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THE LIFE STRATEGY AND DYNAMICS OF SELECTED SPECIES OF PHYTO- AND ZOOPLANKTON IN A DAM RESERVOIR DURING “WET” AND “DRY” YEARS

ABSTRACT: The investigation was carried out during “dry” and “wet” (average: 478.6 mm and 624.7 mm, respectively) years in the Dobczyce Reservoir, which is located in a foothills area of southern Poland. The Reservoir covers 985 ha, has a volume of $108 \times 10^6 \text{ m}^3$, a mean depth of 11 m and an average flushing rate of 2.9 yr^{-1} . Statistical analysis (ANOVA) showed that “dry” and “wet” years differed markedly as regards hydrological variables (water flow and flushing ratio). Among the physico-chemical variables, it was the concentration of $\text{NH}_4\text{-N}$ that differed most in years of the different hydrological types. The main aim of the study was to check the life strategies and dynamics of selected species among the phyto- and zooplankton during the aforementioned “dry” and “wet” years.

The assessment centered on changes in population densities for algal species of differing life strategies according to the Reynolds' classification, particularly S-species (*Microcystis aeruginosa* (Kütz.) Kütz., *Woronichinia naegeliana* (Unger) Elenkin., R-species (*Asterionella formosa* Hass, *Cyclotella* sp.) and C/S-species (*Ceratium hirundinella* O. F. Müller) Bergh, *Cryptomonas* sp.). C species like *Chlorella*, *Rhodomonas* and *Stephanodiscus hantzschii* Grun. (in Cl. & Grunow), which were present in only small numbers, were not taken into consideration. No algal species presented any statistical differences in average population density between the studied years. Factors correlated (Pearson correlation) with the

density of algae were found to be: flow, flushing ratio, transparency, turbidity and $\text{NO}_3\text{-N}$.

Changes in the density of selected zooplankton species representing r-strategists (*Bosmina longirostris* (O. F. Müller, 1785), *Brachionus angularis* Gosse, 1851, *Pompholyx sulcata* Hudson, 1851) and K-strategists (*Daphnia cucullata* Sars, 1862, *Daphnia longispina* O. F. Müller, 1785, *Eudiaptomus gracilis* (Sars, 1863)) were also studied. The densities of *Keratella cochlearis* (Gosse, 1851) and *Mesocyclops leuckarti* (Claus, 1857) differed significantly between hydrological years. Physical environmental factors like flow, flushing ratio, transparency and turbidity were correlated with zooplankton density, as was shown by Pearson correlation coefficient.

Our investigations did not confirm the hypothesis that R (phytoplankton) and r (zooplankton) species are favored by “wet” years, while species of types S (phytoplankton) and K (zooplankton) prefer the conditions present in “dry” years. Only the two zooplankton species characterized as different strategists (i.e. the r-selected *Keratella cochlearis* and K-selected *Mesocyclops leuckarti*) responded in significantly different ways to “wet” and “dry” years.

KEY WORDS: dam reservoir, zooplankton, phytoplankton, life strategy, hydrological variables

1. INTRODUCTION

The planktonic species in dam reservoirs differ from their counterparts in natural lakes in being more vulnerable to rapidly changing environmental conditions like water level and flow. These are preferred by species that tolerate rapid changes, though in fact dam reservoirs are found to contain species representative of various different types of life strategy.

Thus, phytoplankton species are characterized by reference to the C, S or R strategy. The C-S-R strategy of the Grimm theory (Grimm 1977, 1979) replaced the old idea of the r- K strategists (after Wilson and Lee 2000) and offered a better description of the life strategy of algae. Following Reynolds (1988, 1996, 1997) and Elliott *et al.* (1999), three groups of strategists are distinguished:

1) C-species – competitive, invasive, ecological pioneers, whose cells are small with a high surface area-to-volume ratio, and which grow well at low temperatures and are characterized by a short lifespan (e.g. *Chlorella*, *Rhodomonas*, *Stephanodiscus hantzschii*).

