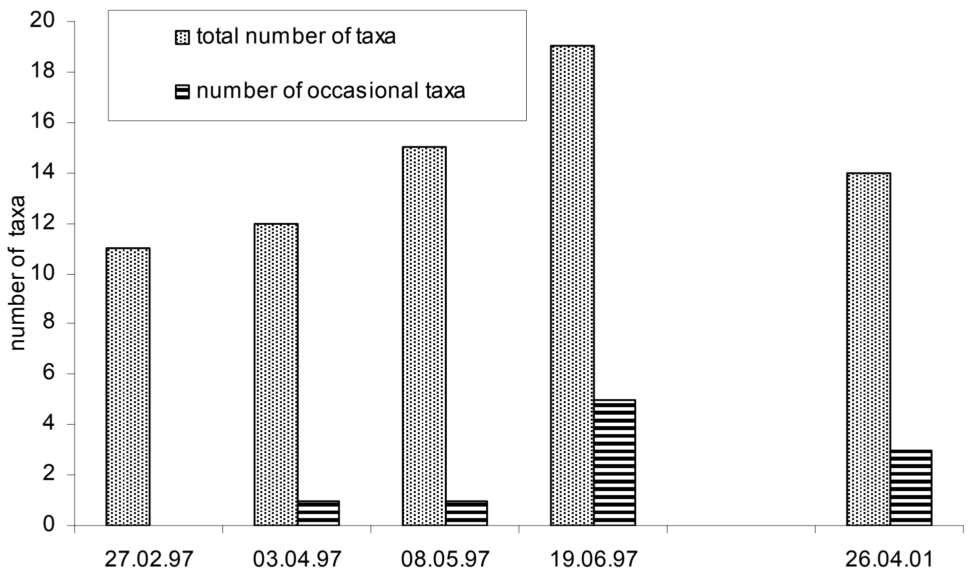

Fig.1. Number of taxa occurred on substrata in period 97.02.27-97.06.19, and in 01.04.26.

The mean density of macrofauna on the substrates sampled in April 1997 and 2001 reached a similar level of about 14 thousand individ.m^{-2}, however it was decisively lower than the maximum numbers of the investigated epifauna found on the polyethylene sheets in June 1997 when the mean value of 221.5 thousand indiv.m^{-2}

was recorded (Table 2). The macrofauna of the first and the fifth year of the investigation significantly differed by the recorded biomass which in the case of the community from 2001 was from six to over 30 times higher compared with the biomass of fauna inhabiting polyethylene sheets in 1997 (Table 2). The numbers of macrofauna taxa on the sheets were also similar in April and May 1997 and on the 5-year old substrata (Fig. 1, Table 3). A slightly higher number of taxa (19) was found on the substrates in mid June. The following eight taxa were characterized with a constant occurrence on the substrates: *Hydra* sp., Naididae*, Piscicola geometra, Corophium curvispinum,* Gammaridae, Chironomidae, *Simuliidae*, and *Dreisena polymorpha* constituting 31% of all the taxa identified on the substrates in both study periods (Table 3). The number of taxa sporadically appearing on the substrates (once in the discussed study period) was most significant in June 1997 and April 2001 when they constituted respectively 26% and 21% of all the taxa identified at that time on the substrates (Fig. 1), however, the density of these species was low and did not affect the structure of dominance in the community. The only exception was the appearance of *Viviparus* sp. in the second half of June 1997; they were not numerous but owing to their big dimensions they disturbed the structure of individual taxa participation in biomass of the community (Fig. 3). The faunal similarity determined using the modified Jaccard formula between the macrofauna settling on five-year old substrates and the communities from one-year old substrates was low varying from 7.2% in comparison with the community from June 19, 1997 to 18.5% for the community from February 27, 1997. Most taxa reached the highest density at the turn of spring and summer 1997 (Table 3). Among the exceptions were the gammarids whose highest density was recorded late in February 1997 and in April 2001; Simuliidae attaining the highest density in April 1997; and also bivalves *D. polymorpha* with the highest density on five-year old substrates. It was over 10 times higher compared with the analogical period of the year 1997 (Table 3). The densities of Chironomidae and *Corophium curvispinum* found on many-year old sheets approximated to the values found for these taxa in the spring period (early April and May) 1997. The peaks of biomass reached by the individual taxa colonizing the substrates exposed in the Cold Canal were associated with the maxima of their density (Table 4). The wet mass of Gammaridae, Simuliidae and Trichoptera found on five-year old substrates approximated to the biomass of these invertebrates colonizing the substrates toward the end of February 1997. In 2001 Chironomiae and *C. curvispinum* biomass reached a level comparable with that represented by these taxa early in spring in the first year of exposure of the substrates (Table 4).

