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Numbers of the great crested grebe, *Podiceps cristatus* L., and the composition of its food in the Dobczyce Reservoir (the River Vistula basin, southern Poland)

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Abstract – The highest density of the great crested grebe in the Dobczyce Reservoir was observed in autumn. In the littoral zone the grebes chiefly stayed during the breeding period. In the stomachs of these birds 6 fish species were found, the most frequent occurrence being perch, *Perca fluviatilis* L. The total length of the consumed fish ranged from 6 to 18 cm. Also insects and additionally bivalves and plant fragments were eaten. In the aspect of the biomanipulation concept, by consuming planktivorous fish this species reduces their pressure on the zooplankton, thereby contributing to the control of algal blooms.

Key words: grebes, consumption, freshwater fish, dam reservoirs, biomanipulation

Liczebność perkoza dwuczubego (*Podiceps cristatus* L.) i skład jego pokarmu na Zbiorniku Dobczyckim (dorzecze Wisły, południowa Polska). Perkoz dwuczuby osiągał największe zagęszczenia na Zbiorniku Dobczyckim w okresie jesiennym. W strefie litoralu perkozy przebywały przede wszystkim w okresie lęgowym. W żołądkach perkozów stwierdzono 6 gatunków ryb, z których najliczniejszy był okoń. Długość całkowita zjadanych ryb wynosiła 6–18 cm. Stwierdzono również zjadanie owadów oraz dodatkowo małży i części roślin. W świetle koncepcji biomanipulacji gatunek ten wyjadając ryby planktonozerne zmniejsza ich presję na zooplankton, a tym samym przyczynia się do ograniczania zakwitów glonowych.

1. Introduction

In the opinion of fishermen, anglers, and fish farmers piscivorous animals are decisively pests, causing damage by consuming great numbers of fish. The pressure of these animals on the ichthyofauna to a great degree depends upon their numbers in a given area and the density of the fish on which they feed.

In the Dobczyce Reservoir great crested grebe, *Podiceps cristatus* L., belongs to the dominant species of waterbirds (Gwiazda 1989). It also dominates in other dam reservoirs, e.g. in Włocławek, Otmuchów, Goczałkowice, and Turawa (Nowysz-Wesołowska 1976, Dyrcz 1981, Bocheński 1986, Stawarczyk and Karnaś 1992). The great crested grebe is classified in the group of fairy numerous of bird species breeding in Poland (Tomiałojć 1990). Its chief food are fish (Cramp and Simmons 1977), hence it affects the ichthyofauna. The food composition of the

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grebe on the territory of Poland has been very little studied (Dunajewski 1943, Sokołowski 1967).

The aim of this work was to assess the numbers of great crested grebe in the Dobczyce Reservoir throughout the year, investigate the composition of its food, and determine the species, size, and weight of the consumed fish.

2. Study area

The Dobczyce Reservoir (49°52' N, 20°02' E) is a mesotrophic dam reservoir built in 1986 at the 60th kilometre of the River Raba in the Pogórze Wielickie Hills between the towns of Myślenice and Dobczyce, about 25 km south of Cracow. The maximum area of the reservoir reaches 1120 ha, its mean depth is 11.1 m, length about 10 km, and width up to 1 km (Pasternak 1980). Dobczyce Reservoir is classified among deep reservoirs, its maximum depth reaching about 29 m. Water transparency varies in range 1.0–4.2 m (data from the Ichthyobiological Station at Brzączowice). The most shores are steep and covered with meadows and forest. No wide tracts of littoral zone or reed thickets occur there (the share of parts with a depth < 2 m reaches only 10%), willow being found on small areas, while reeds, *Phragmites australis* (Cav.) Trin. ex Steud., cover a compact site of less than 1 ha. *Polygonum amphibium* L. occurs on small areas of the reservoir, chiefly in a long and shallow side bay.

3. Material and methods

In the whole reservoir quantitative observations were carried out from the shore, using 10x50 binoculars and a 40x60 field glass. Grebes were counted once or twice a month in 1990 and 1991. Altogether 17 counts in 1990 and 12 in 1991 were made. The density of the grebes was computed as the quotient of their recorded numbers on a given day by the total area of the reservoir, determined from the damming ordinate on the observation day (data from the Ichthyobiological Station at Brzączowice).