2) S-species – stress survivors, large unicells or colonies of small cells whose motility allows them to access nutrients throughout the water column. They are slower-growing, capable of regulating their position in the water column, and resource-conserving. They are defined as *acquisitive strategists* and are favored by low resources but high energy conditions (e.g. *Gomphosphaeria*, *Microcystis*, *Oocystis*, *Sphaerocystis*). *Woronichinia naegeliana* also belongs to the S-species group (Wilk-Woźniak and Mazurkiewicz-Boroń 2003).

3) R-species maintain their growth at low light levels and are tolerant of well-mixed, poor-light environments (e.g. *Asterionella*, *Fragillaria*, *Melosira*, *Oscillatoria*). They are defined as *acclimating strategists* and are pre-adapted to maximize suspension opportunities and low irradiance values. They are favored by high-resource and low-energy conditions.

There is also a fourth group, which is intermediate between the C and S species (e.g. *Anabaena*, *Aphanizomenon*, *Ceratium*, *Cryptomonas*, *Stephanodiscus astrea* (Ehrenberg) Grunow in Cleve & Grunow).

In the case of animals, the two basic types of strategy described (by Pianka 1970, Jones 1976, Nichols *et al.* 1976, Bhatnagar 1999, Reznick *et al.* 2002) are the r- and K-strategies. These have been defined in respect to planktonic invertebrates by Ejsmont-Karabin and Węgleńska (1990).

r-strategist species are characterized by: occurrence in an unstable environment like lotic habitats with increased flow, a food suspension of higher and variable concentration, small body size, high reproductive rate, a short lifespan, a high level of mortality among young, more effective filtration allowing lower and variable concentrations of food to be utilized and lower sensitivity to injuries of the ciliary apparatus by way of suspended mineral matter carried on the water current. Rotifers (e.g. *Brachionus angularis*, *Keratella cochlearis*, *Polyarthra remata* Skorikov, 1896) and small cladocerans (e.g. *Bosmina longirostris*, *Ceriodaphnia quadrangula* (O. F. Müller, 1785)) are representatives of the r- life strategy.

K-strategist species occur in a stable environment (like stagnant waters or those with a slow water flow) with a high concentration of food. Body size is large, few offspring are produced but these have low mortality rates. The lifespan is long, and filtration is very effective, especially in the case of a high concentration of food as fine phytoplankton. Large crustaceans like *Daphnia cucullata*, *D. longispina* and *Eudiaptomus gracilis* are among zooplanktonic K- strategists.

We investigated the dynamics of phyto- and zooplankton species with different types of strategy, during “dry” years (characterized by low river inflow) and “wet” years (high inflow). We speculated that strategists of type R (phytoplankton) and r (zooplankton) should be more abundant during the “wet” years, because such conditions would favour those types of strategy. On the other hand S (phytoplankton) and K (zooplankton) species should achieve high densities during the “dry” years. Finally, C/S strategists (phytoplankton) should not show any differences in line with the different types of year.

2. STUDY AREA

Located in mountain foothills, the Dobczyce Reservoir (at 49°52' N, 20°02' E) was built 60 km along the Raba River (total length 137.4 km – a right-bank tributary of the Vistula), about 30 km south of Kraków (Fig. 1). At the standard damming level (269.9 m a.s.l.), the surface area is 985 ha, the volume $108 \times 10^6 \text{ m}^3$, the mean depth 11 m and the maximum depth about 27 m (Amirowicz 1998). The water level may fluctuate over the altitudinal range 256.7 to 272.6 m, corresponding to a change in area from 387 to 1112 ha and in volume from 18.3 to $137 \times 10^6 \text{ m}^3$. The catchment area is of 763 km² (Pasternak 1980). The Raba River is the main feeder of the reservoir, supplying 89% of total inflow (Mazurkiewicz 1988). In line with an annual average discharge of about $10 \text{ m}^3 \text{ s}^{-1}$ (Punzet 1969), the average flushing rate is of approximately 2.9 yr^{-1} . The reservoir is a dimictic type, stratifying between May and September, and Secchi-disc visibility ranges between 0.3 m (in spring) and 5.7 m (in autumn), (Amirowicz 2000).

The trophic state of the reservoir is meso-eutrophic (Bednarz 2000).