The participation of individual taxa in macrofauna density on the substrates exposed in the Cold Canal passed distinct seasonal changes from late February to mid-June 1997. By the end of winter (February 27, 1997) the most important components of the macrofauna were *Corophium curvispinum* and Chironomidae reaching respectively 51.4% and 39.3% of macrofauna density (Fig.2). Their role in the community distinctly decreased in successive months, *C. curvispinum* showing the lowest participation (7%) in May and Chironomidae in June (19.5%). At the same time the role of Naididae and *Hydra* sp. was growing, reaching the highest participation in the community early in May: respectively 19% and 23% of the macrofauna density. In the group of taxa periodically playing a more important role in the community Gammaridae constituted 3% of the macrofauna towards the end of February and Simuliidae reached 8.1% in the epifauna density in April (Fig. 2). Early in May the seasonally occurring taxa appeared on the substrates: bryozoans *Paludicella articulata* (6%); *Plumatella* sp. (3%); coelenterates *Cordylophora caspia* (1%); and colonies of *Spongilla* sp. (0.8%). The participation of *Plumatella* spp. and *C. caspia* significantly increased in the next month reaching 27% and 17.5% respectively. After almost five years of exposure of the plastic sheets Naididae dominated in the community (39% of macrofauna) and *Corophium curvispinum* constituting 31% of the investigated invertebrates (Fig. 2). The role of Chironomidae (15%) and *Paludicella articulata* (7%) was less important in the macrofauna. The participation of Gammaridae (4% of total density) and *Dreissena polymorpha* (3%) in the community was also observed while the occurrence of Trichoptera, Simuliidae, a colony of *Spongilla* sp. and of *Cordylophora caspia* was recorded but they did not play any significant role in the community.

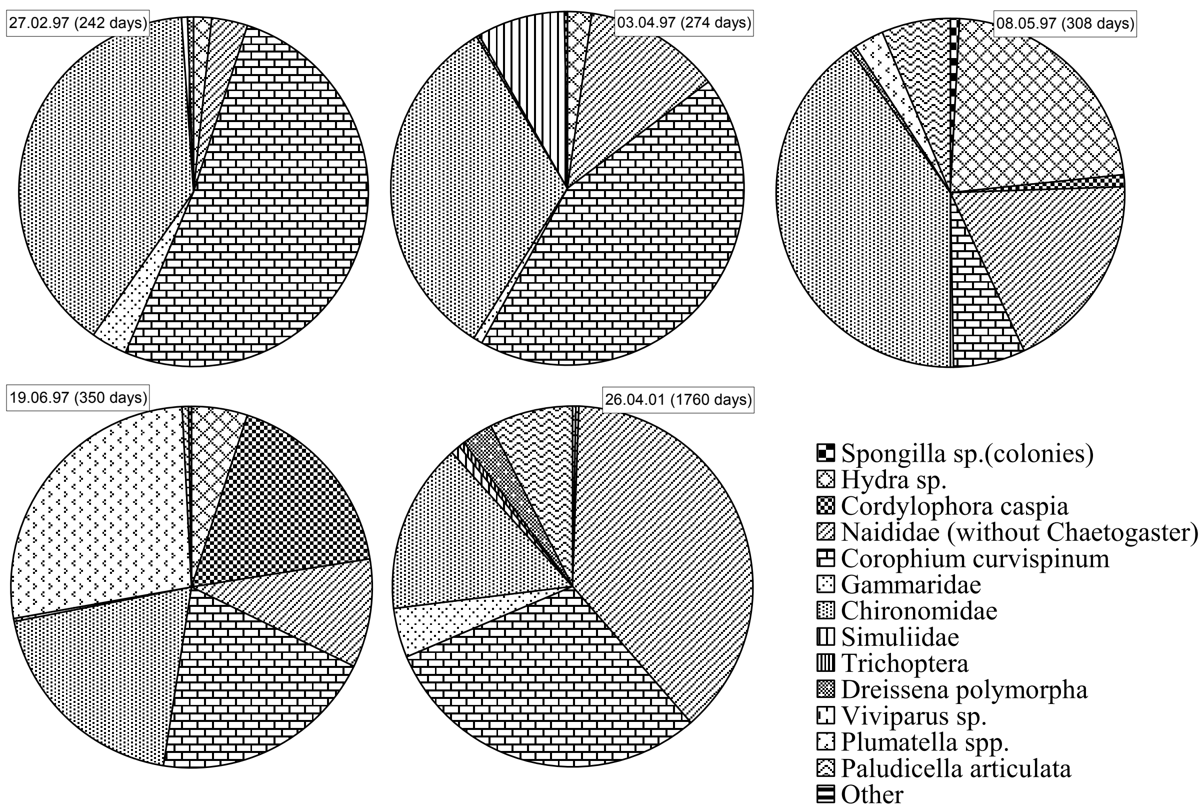

Fig.2. Percentage contribution of the most abudant taxa in makrofauna community settling the substrata during period 02.97-06.97, and in april 2001. Exposure period of substrata (days) was shown in brackets

