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An attempt at estimating the trophic role of birds during formation of the ecosystem of the Dobczyce Reservoir (basin of the River Vistula, southern Poland)

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Abstract — In 1987, 33 species of bird connected with an aquatic environment were observed at the Dobczyce Dam Reservoir, of which 3 were dominant (*Podiceps cristatus*, *Anas platyrhynchos*, and *Larus ridibundus*). Small numbers of birds were noted. The density of birds in various sectors of the reservoir varied. The amounts of energy and food consumed by the birds during the year were estimated.

Key words: dam reservoirs, waters birds, density, food consumption.

1. Introduction

Owing to their high metabolic rate, water birds are an important link in the trophic chain and they considerably accelerate the cycling of nitrogen and phosphorus in the ecosystem. Some species feed on water bodies but they may nest far from them (e.g. herons), others feed partially beyond them but nest in their direct vicinity (e.g. gulls). Such conditions cause water birds to take up organic matter from the water body but at some time provide it with nutrients in the form of excrements originating from food taken elsewhere. Hence, they are one of the elements starting the chain of cycling the organic matter in water bodies (Dobrowolski 1973). Not without importance also is their role in transporting parasites infecting fish. Nevertheless, birds are often neglected in hydrobiological investigations. In order to obtain a full picture of the relationships between the lements of an ecosystem, it is essential to recognize the role they play. Dobrowolski (1957)

pointed out the necessity of carrying out such investigations. The amount they consume may be a measure of the trophic role of birds. To estimate the consumption of food by water birds in the water body, the following elements should be recognized:

— the species composition of the community and its structure (morphoecological types),
— the annual dynamics of dominant species,
— the spatial distribution of dominant species,
— the quantity and kind of food of dominant species.

The aim of the present work was to estimate in a general way the role of birds at the new dam reservoir at Dobczyce in 1987, that is to say in the second year of its being filled.

2. Study area

The investigations were carried out at the Dobczyce Dam Reservoir built in 1986. It was erected on the River Raba between Myślenice and Dobczyce, about 25 km south of Kraków. In 1987 the reservoir was in the process of being filled and its surface extended from 455 ha to 973 ha while the mean depth increased from 5.4 m to 11.0 m during the year. The rise in the water level during the year was the cause of variability in the environment. The reservoir has steep banks, more than 40% of its shoreline having a gradient exceeding 40 degrees. Shallow bays and shallows constitute only a small area. In 1987, places with a depth of less than 1 m occupied under 10% of area of the reservoir.

3. Material and methods

Quantitative observations were carried out from the shore at least once a month, in the morning on cloudless, dry days, using 10 × 50 field glasses and a 40 × 60 telescope. The numbers of birds in larger flocks were estimated. The flocks of diving birds were counted at least three times, and the highest value found was recorded. Only birds living in an aquatic environment were considered in the work (according to the classification of Ferens and Wasilewski (1977)).

Taking into account changes in the numbers of birds during the year, the following phenological periods were conventionally distinguished:

I. spring migration (March-April; 60 days),
II. breeding period (May-July; 90 days),

III. early autumn migration (August-September; 60 days),
IV. late autumn migration (October-December; 90 days).

For further generalizations and calculations, the numbers of birds from actual counting were averaged in phenological periods. These averages should be accepted as estimates, since changes in the numbers of birds with time, particularly in periods of passage, are great.

Considering environmental differences, the Dobczyce Dam Reservoir was divided in 4 sectors (fig. 1):

1. the Dobczyce basin (narrow littoral area, steep banks prevail),
2. the Myślenice basin:
   a) the main sector (narrow littoral area, steep banks prevail),
   b) the backwaters (wide littoral area, flat banks),
3. the Wolnica Bay (wide littoral area, flat banks).