This reservoir was built on the foothills river whose valley is V-shaped (with steep slopes). Consequently, the shores of the reservoir are also sharp and the littoral zone is very poorly developed. The fish community in the epilimnion consists of common bream, roach, silver bream, bleak, chub, silver carp, bighead carp, perch and pike perch, and lake trout. The roach, bream and bleak account for 95% of the total density of fish (Amirowicz *et al.* 2000).

3. MATERIALS AND METHODS

Samples for phyto- and zooplankton analysis were collected from the epilimnion, in the central and deepest part of the Dobczyce Reservoir. Fifty-four samples were collected during the “wet” years (1996, 1997, 1998) (rainfall: 654.0; 689.3; 531.1mm, respectively) and 45 during the “dry” years (1994, 1995, 2000) (rainfall: 535.7; 409.6; 489.5 mm, respectively). Samples were collected biweekly in the years 1994–98, only

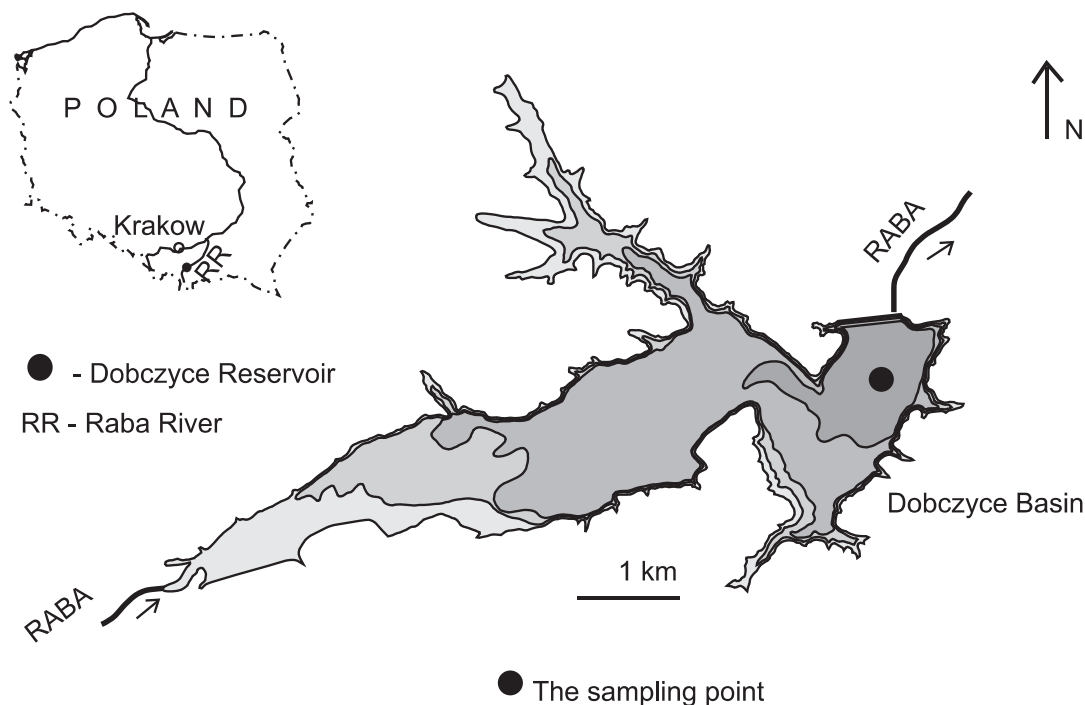


Fig. 1. Location of the Dobczyce reservoir (southern Poland) and a map with the sampling point.

monthly in 2000, sampling being done in the upper (0–2m) layers between April and October. The parameters measured were: transparency, turbidity, TP, N-NH₄⁺ and N-NO₃. The physico-chemical parameters were determined according to APHA (1992) and Hermanowicz *et al.* (1976).

The samples used in the taxonomic and quantitative analyses of algae were preserved with Lugol's solution and concentrated to 25 ml by sedimentation from 1 L. Cyanoprokaryotes and eukaryotic algae were counted using a chamber of 0.4 mm height and 22 mm diameter. For further analysis the dominant species were selected from among those with high frequency (presence in 80–100% samples). These were: S-species – *Microcystis aeruginosa*, *Woronichinia naegeliana*; R-species – *Cyclotella* spp., *Asterionella formosa*; C/S species – *Cryptomonas* spp., *Ceratium hirundinella*. C-species were not taken into consideration because they were neither abundant nor frequent during the years of the investigation.