Analyses of biomass showed that in the structure of macrofauna colonizing the substrates exposed in the Cold Canal the participation of taxa which were less numerous but characterized with larger dimensions increased; among them were *Dreissena polymorpha*, Gastropoda, Gammaridae and *Spongilla* sp. The dynamic of changes in the composition of biomass of the community was characterized by an increased role of fresh-water mussel as the time of exposure of the substrates was prolonged and by a decreased participation of Chironomidae in comparison with the structure of macrofauna density (Fig. 3). Towards the end of February 1997 *D. polymorpha* (32%), Gammaridae (33.5%) and *C. curvispinum* (27%) had the most important part in the wet weight of the community. In early spring (April 03, 1997) the taxa dominating in biomass were amphipods *Corophium curvispinum*, reaching 53% of wet weight of the macrofauna, and Simuliidae (20% of biomass of the community). In May 1997 the role of *Dreissena polymorpha* which constituted 61% of macrofauna biomass on the sheets, increased. The occurrence of *Spongilla* sp. was noted in the community since their participation in the wet weight increased to 12% while the percentages of *C. curvispinum* (7.5%) and Simuliidae (0.4%) were drastically reduced. In the second half of June the role of taxa characterized by seasonal occurrence such as *Plumatella* sp., *Cordylophora caspia* and *Spongilla* sp. increased, their total participation reaching 15% of biomass of the community (Fig. 3). At that time the most important taxa were *Dreissena polymorpha* (25% of the wet weight of macrofauna), *Corophium curvispinum* (24.6%) and Chironomidae (18% of biomass of the community); Gastropoda also played an important role (14.5%).

The most important components of macrofauna colonizing the five-year old substrates were the bivalves *Dreissena polymorpha* which constituted as much as 96% of the wet weight of the community (Fig. 3). Of the remaining taxa amphipods Gammaridae (1.9%) and *Corophium curvispinum* (1.5%) reached a slightly higher percentage. The role of Chironomidae was minimal (0.3% of biomass).

In the age structure of D. polymorpha population colonizing the substrates sampled in April 2001 the one- and two-year old individuals distinctly dominated, constituting 69.5% of the total population (Fig. 4). Bivalves of the "0" generation and the generation of five-year old ones occurred in the lowest numbers, reaching 2.1% and 1.2% respectively. In fact on the substrates taken at the end of April the "0" generation constituted a part of one-year old bivalves in which no line of annual increase was observed.

The investigation carried out so far suggests that the development of a periphyton community occurs in stages. After an early stage of colonization of substrates manifested by dynamic increases in the numbers of species and formation of the community (the initial and juvenile stages) the phase of periphyton stabilization (maturity) follows when a group of constant taxa is separated and a specific size of the community is established [L. Szlauer, B. Szlauer 1999; Szlauer-Lukaszewska 2007] . The climax stage is usually attained by periphyton between the 4^{th} and 6^{th} month of exposure of the substrates, however, it can be disturbed by seasonal changes in the community chiefly observed in the quantitative aspect [Janicki 2000; Szlauer-Lukaszewska].