Materials for investigating the composition of food were obtained from grebes shot on the Dobczyce Reservoir (the shooting of protected bird species by permission of the State Inspectorate for Nature Conservation of 30 March 1993). A total of ten individuals were shot (five birds each on 15 April and 20 September 1993). The birds were weighed with accuracy to 1 g; the sampled stomach content was macroscopically inspected, remnants of fish being selected. The residue was placed in a glass cylinder, flooded with water and floated, feathers great numbers of which occurred in the gastric contents, being removed. Subsequently, the water was drained and the obtained material was surveyed under a binocular (magnification 16x), animal and plant debris being selected. Complete individuals were identified and their lengths measured. In the case of fish remnants pharyngeal teeth (ossa pharyngea inferiora) and opercular bones were used for identification. Cyprinids were identified using Horoszewicz's elaboration (1960), percids individuals being determined on the basis of the characteristic operculum. The size of prey was estimated on the basis of regression equations (A. Amirowicz unpubl.). Insects were identified on the basis of the head and prothorax shape and the occurrence of wing covers (Macan 1959). Insects were identified as to order and

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fish as to species. The number of prey was determined on the basis of the number of remnants used for identification.

The nutritional requirements of the grebe were calculated on the basis of the estimated magnitude of metabolism and the calorific value and digestibility of the food. Daily metabolism was determined on the basis of the regression equation given by Nagy (1987) for birds investigated in natural conditions, using the method of doubly labelled water:

$$\log y = 0.681 + 0.749 \log x$$

where: y — metabolism (kJ); x — mean body weight (g).

It was accepted that the calorific value of fish was 1493 cal g^{-1} WW, i.e. 6.25 kJ g^{-1} (Cummins and Wuycheck 1971: 27). The assumed coefficient of assimilation (digestibility) was 70%. The food demand was calculated according to the formula:

$$Z = y/sk$$

where: y — metabolism (kJ); s — digestibility (kJ g^{-1}); k — calorific value of food (%).

With the assumption that the grebes fed only on fish, the weight of fish consumed by their population in the Dobczyce Reservoir was estimated for the period March–December in 1990 and 1991. It was calculated as the total of products of grebe numbers in a given month, number of days in the month, and the estimated daily food demand.

4. Results

The great crested grebe occurred in the Dobczyce Reservoir from the early March up to the end of December. Its greatest numbers, up to 350 individuals in 1990 and 178 in 1991 recorded in autumn, correspond to the density of 3.6 and 1.8 ind. per 10 ha, respectively (fig. 1). In the breeding period 1990 fifteen pairs and in 1991 twenty-two pairs of this species were observed to nest.

It was assessed that in different seasons of the year grebes foraged in various parts of the reservoir. In spring and summer 34–52% of the grebes stayed in the littoral zone in a long and shallow side bay, most suitable for nesting. In the period of autumn migration 80–85% of birds foraged along the main axis of the reservoir in the off-shore zone (fig. 2).

In the stomachs of the grebes fish were found in 9 birds, insects in 10, fragments of plants and seeds in 4, and shellfish in 1 bird (Table I). Analysis of the gastric contents of the grebes shot in April showed the occurrence of 6 fish species (15 individuals), of which roach, *Rutilus rutilus* L., and bleak, *Alburnus alburnus* (L.), were most numerously represented (4 individuals each). In September 4 fish species were found in the food (19 individuals) with the greatest number of perch, *Perca fluviatilis* L. (13 individuals). The second group composing grebe food were insects, especially beetles (Coleoptera; in April and September) and caddis fly larvae (Trichoptera; in September). Also Diptera, Hemiptera, and Hymenoptera were recorded. The total length of fish in the stomachs of the grebes shot in April was in range 6.8–17.7 cm, (mean 11.4 cm, SD = 3.76, n = 15). In September the length of prey of the shot birds was similar (range 6.0–17.4 cm, mean 9.5 cm, SD = 2.70, n = 19). The largest fish consumed were bleak (17.7 cm), perch (17.4 cm), and roach (17.0 cm).

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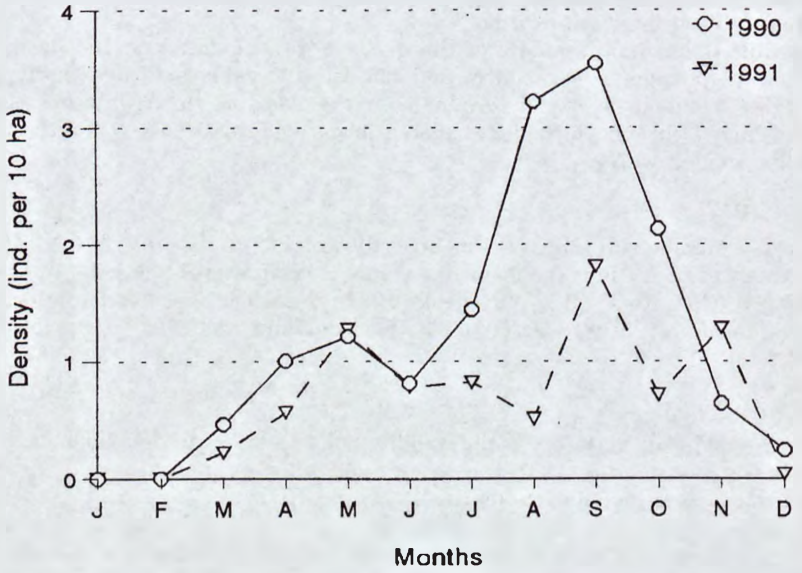

Fig. 1. Density of the great crested grebe, *Podiceps cristatus* L., in the Dobczyce Reservoir in 1990 and 1991.