Zooplankton samples were taken from the same station and at the same intervals as phytoplankton. Samples for taxonomic and quantitative analyses were collected using a 5-L sampler. The samples were concentrated with a plankton net (# 50 µm) and treated with a 4% formalin solution, after which subsamples were analyzed under a microscope (magnification 10–20×) in 0.5 ml chambers. The taxonomic and numerical analyses of zooplankton were elaborated following the methods used in previous hydrobiological studies (Starmach 1955, Hillbricht-Ilkowska and Patalas 1967, Pociecha and Wilk-Woźniak 2000).

For the purpose of analyses, two groups of zooplankton species were chosen. r-strategist rotifers like *Brachionus angularis*, *Keratella cochlearis* and *Pompholyx sulcata*, and cladocerans like *Bosmina longirostris*. Selected as K-strategists were the cladocerans – *Daphnia cucullata* and *Daphnia longispina*, and copepods like *Eudiaptomus gracilis* and *Mesocyclops leuckarti*.

ANOVA was used to indicate differences between the population densities of selected species of phytoplankton and zooplankton, as well as between the hydrological and physico-chemical properties of water in “wet” and “dry” years. The data were transformed logarithmically to obtain homogenous variance. Statistical calculations were carried out using the program SPSS for Windows Version 11.5.0.

The program Statistica 5.0 (Pearson coefficient correlation) was also used for statistical analyses.

4. RESULTS

The “wet” years were characterized by high mean annual inflow and high annual discharge, and the “dry” years – by low mean annual inflow and low annual discharge. The statistical analysis ANOVA revealed significant differences between “dry” and “wet” years in terms of water flow and flushing ratio (Table 1). During the “dry” years, the highest monthly average inflow took place in the spring and beginning of summer (except in 2000 when it was observed in July). During the “wet” years, the highest monthly average inflow took place during the summer and late autumn, but was not observed in

Table 1. Hydrological parameters (April–October) of river supplying Dobczyce Reservoir (Raba River) in the “dry” and “wet” years and their statistical (ANOVA) significance (N = 21 for “dry” years and N = 21 for “wet” years).

Parameter	“Dry” years				“Wet” years			Mean ± SD	P
	1994	1995	2000	Mean ± SD	1996	1997	1998		
Average annual flow (m ³ s ⁻¹)	8.10	10.07	9.61	9.26 ± 8.84	20.00	20.17	12.60	17.57 ± 14.76	<0.01
Annual volume of flow (mln m ³)	99.21	102.38	98.53	100.04 ± 0.14	106.80	102.90	97.35	102.33 ± 9.95	ns
Flushing ratio (y ⁻¹) *	0.92	1.14	1.12	1.06 ± 0.96	2.20	2.29	1.51	2.00 ± 1.55	<0.01

* according to Amirowicz (1998), ns – not significant

springtime. As a consequence of high or low annual discharges, the chemical parameter ($\text{NH}_4^+\text{-N}$) differed in particular years – as the ANOVA was able to demonstrate (Table 2).

While there were no significant differences in phytoplankton average annual densities between “dry” and “wet” years (Table 3),

such difference were noted for zooplankton (Table 4). The species whose densities differed significantly were: *Keratella chochlearis* (r-strategy) and *Mesocyclops leuckarti* (K-strategy).

Pearson correlations coefficients between the density of species and physico-chemical

Table 2. Average annual (April–October) values for selected chemical parameters in the Dobczyce reservoir during the investigated years and their statistical (ANOVA) significance (N = 45 for “dry” years and N = 54 for “wet” years).