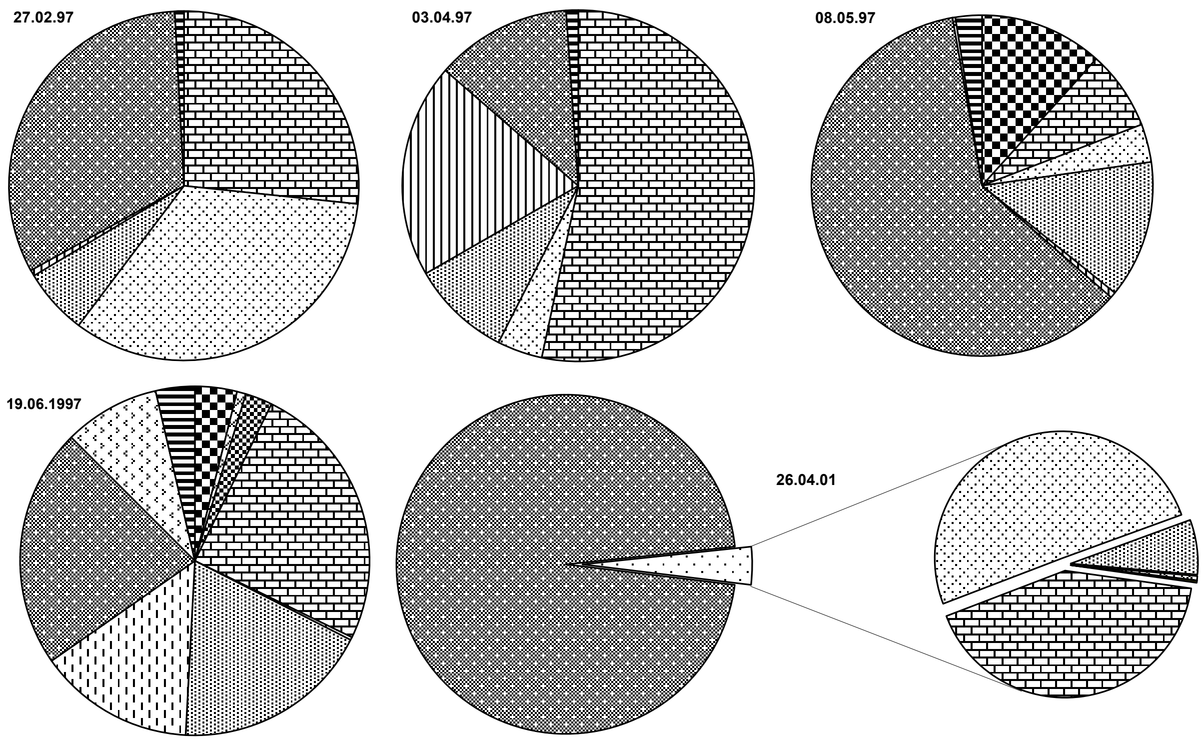

Fig.3. Percentage contribution of the main taxa in biomass community settling the substrata during period 02.97-06.97, and in april 2001. See fig.1 for details.

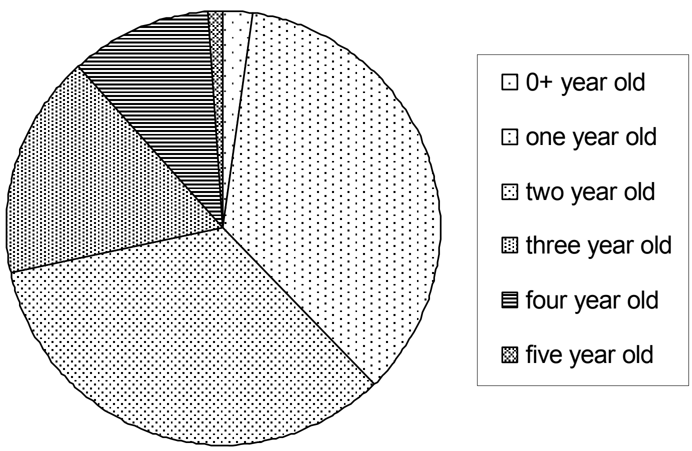

Fig.4. Age distribution of *Dreissena polymorpha* individuals settling the substrata collected from Cold Canal in 2001

The macrofauna community colonizing the substrates in the period between February and June 1997 (i.e., between the 8th and 12th month of exposure of the polyethylene sheets in the canal) manifested the traits of the mature phase being characterized with a fairly high number of taxa in all the seasons of the year and with a similar density and biomass maintained up to the time when the community reached a seasonal maximum in its development. In the composition of the group of taxa