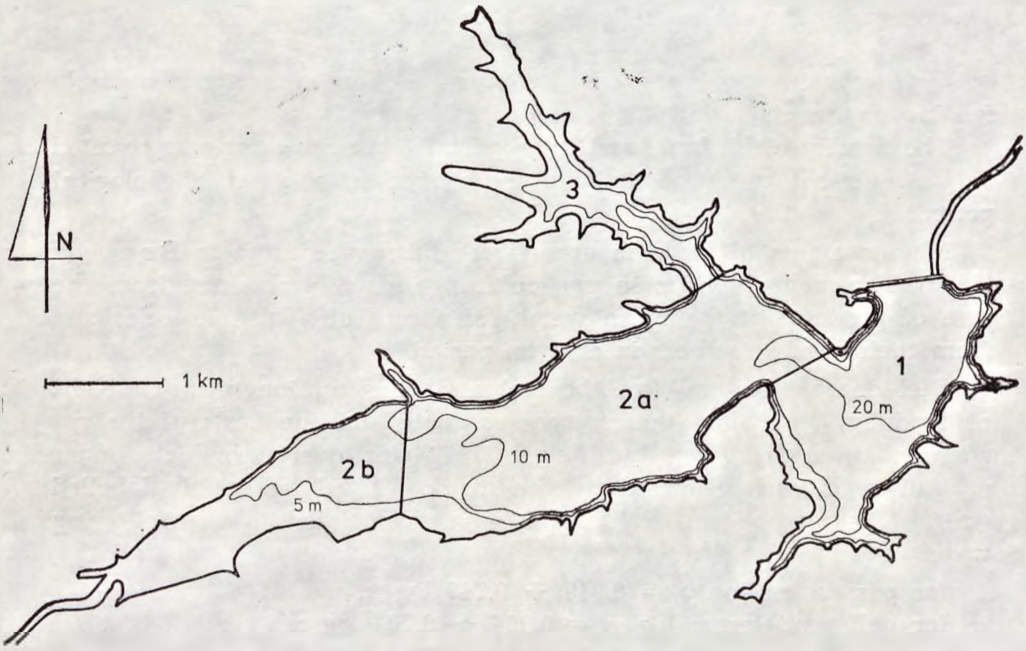

Fig. 1. The Dobczyce Reservoir divided into sectors (state of December 1987): 1 — the Dobczyce basin; the Myślenice basin: 2a — main sector; 2b — back waters; 3 — the Wolnica Bay

Table I presents mean areas and depths of particular sectors of the reservoir in phenological periods. The division into morphoecological types was taken according to Dobrowolski (1973).

On account of the different kinds of food, the following groups of birds were distinguished: ichthyophagous (mainly feeding on fish), phytophagous (feeding mostly on plants), benthophagous (mainly feeding

Table I. Average area (ha) and in parantheses depth (m) of sectors of Dobczyce Reservoir in phenological periods of 1987. 1 — Dobczyce basin; Myślenice basin: 2a — main sector, 2b — backwaters; 3 — Wolnicąa bay

Phenological periods	Sectors of reservoir			
	1	2a	2b	3
Spring migration	202.7	292.4	0	10.1
	(9.3)	(3.6)	(0)	(1.0)
Breeding period	227.6	372.5	40.4	37.0
	(12.4)	(6.9)	(1.4)	(2.9)
Early autumn migration	239 2	387.3	90.7	58.4
	(13.9)	(8.8)	(2.2)	(3 6)
Late autumn migration	253 5	406.8	146.6	92 6
	(15.7)	(10.9)	(3.5)	(4.4)

on invertebrates), polyphagous (omnivorous), entomophagous (mainly feeding on insects).

The density of birds in particular parts of the reservoir was counted as the quotient of numbers by a mean area in a given phenological period.

Mean weights of birds in gram were taken according to B r o u g h (1983). The mean biomass in particular periods was obtained from the sum of products of the mean weight of a bird of a given species and from their mean numbers in a given period.

Diel energy demand (metabolism) and consumption of dry weight of food by particular species were estimated on the basis of the regression equations given by N a g y (1987) for energy budgets under natural conditions measured by the method based on doubly labelled water. The metabolism in kJ 24 h^{-1} was calculated in the following way:

for passerines: $\log y = 0.949 + 0.749 \log x$,

for gulls and terns: $\log y = 0.904 + 0.704 \log x$,

for the remaining species: $\log y = 0.681 + 0.749 \log x$,

where:

y — metabolism,

x — body weight.

The amount of energy taken by a given species from the reservoir in the distinguished periods was counted as the product of the diel energy demand of a given species, its average numbers in a given period, and of the number of days in the period. The sum of products for all the observed species gave the amount of energy taken by the birds during the year.

The amount of food consumed during twenty-four hours in grams of dry weight was calculated as follows:

for passerines: $\log y = -0.400 + 0.850 \log x$,

for gulls and terns: $\log y = -0.306 + 0.704 \log x$,

for remaining species: $\log y = -0.521 + 0.751 \log x$,

where:

y — amount of food,

x — body weight.