Parameter	“Dry” years				“Wet” years				P
	1994	1995	2000	Mean ± SD	1996	1997	1998	Mean ± SD	
Transparency (m)	2.07	2.15	2.80	2.34 ± 0.92	1.64	1.62	2.42	1.89 ± 0.75	ns
Turbidity (mg dm^{-3})	4.66	4.71	4.06	4.48 ± 1.90	5.22	5.61	4.61	5.15 ± 1.51	ns
TP (mg dm^{-3})	0.003	0.023	0.063	0.029 ± 0.027	0.020	0.019	0.023	0.021 ± 0.011	ns
N- NH_4 (mg dm^{-3})	0.251	0.322	0.447	0.34 ± 0.095	0.275	0.281	0.293	0.283 ± 0.041	<0.05
N- NO_3 (mg dm^{-3})	1.148	1.229	1.012	1.13 ± 0.43	1.465	1.277	1.186	1.31 ± 0.314	ns

ns – not significant

Table 3. Average annual (April–October) density (ind. l^{-1}) of phytoplankton species of different life strategies (R, C/S, S see text) and their statistical (ANOVA) significance (N = 45 for “dry” years and N = 54 for “wet” years) between “dry” and “wet” years.

		“Dry” years Mean ± SD	“Wet” years Mean ± SD	P
R-species	<i>Asterionella formosa</i>	369.5 ± 516.0	224.1 ± 414.1	ns
	<i>Cyclotella</i> sp. div.	724.7 ± 1343.7	430.1 ± 613.9	ns
C/S-species	<i>Ceratium hirundinella</i>	36.1 ± 56.1	10.9 ± 13.9	ns
	<i>Cryptomonas</i> sp. div.	316.4 ± 377.3	289.7 ± 220.0	ns
S-species	<i>Microcystis aeruginosa</i>	3.0 ± 8.5	4.3 ± 8.7	ns
	<i>Woronichinia naegeliana</i>	4.7 ± 10.1	5.4 ± 7.7	ns

ns – not significant

Table 4. Average annual (April–October) density (ind. l^{-1}) of zooplankton species of different life strategies (r, K) and their statistical (ANOVA) significance (N = 45 for “dry” years and N = 54 for “wet” years) between “dry” and “wet” years.

		“Dry” years Mean ± SD	“Wet” years Mean ± SD	P
r-species	<i>Brachionus angularis</i>	20.6 ± 44.2	3.6 ± 8.1	ns
	<i>Keratella chochlearis</i>	65.2 ± 69.4	19.2 ± 24.0	<0.01
	<i>Pompholyx sulcata</i>	54.1 ± 85.1	43.1 ± 54.0	ns
	<i>Bosmina longirostris</i>	36.1 ± 54.4	16.9 ± 16.1	ns
K-species	<i>Daphnia cuculatta</i>	44.5 ± 41.6	38.3 ± 36.8	ns
	<i>Daphnia longispina</i>	17.5 ± 19.0	11.1 ± 9.0	ns
	<i>Eudiaptomus gracilis</i>	9.4 ± 7.4	10.0 ± 8.2	ns
	<i>Mesocyclops leuckarti</i>	10.3 ± 6.5	5.3 ± 6.5	<0.05

ns – not significant

Table 5. Significant correlation coefficients between the density of phyto-, zooplankton species and hydrological parameters and NO₃-N concentration during “dry” (D) and “wet” years (W) (* – $P < 0.05$, ** – $P < 0.01$, *** – $P < 0.001$, ns – not significant). R, S, S/S, r, K – types of life-strategy (see text).

	Flow		Flushing ratio		Transparency		Turbidity		NO ₃ -N	
	D	W	D	W	D	W	D	W	D	W
Phytoplankton										
<i>Cyclotella</i> sp. (R)	0.49*	ns	0.47*	ns	0.55*	ns	0.78***	ns	0.51*	0.47*
<i>Woronichinia naegeliana</i> (S)	ns	ns	ns	ns	ns	ns	ns	ns	-0.48*	ns
<i>Ceratium hirundinella</i> (C/S)	ns	0.58**	ns	0.57**	ns	ns	ns	ns	-0.49*	ns
Zooplankton										
<i>Brachionus angularis</i> (r)	ns	ns	ns	ns	ns	0.47*	ns	ns	ns	ns
<i>Keratella cochlearis</i> (r)	-0.53*	ns	-0.53*	ns	ns	ns	ns	ns	ns	ns
<i>Pompholyx sulcata</i> (r)	-0.46*	ns	-0.47*	ns	ns	ns	ns	ns	ns	ns
<i>Daphnia cucullata</i> (K)	ns	ns	ns	ns	ns	ns	-0.44*	ns	ns	ns
<i>Daphnia longispina</i> (K)	ns	ns	ns	ns	ns	0.51*	ns	ns	ns	ns

parameters revealed more significant relationships in “dry” than “wet” years (Table 5).