date and duration of exposure (days)	27.02.97	03.04.97	08.05.97	19.06.97	26.04.01
takson	242	274	308	350	1760
Spongilla sp.-kolonie	0,0 ± 0,00	0,0 ± 0,00	74,0 ± 23,83	109,5 ± 108,61	5,5 ± 7,71
Hydra sp. razem	253,7 ± 72,24	291,0 ± 54,31	2210,4 ± 708,10	11016,1 ± 178,26	16,4 ± 23,12
Cordylophora caspia (zooidy)	0,0 ± 0,00	0,0 ± 0,00	107,8 ± 48,22	38709,0 ± 53114,96	38,4 ± 12,59
Dugesia lugubris	0,0 ± 0,00	0,0 ± 0,00	5,7 ± 8,10	0,0 ± 0,00	0,0 ±0,00
Stylaria lacustris	0,0 ± 0,00	39,4 ± 3,89	318,3 ± 0,49	12028,4 ± 1944,47	0,0 ± 0,00
Ripistes sp.	0,0 ± 0,00	27,15 ± 21,14	91,6 ± 14,50	0,0 ± 0,00	0,0 ± 0,00
Naididae - inne	491,3 ± 338,59	1627,05 ± 378,51	1405,5 ± 80,47	9010,1 ± 1118,50	5353,1 ± 6043,36
Piscicola geometra	9,7 ± 16,80	6,1 ± 8,63	5,7 ± 8,06	18,8 ± 11,10	0,0 ± 0,00
Erpobdella octoculata	4,2 ± 7,22	0,0 ± 0,00	0,0 ± 0,00	142,2 ± 62,37	0,0 ± 0,00
Corophium curvispinum	7616,2 ± 4373,73	5761,8 ± 3325,17	653,7 ± 359,63	45194,5 ± 4606,23	4212,6 ± 1249,03
Gammaridae	474,5 ± 401,56	118,1 ± 11,67	34,1 ± 15,98	89,0 ± 12,80	599,0 ± 76,58
Asellus aquaticus	0,0 ± 0,00	0,0 ± 0,00	0,0 ± 0,00	13,3 ± 18,81	0,0 ± 0,00
Heptagenia sp.	0,0 ± 0,00	0,0 ± 0,00	0,0 ± 0,00	167,6 ± 86,41	0,0 ± 0,00
Caenis sp.	0,0 ± 0,00	0,0 ± 0,00	0,0 ± 0,00	13,3 ± 18,81	0,0 ± 0,00
Corixa sp.	0,0 ± 0,00	0,0 ± 0,00	0,0 ± 0,00	21,8 ± 30,83	0,0 ± 0,00
Chironomidae	5818,4 ± 1958,74	4366,8 ± 2585,82	3929,7 ± 1120,13	42972,5 ± 5627,86	2169,4 ± 1053,66
Simuliidae	58,3 ± 17,69	1078,0 ± 1265,65	17,1 ± 8,06	18,8 ± 11,10	107,3 ± 60,10
Empididae	0,0 ± 0,00	0,0 ± 0,00	0,0 ± 0,00	0,0 ± 0,00	5,5 ± 7,71
Hydropsyche spp.	0,0 ± 0,00	0,0 ± 0,00	0,0 ± 0,00	0,0 ± 0,00	9,1 ± 2,62
Neureclipsis bimaculata	5,2 ± 8,95	6,1 ± 8,63	0,0 ± 0,00	0,0 ± 0,00	0,0 ± 0,00
Ecnomus tenellus	0,0 ± 0,00	0,0 ± 0,00	0,0 ± 0,00	0,0 ± 0,00	14,4 ± 20,40
Orthotrichia sp.	27,6 ± 47,80	0,0 ± 0,00	0,0 ± 0,00	0,0 ± 0,00	43,8 ± 15,41
Piona sp.	0,0 ± 0,00	21,1 ± 29,77	0,0 ± 0,00	0,0 ± 0,00	0,0 ± 0,00
Dreissena polymorpha	50,1 ± 7,12	24,7 ± 17,75	39,8 ± 23,97	36,1 ± 19,66	412,8 ± 187,55
Viviparus sp.	0,0 ± 0,00	0,0 ± 0,00	0,0 ± 0,00	13,3 ± 18,80	0,0 ± 0,00

Plumatella spp.	0,0 ± 0,00	0,0 ± 0,00	288,9 ± 32,67	59938,3 ±29059,90	0,0 ± 0,00
Paludicella articulata	0,0 ± 0,00	0,0 ± 0,00	601,3 ± 634,42	1969,7 ± 536,91	1026,4 ± 1064,70

Tab.3. Average density (± SE) of taxa colonising substrata during investigation.

characterized with 100% frequency there were found most representatives of the macrofauna which were reaching the status of dominants with respect to density or biomass, intensifying the similarity of epifauna communities on the substrates in particular months. In a one-year old community the dynamic of changes in the structure of dominance was to a high degree affected by seasonal changeability which was observed even in the period of stabilized density and biomass of the community and which was brought about by divergent developmental strategies as well as the adaptation of individual taxa to various environmental conditions. A part of *Corophium curvispinum* and Chironomidae populations which are reaching the peak of density in late spring or in summer have the ability of wintering and reproduction in the next season. In spite of a decreasing tendency in their numbers in the winter and early-spring season they can develop a fairly numerous all-year-round population [Kornijow 1989; Piesik et al. 1991; Wawrzyniak-Wydrowska 1997] therefore they constituted the chief component in macrofauna density on the substrates from February to May 1997. In spring the improvement of environmental conditions (increases in the ambient temperature and in the food base) was favourable for the development of both the taxa occurring on the substrates all the year round and these appearing only seasonally, e.g., *Spongilla* sp., *Cordylophora caspia, Palucidella articulate* and *Plumtella* sp. whose participation in the density and biomass of the community was growing more and more significant during the vegetation season. Owing to the reproduction of a part of taxa (e.g. Naididae, *Corophium curvispinum*, Chironomidae) and the development of thermophilous species (*Plumatella* sp., *Cordylophora caspia*) on the substrates in the second part of June a group of taxa was formed characterized by a similar participation in the density of the community. This system could be regarded as transitory since it probably might have ended by the distinct dominance of the *Plumatella* sp. population intensively developing in summer (Kaminski 1991). In June the colonization of the substrates by a group of new taxa (among them *Asellus aquaticus*, *Heptagenia* sp., *Corixa* sp. and *Viviparus* sp.) was probably associated with the seasonal development of periphyton constituting the food base of these invertebrates on the substrates. The migration significantly affected the structure of the community which colonized polyethylene sheets. Here the strong variation in the density and biomass of Gammaridae can be quoted as an example. They probably did not form a constant group strongly attached to the substrates but rather used them as potential feeding grounds. The effect of migration of big invertebrates on the fluctuation of macrofauna biomass connected with submerged vegetation was observed by Kornijow (1989). The zoocenoses investigated by the above author were characterized by strong seasonal changes in the structure of dominance, density and biomass, however, their species composition only slightly changed, this differing them from the community found on the substrates in the Cold Canal. The difference was due to the absence of seasonally occurring taxa in the communities investigated by Kornijow while they were numerously represented on the substrates exposed in the canal.