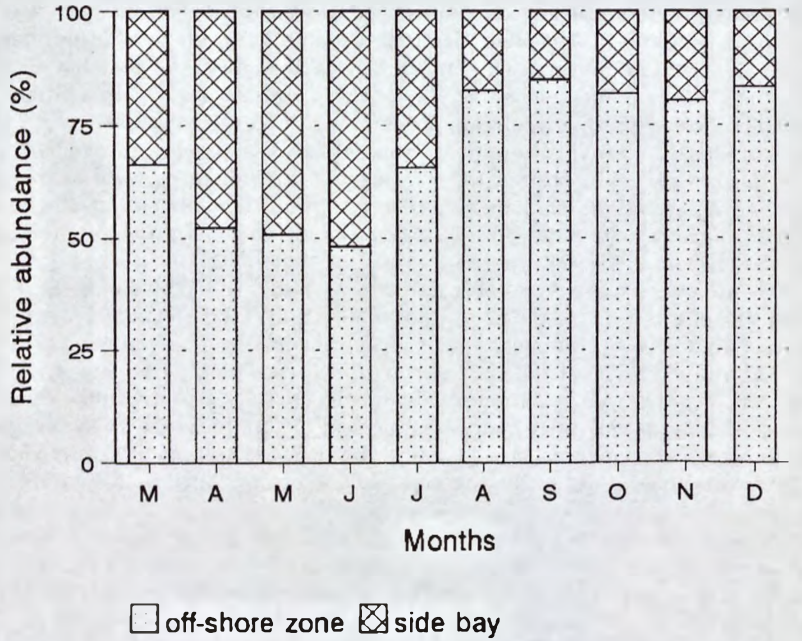

Fig. 2. Occurrence of the great crested grebe, *Podiceps cristatus* L., in the side bay and in the off-shore zone of the Dobczyce Reservoir in 1990–1991

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Table 1. Composition of food of the great crested grebe, *Podiceps cristatus* L., in the Dobczyce Reservoir based on analysis of the gastric contents of grebes shot on 15 April and 20 September 1993 (5 birds at each date). The total number of consumed specimens and of stomachs containing given kind of food (in brackets) is presented.

Kind of food	Month	
	April	September
PISCES		
Alburnus alburnus (L.)	4 (3)	
Gymnocephalus cernuus (L.)	1 (1)	4 (3)
Leuciscus cephalus (L.)	2 (1)	1 (1)
Perca fluviatilis L.	1 (1)	13 (4)
Rutilus rutilus (L.)	4 (2)	1 (1)
Scardinius erythrophthalmus (L.)	3 (2)	
Total	15 (5)	19 (4)
MOLLUSCA (Bivalvia)	1 (1)	
INSECTA		
Heteroptera	1 (1)	
Coleoptera	45 (5)	48 (5)
Trichoptera		52 (5)
Diptera	2 (1)	7 (4)
Hymenoptera		3 (2)
Total	48 (5)	110 (5)
MACROPHYTA	2 (1)	8 (3)

The mean weight of great crested grebes shot in the Dobczyce Reservoir was 1049.2 g (SD = 148.4, $n = 10$). Energy requirements of the grebe were estimated as 878.3 kJ day^{-1}, this value converted into fish weight being about 200 g WW day^{-1}. It was estimated that in the period March–December 1990 great crested grebes ate about 8800 kg of fish in the Dobczyce Reservoir, 60% of this amount being consumed in the period August–October. In 1991 the birds ate about 4800 kg of fish.

5. Discussion

The great number of grebes in the autumn is associated with their gathering in environments with rich food resources (Dyrcz et al. 1991), where they moult, losing their flying ability for a period of 3–4 weeks (Sokołowski 1967, Cramp and Simmons 1977), and prepare for migration to wintering places. In the breeding period grebes above all stay in places which are suitable for nesting, i.e. shallower areas overgrown by emergent macrophytes. In migration periods the grebes decisively avoid such places (Sokołowski 1967). Birds which migrate along rivers stop to rest and forage in dam reservoirs, not visiting any side bays of these waters.