The amount of food taken by a species in the distinguished periods was calculated by multiplying the amount taken during twenty-four hours by the mean numbers of a species in a given period and the number of days in the period. The sum of products gave the amount of food taken by the birds from the reservoir during the year.

On the basis of the data of Dobrowolski (1973) it was assumed that the daily food demand for the great crested grebe is 200 g, and for the mallard 150 g. Glutz (1982) states that the daily amount of food of the black headed gull ranges from 70 to 225 g. Because of the lack of more accurate data 100 g value was accepted. The food of the great crested grebe consists of 80% fish and 20% invertebrates (Sokołowski 1967) and that of the mallard of 80% plants and 20% invertebrates, (Dobrowolski 1973), while that of the black headed gull is composed of 90% inwertebrates and 10% plants (Ferens, Wasilewski 1977).

The quantity of food taken from the reservoir in the particular periods of the vegetation season, when divided into kinds of food, was counted as the product of the amount of a given kind of food, daily consumed by a given species of its average numbers in the phenological period and the number of days of the period.

The calculations of quantities of energy and food consumed by birds from the reservoir are estimated and indicate only the order of magnitude.

4. Results

In 1987, 33 species of bird associated with an aquatic environment were recorded at the Dobczyce Reservoir (Table II). *Podiceps cristatus*, *Anas platyrhynchos*, and *Larus ridibundus* decidedly dominated and constituted from 71 to 90% of the whole group, depending on the season. Figure 2 shows the numbers of those species in the annual cycle. The density of birds in various phenological periods and various parts of the reservoir was not identical. The highest average density was found in the early autumn period (8.9 indiv. · 10 ha^{-1}), and the lowest in the breeding season (4.0 indiv. · 10 ha^{-1}). Higher density than

Table II. Numbers of species observed at Dobczyce Reservoir in phenological periods of 1987. I — spring migration; II — breeding period; III — early autumn migration; IV — late autumn migration. + — report by third person concerning occurrence of species

No	Species	Phenological periods			
		I	II	III	IV
1	Gavia arctica				5
2	Gavia stellata				1
3	Podiceps cristatus	13.0	47.8	142.3	45.0
4	Podiceps griseigena	0.5			4.2
5	Podiceps nigricollis				5.0
6	Tachybaptus ruficollis	1.5		0.7	0.5
7	Ardea cinerea		0.8	14.0	
8	Ciconia ciconia		2.8		
9	Ciconia nigra	+			
10	Cygnus olor	1	0.8	1.3	1.5
11	Anas platyrhynchos	96.0	41.5	361.7	465.5
12	Anas querquedula	1.0	1.0		
13	Anas clypeata	1.0			
14	Aythya ferina	29.0	3.0	0.3	17.8
15	Aythya nyroca			1.3	1.5
16	Aythya fuligula	29.5	30.2	1.3	11.2
17	Bucephala clangula	3.5			
18	Clangula hyemalis				0.3
19	Mergus merganser	1.0			
20	Pandion haliaetus			0.3	
21	Gallinula chloropus			1.0	
22	Fulica atra	2.0		37.0	29.8
23	Charadrius dubius		0.5		
24	Vanellus vanellus	11.5	16.5	1.3	
25	Actitis hypoleucos	1.5	7.2	2.7	
26	Tringa ochropus			0.7	
27	Tringa totanus		0.5		
28	Larus ridibundus	207.0	101.8	113.3	183.8
29	Larus canus				2.0
30	Larus argentatus				2.0
31	Chlidonias nigra		+		
32	Sterna hirundo	1.0	16.0	12.0	
33	Emberiza schoeniclus		1.0		
	Total	400.0	271.4	691.2	775.3

in other parts of the reservoir (fig. 3) was recorded in backwaters and in the Wolnica bay. The highest density of *Podiceps cristatus* was recorded in backwaters in the early autumn (7.8 indiv. · 10 ha^{-1}) and *Anas platyrhynchos* in the Wolnica bay in the late autumn (11.7 indiv. · · 10 ha^{-1}). *Larus ridibundus* reached its highest numbers in the Wolnica bay in the arly autumn (9.5 indiv. · 10^{-1}). *Podiceps cristatus* was