date and duration of exposure (days)	27.02.97	03.04.97	08.05.97	19.06.97	26.04.01
takson	242	274	308	350	1760
Spongilla sp.	0,000 ± 0,000	0,000 ± 0,000	2,134 ± 0,192	4,398 ± 2,896	0,045 ± 0,063
Hydra sp.	0,018 ± 0,005	0,021 ± 0,004	0,132 ± 0,055	0,833 ± 0,013	0,001 ± 0,002
Cordylophora caspia -zooidy	0,000 ± 0,000	0,000 ± 0,000	0,004 ± 0,003	2,644 ± 3,304	0,002 ± 0,001
Dugesia lugubris	0,000 ± 0,000	0,000 ± 0,000	0,081 ± 0,115	0,000 ± 0,000	0,000 ± 0,000
Stylaria lacustris	0,000 ± 0,000	0,004 ± 0,000	0,080 ± 0,000	2,438 ± 0,394	0,000 ± 0,000
Hirudinea -razem	0,159 ± 0,167	0,094 ±0,133	0,170 ±0,240	0,2645 ± 0,289	0,000 ± 0,000
Corophium curvispinum	6,359 ± 3,778	11,08 ± 6,111	1,357 ± 0,746	27,749 ± 2,828	10,088 ± 2,073
Gammaridae	8,018 ± 4,136	0,866 ± 0,086	0,631 ± 0,182	0,331 ± 0,016	12,112 ± 2,478
Ephemeroptera	0,000 ± 0,000	0,000 ± 0,00	0,000 ± 0,000	1,230 ± 0,245	0,000 ± 0,00
Heteroptera	0,000 ± 0,000	0,000 ± 0,000	0,000 ± 0,000	0,196 ± 0,276	0,000 ± 0,000
Chironomidae	1,519 ± 0,654	1,913 ± 1,133	2,372 ± 0,736	20,307 ± 2,659	1,650 ± 0,075
Simuliidae-razem	0,122 ± 0,037	4,086 ± 4,869	0,071 ± 0,034	0,037 ± 0,013	0,135 ± 0,051
Trichoptera razem	0,011 ± 0,019	0,089 ± 0,122	0,000 ± 0,000	0,000 ± 0,000	0,028 ± 0,001
Viviparus sp.	0,000 ± 0,000	0,000 ± 0,000	0,000 ± 0,000	16,013 ± 22,646	0,000 ± 0,000
D.polymorpha	7,696 ± 2,029	2,628 ± 0,289	11,034 ± 1,901	24,355 ± 15,479	631,044 ± 240,124
Plumatella spp.	0,000 ± 0,000	0,000 ± 0,000	0,028 ± 0,003	9,809 ± 4,755	0,000 ± 0,000

Tab.4. Average biomass (± SE) of some taxa occurred on substrata in Cold Canal during investigation