A positive correlation was revealed for the density of the *Cyclotella* population during “dry” years and for *Ceratium hirundinella* during “wet” years. *C. hirundinella* showed a positive correlation with flow and flushing ratio during “wet” years. *Cyclotella* correlated positively (in hydrological years of both types), with NO₃-N a very strong correlation with transparency and turbidity during “dry” ones, whereas *Woronichinia naegeliana* and *C. hirundinella* correlated negatively with NO₃-N and only during “dry” years (Table 5).

Among the zooplankton species, only the density of *Brachionus angularis* and *Daphnia longispina* correlated positively with transparency during “wet” years. During “dry” ones, *Keratella cochlearis* and *Pompholyx sulcata* correlated negatively with flow and flushing ratio. *Daphnia cucullata* correlated negatively with turbidity during the “dry” years.

5. DISCUSSION

Hydrological variables are important fac-

tors influencing the life strategies of planktonic organisms in dam reservoirs, e.g. as regards development and mortality (Pocięcha and Wilk-Woźniak 2000, 2003). Our investigation showed that hydrological parameters such as water flow and flushing ratio differed significantly in relation to whether years were of the ‘dry’ or ‘wet’ types. However, physical parameters are joined with chemical ones in its effect on planktonic organisms (Sommer *et al.* 1986). This study revealed that NH₄⁺-N concentration was the most important factor. The importance of nitrogen in the functioning of the Dobczyce Reservoir refer also to the studies of other authors, its importance being shown to relate to agriculture in the basin (Mazurkiewicz-Boroń 2000, 2002).

Among the phytoplankton species, the R-strategist *Cyclotella* sp. showed correlation with flow of water (but only during “dry” years), and positive correlation with nitrate-nitrogen in both hydrological periods. The same strong dependence of *Cyclotella* and spring plankton assemblages on NO₃-N was noted in the Dobczyce Reservoir dur-

ing the years 1992–1995 (Wilk-Woźniak and Kosiński 2001). Another R-strategist species – *Asterionella formosa* – showed no relationship with physico-chemical parameters. However, in earlier studies *Asterionella* populations had been found to relate to water temperatures (Wilk-Woźniak and Kosiński 2001, Bertrand *et al.* 2003).

Neither of the S-species (*Microcystis aeruginosa* or *Woronichinia naegeliana*) showed differences in population density in the different years. The lack of significant differences in the population densities of S-species, in years differing in their hydrological conditions, might be explained by reference to the ‘plasticity’ of different algal species, e.g. *Microcystis*. Reynolds (1997) showed that, as the diameter of large and spherical colonies decreases, *Microcystis* moves from a ‘more S’ to a definitely ‘S’ strategy. As they tend to become narrower and the proportionality between their maximal linear dimension and width increases, they also exhibit a shift toward the R-strategy. *Microcystis* colonies were smaller during the “wet” years than during the “dry” ones (Wilk-Woźniak unpub. data). We speculated that, for example, *Microcystis* becomes more S-strategist during the “dry” years, but is only a ‘weaker’ S-strategist, or even an R-strategist, during ‘wet’ ones. *Microcystis* did not show any relationship with physico-chemical variables, but the population density of *Woronichinia* was seen to correlate negatively with the concentration of nitrate nitrogen during the “dry” years. This relationship was confirmed during autumnal *Woronichinia* blooms. The highest density of this species was noted when river-flows were lowest and $\text{NO}_3\text{-N}$ had been depleted by eukaryotic algae that had developed before (Wilk-Woźniak 1998, Wilk-Woźniak and Mazurkiewicz-Boroń 2003). $\text{NH}_4^+\text{-N}$ was probably a source of nitrogen for *Woronichinia* (Pociecha and Wilk-Woźniak 2003) because, as authors like Blomquist *et al.* (1994) have shown, non-fixing cyanoprokaryotes are favored where ammonium-nitrogen is present.