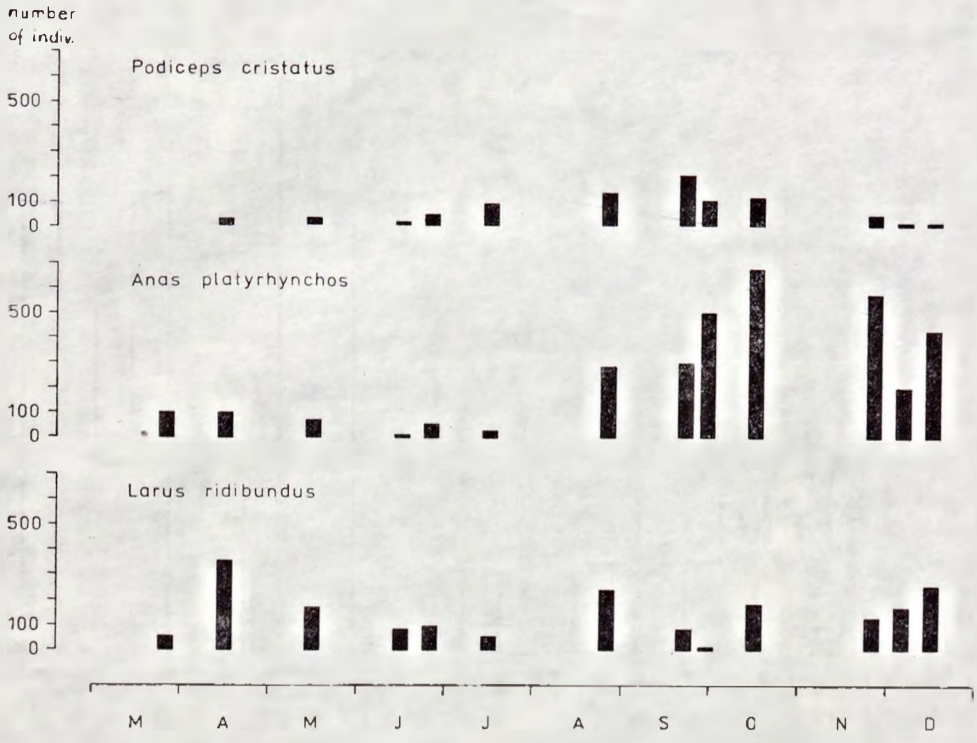

Fig. 2. Number of species dominating at the Dobczyce Reservoir in the period March to December 1987

found to be a species spaced fairly uniformly over the whole reservoir, while *Anas platyrhynchos* and *Larus ridibundus*, reach a much higher density in shallower places with a flat shore than in the deep open water zone.

18 species of swimmer, 8 of semiaquatic wader, 6 of flight feeders, and 1 species of bush and tree creeper were found at the Dobczyce Reservoir. The most numerous, 9 species each, were ichthyophagous and entomophagous (Table III).

In all seasons, phytophages were characterized by the highest biomass (from 53.2 to 540.0 kg). In the early autumn season ichtyophagous reached a comparatively high biomass (163.8 kg). Birds feeding on animals constituted from 21% of the biomass of the community in the late autumn migration season (140.8 kg) to 69% in the breeding season (116.8 kg).

The average weights of birds, diel energy demand and consumption of dry weight of food by the species observed at the Dobczyce Reservoir in 1987 are given in Table III. The sum of energy taken in food by water birds from the reservoir in the period March to December were