The fairly low index of faunal similarity between the communities in the first and fifth year of the investigation might suggest that in the spite of the attained maturity stage the investigated zoocenosis was not stable and underwent further long-term changes with the passage of time. Nevertheless, a similarity can be found in the structure of dominance of macrofauna communities in early April and May 1997 and late April 2001 (thus, at the analogical phenological period): the groups of dominants and sub-dominants were composed to a great degree by the same taxa (*Corophium curvispinum*, Chirinomidae, Naididae, *Paludicella articulata*). Their attained a varied participation in the numbers of different communities owing to the dynamic seasonal changes occurring in this period. The quantitative structure of epifaunal taxa colonizing the substrates towards the end of April 2001 in a part agrees with these changes, i.e., decreases in the participation of *Simulium* sp. and *C. curvispinum*; the appearance of *P. articulata* in the community; and an increase in the role of Naididae observed in the period April – May 1997. The participation of these taxa in the structure of dominance in the community toward the end of April 2001 took intermediate values between their participation in the numbers of macrofauna from early April and May 1997. This can be an indirect proof of the occurrence of a constant cycle of seasonal changes. In the different years of functioning of a community it can be disturbed in analogical phenological periods by the fluctuations of environmental conditions (water temperature, abundance of the food base, amount of detritus deposited on the substrates) which affect the growth rate of some invertebrate communities on the substrates, contributing to the fluctuations of their numbers and to changes in the structure of dominance. The occurrence of a constant cycle of seasonal changes and a constant group of periodically interchanging dominants can confirm that the community reached the stage of climax observed by L. Szlauer and B. Szlauer (1999) on the substrates exposed for a couple of years in Lake Krąpsko. After that time in both investigated communities a distinct increase was noted in the role of the bivalves D. *polymorpha* which constituted the chief component of macrofauna with respect to weight and qualitative composition on the substrates in Lake Krąpsko and with respect to biomass on the substrates from the Cold Canal. Moreover, the two populations were similar with respect to the age structure with one- and two-year individuals dominating, however, in Lake Krąpsko in the population of *Dreissena* the participation of older individuals was decisively lower while at the same time the total density of fresh-water mussels was two times lower on the substrates (Szlauer-Lukaszewska 1999). In general, the age structure of D. *polymorpha* occurring in the Cold Canal in 2001 strongly approximated to that observed by Wiktor (1969) in "natural" communities of fresh-water mussel in the Szczecin Lagoon connected with the River Odra. Therefore it may be conjectured that the investigated population of fresh-water mussel was stable and completely formed. The numbers and biomass of the bivalves increasing in the five-year long period of the investigation were the most characteristic changes in the structure of the macrofauna settling the substrates from the Cold Canal.

In the aspect of the dynamic seasonal changes recorded in the first year of the investigation the appearance of the numerously represented population of *D. polymorpha* which permanently dominated in the community of epifauna with respect to biomass, can be regarded as a sign of the succession occurring here. On the basis of the presented studies it is difficult to estimate the actual effect of fresh-water mussels on quantitative and qualitative changes in the composition of macrofauna.

Bivalves can contribute to an increased heterogeneity of such microhabitats as polyethylene substrata, contributing to an increased biodiversity of species and growing numbers of invertebrates settling them (Riccardi et al. 1997). However, a significant modification of the structure of dominance in a community due to the food competition between *D. polymorpha* presenting the type K strategy and numerous opportunistic species of filtrators appearing on the substrates (bryozoan *Plumatella* spp., amphipods *Corophium curvispinum*, sponges *Spongilla* sp.) is only probable to a very low degree. The relatively high content of phytoplankton in the waters of the Regalica and the occurrence of the current in the canal ensure the affluence of the environment and hence the decisive ecological factor shaping the macrofauna community on the substrates is the competition for place.

CONCLUSIONS

1. Qualitative and quantitative structure of one- and five- year old macroinvertebrate community settling on artificial substrates submerged in the inflow canal of power plant was compared
2. Strong seasonal changes were observed in the qualitative composition, density, biomass and dominance structure of epifaunal communities in the first period of the research. The fluctuations were brought about by the intense development of species which seasonally occurred on the polyethylene sheets, such as bryozoan, some cnidarians and sponges, and also by the reproduction and migration of numerous others.
3. Nevertheless after a few months of development, the macrofauna community settling the substrates manifested the traits of the mature phase being characterized with a relatively high number of taxa, persistent density and biomass maintained up to a seasonal peak of community development.
4. Both communities (one and five year old) reached in analogical phenological period similar density and level of taxa richness, however, the faunal similarity of these communities, calculated using the modified Jaccard formula, was relatively low reaching from 9% to 18.5%. The biomass of the macrofauna community after the long-term development was about 30 times higher, than recorded in the same season in the first year of research. The main part (96%) of the above biomass composed the population of *Dreissena polymorpha*.
5. Certain similarity in the structure of dominance of macroinvertebrate communities in early April and May 1997 and late April 2001 can be an indirect proof of the occurrence of a constant cycle of seasonal changes.
6. Increase of significance of *D. polymorpha* which became permanently dominant in the older community of epifauna with respect to biomass, can be regarded as a sign of the succession occurring here. The change was expressed by an increase in *k*-strategies importance in comparison with the one-year old macroinvertebrate aggregation.

REFERENCES

BOWNIK L.J. (1970): The periphyton of the submerged macrophytes of Mikołajskie.- *Ekologia Polska* 17: 505-520, Warszawa.

COVER E.C., HARREL R.C. (1978): Sequences of colonization, diversity, biomass and productivity of macroinvertebrates on artificial substrates in freshwater canal. -*Hydrobiologia*, 50: 81-95, Brussels

BIESIADKA E. (1977): Hydracarina. In: Wróblewski A. (ed.) Bottom fauna of heated Konin Lakes.-*Mongrafie Fauny Polski*, 7: 281-350, Kraków.

GERRISH N., BRISTOW J.M. (1979): Macroinvterebrate associations with aquatic macrophythes and artificial substrates. -*Journal of Great Lakes Research* 5(1): 69-72.