The C/S species showed quite different dynamics to each other. *Cryptomonas* density was not found to be related to environmental variables, whereas *Ceratium hirundinella*

showed negative correlations with concentration of $\text{NO}_3\text{-N}$ during “dry” years. This species can also develop in reservoirs with lower nutrient concentrations (Naselli-Flores and Barone 2003, Salmaso 2003). *Cryptomonas* and *Ceratium* are mixotrophs, which is to say that they can use optional sources of food. Genus *Cryptomonas* can make efficient use of nitrogen and phosphorus from bacterial cells under conditions of mineral-nutrient depletion (Urabe *et al.* 2000). It might be useful to explain why these species show features of the C and/or S strategies, and why they are difficult to classify into one group.

We were unable to observe any statistically significant differences between densities of population of the algal species and the hydrological type of year. However, some hydrological parameters were important to the algae dynamics. There were more correlations for algal species during “dry” years than “wet” ones. Does this mean that “dry” conditions are more difficult than “wet” ones? What was surprising was the failure to observe clear correlations between R and C species during “wet” years, or S and C/S species during “dry” years. However, *Cyclotella* did show the expected relationships of an R-species with water flow, flushing ratio, transparency, turbidity and nutrient concentration.

Where zooplankton population density was concerned, the two species presented significant differences in population density between “dry” and “wet” years, notwithstanding the fact that *Keratella cochlearis* and *Mesocyclops leuckarti* are an r- and a K-strategist respectively. For planktonic invertebrates the hydrological and physical factors like water flow, flushing ratio, transparency and turbidity appeared to be important. These are the factors that might be responsible for destroying zooplankton communities or for washing them out. A high mortality of zooplankton may also result from mechanical damage to the filtering apparatus. Mineral suspension carried into a reservoir first of all eliminates cladoceran species that are known to be the most efficient filtrators (Wróbel and Wójcik 1990). This was confirmed by the negative correlation between the density of the *Daphnia cucullata* and turbidity. We observed a positive correlation between the density of

Daphnia longispina and water transparency during “wet” years, showing that *Daphnia* prefer more ‘transparent’ water – a rarer situation during “wet” years than “dry” ones.

An increase in the amount of suspended matter (following violent inflow) had a stimulating effect upon rotifers (Żurek 1982, Ejsmont-Karabin and Węgleńska 1990), especially during the “wet” years. Pociecha and Wilk-Woźniak (2000) and Godlewska *et al.* (2003) observed the same situations after a flood or the passage of peak high water, in that zooplankton communities appeared to have a high proportion of Rotatoria. Short-lived species of the r-strategist kind could be promoted by frequent disturbance (Ejsmont-Karabin and Węgleńska 1990, Gliwicz 2003). However, these studies did not reveal a dependence of r-strategists upon flow or turbidity. Indeed, they showed quite the opposite phenomenon, whereby r-strategists (*Keratella cochlearis*, *Pompholyx sulcata*) correlated negatively with water flow and flushing ratio only during “dry” years.

It should be pointed out that the density of K-strategist might reflect, not only changes of hydrological parameters, but also of fish predation. Pociecha and Amirowicz (2003) showed that, in general, the impact of fish on the cladocerans and copepods of the Dobczyce Reservoir is rather a severe one.

Previous studies have documented that turbid waters can protect large-bodied *Daphnia*, against predation by visually-oriented planktivorous fish (Gliwicz 2003). On the other hand, an increased amount of suspended mineral particles contributes to mechanical damage of the filtration apparatus and even to the extinction of large-body cladocerans. The hydrological effect of a river in flood on large crustaceans like *Daphnia longispina* can enhance the already high mortality among these animals and cause them to wash out of the reservoir environment (Pociecha 2002).

Our investigations did not confirm the hypothesis that R (phytoplankton) and r (zooplankton) species are favored by “wet” years, while species of types S (phytoplankton) and K (zooplankton) prefer the conditions present in “dry” years. Only the two zooplankton species characterized as different strategists

(i.e. the r-selected *Keratella cochlearis* and K-selected *Mesocyclops leuckarti*) responded in significantly different ways to “wet” and “dry” years. Among the phytoplankton no species at all presented these differences; it can be accounted for the very short life cycles of algal species.

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