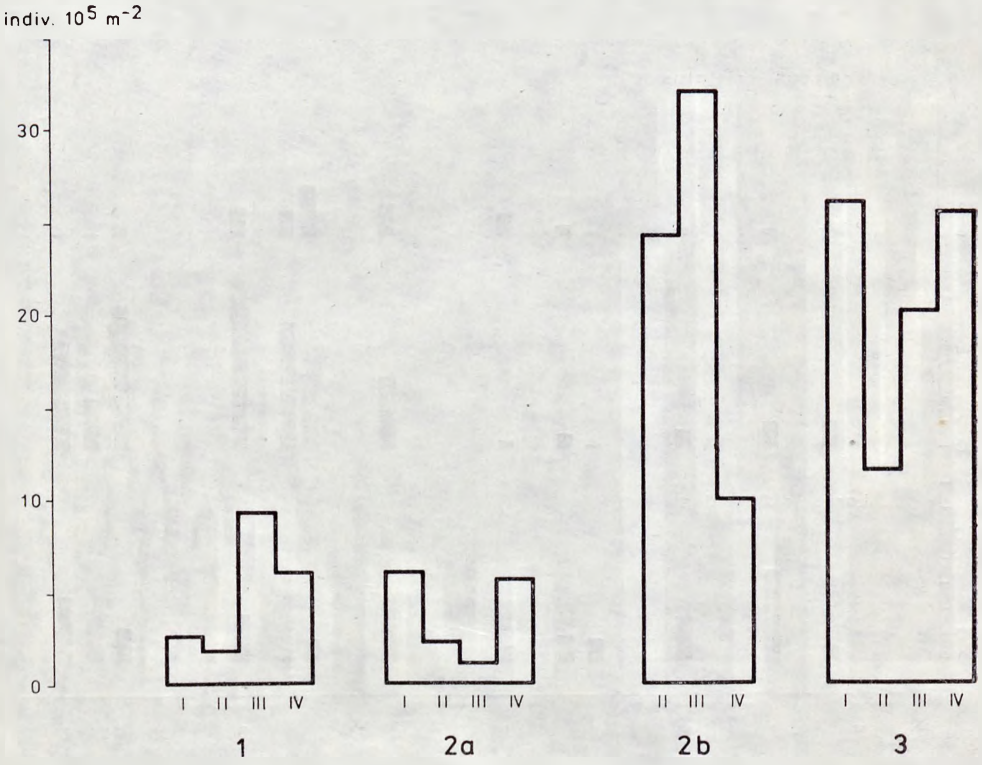

Fig. 3. Density of water birds in sectors of the Dobczyce Reserrvoir (1—3) in various phenological periods: I — spring migration; II — breeding period; III — early autumn migration; IV — late autumn migration. The remaining explanations as for fig. 1

estimated as about $115 \cdot 10^3$ MJ. Birds took from the reservoir about 7330 kg of dry weight of food.

It was estimated that the dominant species (*Podiceps cristatus*, *Anas platyrhynchos*, and *Larus ridibundus*) took from the reservoir about 2827 kg of fish (3.9 kg ha^{-1}), about 7818 kg of invertebrates (10.7 kg ha^{-1}), and about 10 222 kg of plants (14.0 kg ha^{-1}). The greatest pressure on fish was found in the backwaters of the reservoir (10.8 kg ha^{-1}) and on invertebrates and plants in the Wolnica Bay (27.2 kg ha^{-1} and 34.3 kg ha^{-1} respectively).

5. Discussion

In 1987, the numbers of birds at the Dobczyce Reservoir were low (from 271 to 775 specimens, depending on the phenological period), this being connected with the lack of convenient nests and feeding

Table III. Morphoecological type, food group, average weight, daily metabolism, and food consumption of bird species occurring at Dobczyce Reservoir 1 — swimmers, 2 — semiaquatic waders, 3 — flight feeders, 4 — bush and tree creepers; I — ichthyophagous, F — phytophagous, B — benthophagous, P — polyphagous, E — entomophagous

No	Species	Type	Group	Weight g	Metabolism kJ $24h^{-1}$	Consumption g $24h^{-1}$
1	Gavia arctica	1	I	2340	1691.6	102.2
2	Gavia stellata	1	I	1540	1170.7	74.6
3	Podiceps cristatus	1	I	990	840.9	53.5
4	Podiceps griseigena	1	I	760	689.8	43.9
5	Podiceps nigricollis	1	E	325	365.1	23.2
6	Tachybaptus ruficollis	1	E	190	244.2	15.5
7	Ardea cinerea	2	I	1500	1147.9	73.2
8	Ciconia ciconia	2	P	3400	2118.7	135.3
9	Ciconia nigra	2	I	3000	1929.1	123.1
10	Cygnus olor	1	F	10000	4753.4	304.1
11	Anas platyrhynchos	1	F	1080	897.5	57.2
12	Anas querquedula	1	F	385	414.5	26.3
13	Anas clypeata	1	F	600	577.9	36.8
14	Aythya ferina	1	B	950	756.7	48.2
15	Aythya nyroca	1	B	570	556.1	35.4
16	Aythya fuligula	1	B	740	676.2	43.0
17	Bucephala clangula	1	B	830	736.9	46.9
18	Clangula hyemalis	1	B	720	669.3	42.6
19	Mergus merganser	1	I	1450	1119.1	71.3
20	Pandion haliaetus	3	I	1525	1162.2	74.1
21	Gallinula chloropus	1	F	300	343.8	21.8
22	Fulica atra	1	F	745	679.6	43.3
23	Charadrius dubius	2	E	38	73.2	4.6
24	Vanellus vanellus	2	E	215	267.9	17.0
25	Actitis hypoleucos	2	E	44.5	82.3	5.2
26	Tringa ochropus	2	E	82.1	130.3	8.3
27	Tringa totanus	2	E	130	183.8	11.7
28	Larus ridibundus	3	P	275	418.1	25.8
29	Larus canus	3	P	420	563.3	34.7
30	Larus argentatus	3	P	1020	1052.1	64.9
31	Chlidonias nigra	3	E	65	151.5	9.3
32	Sterna hirundo	3	I	120	233.2	14.4
33	Emberiza schoeniclus	4	E	19.4	82.0	5.0