JANICKI D. (2000): Zespół porośłowy tworzący się na sztucznym podłożu foliowym i jego wpływ na poprawę wybranych parametrów fizyk-chemicznych wody jeziora eutroficznego. *Doctor's thesis*. Msc. University of Szczecin, Department of Invertebrate Zoology and Limnology, 102pp.

KAMIŃSKI M. (1992): Life cycle of the freshwater bryozoan *Plumatella fungosa* (Pall.). 1. Seasonal changes in numbers and biomass. -*Acta Hydrobiologica* 34: 227-23, Kraków

KORNIJÓW R. (1989): Seasonal changes in the macrofauna living on submerged plants. *Archiv für Hydrobiologie* 117(1): 49-60, Stuttgard.

LANDSBERG - UCZCIWEK M. (ed.) (1997): Raport o stanie środowiska w województwie szczecińskim w latach 1995-1996.- *Biblioteka Monitoringu Środowiska*. Szczecin, 192pp

LANDSBERG - UCZCIWEK M. (ed.) 1999. Raport o stanie środowiska w województwie zachodniopomorskim w latach 1997-1998. -*Biblioteka Monitoringu Środowiska*. Szczecin.127pp

MIHALJEVIĆ Z., KEROVEC M., TAVČAR V., BUKVIĆ I. (1998): Macroinvertebrate community on an artificial substrate in the Sava river: long-term changes in the community structure and water quality. -*Biologia* 53/5: 611-620, Bratislava.

NIEWIADOMSKA U. (1981): Influence of the communal sewage on periphyton in the littoral of Mikołajskie Lake. –*Ekologia Polska*, 29(1): 3-33, Warszawa.

PIESIK Z., ŚWIERCZYŃSKA I., CANH T. (1991): Bezkręgowce zasiedlające bariery utworzone ze sztucznego podłoża w wodach płynących o różnym stopniu zanieczyszczenia (Inverterbrates inhabiting barriers made of artificial substrate in streams variously polluted). -*Zeszyty Naukowe AR Szczecin*, 143: 73-93, Szczecin.

RICCARDI A., WHORISKEY F.G., RASMUSSEN J.B. (1997): The role of the zebra mussel (*Dreissena polymorpha*) in structuring macroinvertebrate communities on hard substrata.- *Canadian Journal of Fisheries and Aquatic Sciences* 54: 2596-2608, Toronto.

SCHMUDE K.L., JENNINGS M.J., OTIS K.J., PIETTE R.R. (1998). Effects of habitat complexity on macroinvertebrate colonization of artificial substrates in north temperate lakes. -*Journal of North American. Benthological Society* 17 (1): 73-80

SOSZKA G. (1975): The invertebrates on submerged macrophytes in tree masurian lakes.- *Ekologia Polska* 23 (3): 371-391, Warszawa.

SZLAUER B., SZLAUER L. (1997): Organisms colonizing polythene sheets deployed in Lake Miedwie (northwestern Poland). -Acta Hydrobiolca 39: 111-119, Kraków.

SZLAUER B., SZLAUER L. (1998): Organisms colonising polyethylene sheets deployed in river Odra mouth. -*Folia Universitatis Agriculaturea. Stetinensis* 184 *Piscaria* (24): 79-90, Szczecin.

SZLAUER L., SZLAUER B. (1999): Periphyton community on polyethylene sheets after a few years of exposure in a lake. Polskie Archiwum. Hydrobiologii, 46, 3-4, 339-344, Kraków.

SZLAUER-ŁUKASZEWSKA A. (2000): Dreissena polymorpha settlement on polyethylene film and natural substrates submerged in lake Krąpsko. -*Folia Universitatis Agriculaturea. Stetinensis* 205 *Piscaria* (26): 97-102, Szczecin.

SZLAUER-ŁUKASZEWSKA A. (2007): Succession of periphyton developing on artificial substrate immersed in a polysaprobic waste water reservoir. -*Polish Journal of Environmental Studies* 16 (5): 753-762, Olsztyn

WAWRZYNIAK- WYDROWSKA B. (1996): Występowanie i biologia skorupiaków z rodzaju *Corophium* Latr. w estuarium odrzańskim. -*Doctor`s thesis* Msc. University of Szczecin, Department of Paleooceanology, 190pp.

WIKTOR J. (1969): Biologia *Dreissena polymorpha* (Pall.) i jej znaczenie w Zalewie Szczecińskim (Biology of *Dreissena polymorpha* (Pall.) and it role in the Szczecin Lagoon) -*Studia i Materiały MIR*, Gdynia, 88pp.

ZAWAL A., PIETRZAK L., WOJNIAK D. (2003): Wykorzystanie sztucznych podłoży do analizy sukcesji w izolowanych siedliskach (The use of artificial substrates for the analysis of succession in isolated habitats) . -*Acta biologica* 10: 176-197, Szczecin