Neither Dunajewski (1943) nor Sokołowski (1967) recorded perch, ruff (*Gymnocephalus cernuus* (L.)), chub (*Leuciscus cephalus* (L.)), or rudd (*Scardinius*

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erythrophthalmus (L.)) in the food of grebes. Dunajewski (1943) claims that great crested grebes chiefly feed on bleak and also stickleback (*Gasterosteus aculeatus* (L.)), common bream (*Abramis brama* (L.)), tench (*Tinca tinca* (L.)), roach, and pike (*Esox lucius* L.). According to Sokołowski (1967) the food of grebes is chiefly composed of bleak and young roach, common bream, European whitefish (*Coregonus lavaretus* (L.)) and pygmy marane (*Coregonus albula* (L.)). Also other fish species were found in the food, among them brown trout (*Salmo trutta* m. *fario* L.), dace (*Leuciscus leuciscus* (L.)), eel (*Anguilla anguilla* (L.)), gudgeon (*Gobio gobio* (L.)), and crucian carp (*Carassius carassius* (L.)) (Cramp and Simmons 1977). Thus, grebes exert pressure on various fish species occurring in the environment and meeting the criterion of size and shape suitable for consumption. Fish with a high dorsal index, e.g. common bream, soon cease to be the prey of grebes since the narrow oesophagus of the birds does not permit them to swallow fish 6 cm in height (Sokołowski 1967). Most frequently the prey of grebes are the fish most numerous in the environment. Also Hanzak (1952) and Sokołowski (1967) state that grebes feed on the most numerous small fish. The records showing that in the Dobczyce Reservoir grebes chiefly ate perch, roach, and bleak, are associated with the dominance of these species there. They constitute about 82% of the fish association in the littoral and 80% of the total fish association in the pelagial (A. Amirowicz unpubl.) The occurrence of ruff and rudd in the food evidences the feeding in the coastal zone, since in the Dobczyce Reservoir these species are only encountered in the littoral. The grebes foraged for fish a few to several centimetres in length, this confirming the data given by different authors (Hanzak 1952, 8–17 cm; Geiger 1957, 13 cm; Madsen 1957, 3–20 cm; Cramp and Simmons 1977, 3–21 cm; Winfield 1990, 6–17 cm).

Apart from fish, other components of food (chiefly insects) were also noted, though they constituted only a small biomass. A study of grebes on fish farms in the delta of the Volga (Markuze 1965) showed that invertebrates constituted 66–97% of the great crested grebe food with respect to numbers and 10–49% with respect to weight. Insects were found in the stomachs of all grebes shot in the Dobczyce Reservoir. Similarly, in analyses of 25 stomachs of great crested grebes from freshwater environments in Denmark insects were recorded in 23 of them (Madsen 1957). The occurrence of insects in the diet of the grebe was also assessed by Hanzak (1952), Sokołowski (1967), and Cramp and Simmons (1977). Bivalves and larvae of caddis flies in the stomachs evidence the active foraging of grebes near the bottom. The feeding of grebes on plants, which were also found in the stomachs, was earlier reported by Hanzak (1952), Sokołowski (1967) and Cramp and Simmons (1977). The composition of food changes throughout the year on account of the life cycle of the prey and their accessibility. Winfield et al. (1992) found close relations between the population of the great crested grebes as predators and the roach as prey in Lough Neagh (Northern Ireland). Great numbers of feathers in stomachs are connected with active feather-eating and are important in pellet formation (Simmons 1956, Piersma and Eerden 1989).

The estimated weight of daily food consumption of the grebe approximates to the data given in the literature (Harrison and Hollom 1932, 340 g; Dunajewski 1943, 200–250 g; Geiger 1957, 200 g; Markuze 1965, 200 g; Sokołowski 1967, 200 g; Cramp and Simmons 1977, 150–200 g; Büttiker 1985, 200 g; Ulenaers and Vessem 1994, 222 g). In the Dobczyce Reservoir the grebes chiefly ate small fish one or two years old, whose mortality was in any case very high. The species and size of consumed fish being taken into consideration, the great crested grebe does not inflict any significant economic damage to the fish populations of reservoirs (EIFAC 1989).

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In the aspect of the biomanipulation concept the reduction of cyprinids by such predators as the grebe is a positive activity. The feeding of planktivorous fish affects the density of the zooplankton. If the density of these fish species is reduced, the pressure of ichthyofauna on large filter-feeding cladocerans is reduced and they are able to control the development of the phytoplankton (Gliwicz 1986, Jachner 1988). This is desirable in the case of a tap-water reservoir as is the Dobczyce one, since the excessive development of algae may result in a deterioration of water quality by poisoning it with metabolites of decayed organisms. In metabolizing organic matter taken from aquatic organisms, the grebes do not utilize oxygen dissolved in water. This is important for the functioning of the ecosystem since the amount of oxygen is usually limited. Therefore, in such ecosystems the activity of the grebes is from the standpoint of water management not only harmless but even very favourable.

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