grounds (few shallows and areas covered with emergent vegetation) and with variability of environment (constant rise in water level). In shallow places with flat banks the density of birds was to about 30 times greater than those in the deep open water zone. Thus, their role as consumers of certain groups of organisms and as an element of eutrophication of the reservoir through their load of excrements is more important in these places. Much greater numbers of birds are

found on shallow lakes and ponds. For instance on the shallow Lake Łuknajno (620 ha), densely covered with vegetation, 5 species of bird included from 1180 to 12 330 specimens, depending on the season (Dobrowolski et al. 1976). The character of the environment of the Dobczyce Roservoir explained the relatively small numbers of *Anas platyrhynchos* there. Greater numbers of this species are encountered in water bodies with a larger shallow area and emergent vegetation, e.g. in the Otmuchów Reservoir (Dyrcz 1981). A narrow littoral area is not, however, a limiting factor for *Podiceps cristatus*, which, as a species of deep open water manifests different environmental requirements. Dominant species at the Dobczyce Reservoir prevail also in other water bodies, e.g. *Podiceps cristatus, Anas platyrhynchos*, and *Larus ridibundus* dominated in the deep open water zone of the Otmuchów Reservoir (Dyrcz 1981). *Anas platyrhynchos* and *Larus ridibundus* reached maximum numbers on shallow littoral waters of that reservoir, which corresponds to the results of the investigations carried out at Dobczyce.

The role of birds at the Dobczyce Reservoir on account of the small numbers, is not great. They play a much greater role at Lake Łuknajno, from which they take about 6.2 t fish (10 kg ha^{-1}) during one vegetation season, about 20 t invertebrates (60 kg ha^{-1}), and about 125 t aquatic plants (200 kg ha^{-1}) (Dobrowolski et al. 1976).

One may suppose that together with overgrowing of the Dobczyce Reservoir and stabilization of the ecosystem the numbers of birds will rise and their throphic role will thus become more important.

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6. Polish summary

Próba oceny roli troficznej ptaków w czasie formowania się ekosystemu Zbiornika Dobczyckiego (dorzecze Wisły, południowa Polska)

Badania prowadzono na zbiorniku zaporowym w Dobczycach w 1987 roku, w drugim roku napełniania. Zbiornik w czasie badań podzielono na części różniące się powierzchnią litoralu i charakterem brzegów (ryc. 1). Średnie powierzchnie i głębokości poszczególnych części w wyróżnionych okresach fenologicznych przedstawiono w tabeli I. Zaobserwowano 33 gatunki ptaków związanych ze środowiskiem wodnym. Stwierdzono małe ich liczebności, co było zwią-

zane z warunkami środowiskowymi zbiornika (brak dogodnych miejsc gniazdowych i żerowiskowych, stały wzrost poziomu wody). Dominantami były *Podiceps cristatus*, *Anas platyrhynchos* i *Larus ridibundus*, których liczebności w 1987 roku przedstawia rycina 2. Najwięcej ptaków obserwowano w okresie przelotu późnojesiennego, zaś najmniej w okresie lęgowym (tabela II). Największe zagęszczenie ptaki osiągały w cofce i w Zatoce Wolnicy (rycina 3). Dla występujących gatunków obliczono metabolizm dobowy i konsumpcję pokarmu (tabela III). Większość z nich zaliczono do ichtiofagów (9 gatunków) i do entomofagów (9 gatunków) (tabela III). Stwierdzono, że ptaki odżywiające się pokarmem zwierzęcym stanowią w zależności od okresu fenologicznego od 21% do 69% biomasy wszystkich ptaków. Oszacowano ilość energii i pokarmu, pobrane przez ptaki w okresie od marca do grudnia. Badania wykazały małą rolę ptaków w okresie formowania ekosystemu zbiornika.

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