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Piotr CEMPULIK

Breeding ecology of the Moorhen *Gallinula chloropus* in Upper Silesia (Poland)

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Abstract. Two local populations of the Moorhen *Gallinula chloropus* were studied in Upper Silesia. One was a migratory, lower density, population in the Wielikąt complex of ponds, and the other was a population with a density about 20 times higher, at industrial reservoirs in the suburban landscape of Bytom-Rozbark. The migratory population (at Wielikąt) was characterized by the facts that: it constituted only up to 4% of the breeding community of waterbirds; second broods were recorded only in isolated cases; and breeding losses amounted to 30% – of which half were caused by predators, and the remainder mainly by waves. The other population (at Bytom-Rozbark) was characterized by the facts that: it constituted as much as 16% of the breeding community of waterbirds; breeding started earlier (75% of first broods were initiated in the first half of the breeding season); 30% of pairs went on to have second brood; and all breeding losses (15%) were exclusively the results of predation. The migratory population did not saturate the available habitat. Channels between the Wielikąt ponds were the optimal habitat. Territories there were occupied earlier than in the ponds, and more pairs began breeding in the first half of the breeding season. The highest average clutch sizes and the largest eggs were also recorded there. It was shown that this species prefers channels and then small, shallow industrial reservoirs with a wide fringe of emergent vegetation and a high representation of *Typha sp.* – because the inundation of nests, as a result of waves, did not occur there.

Key words: Moorhen *Gallinula chloropus*, waterfowl, breeding ecology, anthropogenic impact

Upper Silesian Museum, Dept. of Natural History, pl. Jana III Sobieskiego 2, 41-902 Bytom, POLAND

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INTRODUCTION

The purpose of this study was to account for the many times higher population density of breeding Moorhens in the industrial reservoirs of Upper Silesia, in comparison with the density of the species in the fish ponds of the region. This aim was achieved through research into some aspects of breeding ecology in the chosen habitats of the fish ponds and industrial reservoirs of Upper Silesia, and by comparisons between them, as well as with data concerning populations living in other European habitats. The Moorhen may be classed as a "winner" species, and as one widespread in the "civilized" landscape of Europe. Since the second half of the 19th century this species has been increasing in numbers and in its breeding range (Engler 1980, Ilyicev & Flint 1987). Knowledge so far obtained about this species, and contained for example in the monographs of Glutz v. Blotzheim *et al.* (1973), Cramp & Simmons (1980) and Engler (1980), concerns mainly the resident populations of Western Europe. In Poland, this is a widely-distributed, moderately common, breeding bird (Tomiałojć 1990), which in general flies away for the winter – probably above all to Western and Southern Europe (Engler 1980). At the beginning of the 19th century, the Moorhen occurred in all the ponds and ditches in Silesia (Kaluza 1814). Pax (1925) reported that it occurred throughout Silesia to 500 m a.s.l. Brinkmann (1931), describing the avifauna of the Racibórz region, reported that it occurred infrequently in the ponds in Łężczak and on the old islands in the Oder River. At that time this species had already colonized reservoirs of the industrial type in Upper Silesia (Brinkmann 1939). In this same period, the Moorhen began to nest in city parks in western and central Germany. This phenomenon was not known at that time in Silesia, and is only in its early stages there even today.

STUDY AREA

Research into breeding ecology was conducted in the industrial parts of Upper Silesia in south-west Poland, in two different types of habitat: in the Wielikąt complex of fish ponds near Racibórz, and in the

industrial reservoirs of Bytom (Bytom-Rozbark). These habitats differed greatly in their period of existence, area of open water and bulrushes, surroundings, and degree of anthropopressure.

The complex of fish ponds and channels at Wielikąt

The fish ponds at Wielikąt came into existence more than 400 years ago. The area of ponds with water amounts to between 222.7 and 260.4 ha, of which emergent aquatic vegetation covers between 8.7 ha (4%) and 12.4 ha (5%). The channels near the ponds have a total length of 3 km and a width of 2–4 m. These are to a great extent overgrown. In this area, the major part of the emergent aquatic vegetation is comprised of *Phragmites communis*, followed by *Typha angustifolia* and *T. latifolia*. The Wielikąt ponds are very fertile. The culturing of carp has always been carried out there, and has lately been done intensively (with supplementary feeding and manuring). Cultivated fields and meadows are found in the immediate surroundings of the pond complex.

The industrial reservoirs of Bytom

The river Bytomka flows through the southern part of the city and there, above all, are the industrial reservoirs – which appeared in subsidences over coal mines. Also included amongst them are old and current siltation reservoirs. In the last 40 years the area of industrial reservoirs in Bytom has increased almost threefold. In 1985, there were 156 reservoirs there with a total area of 190 ha. Of these, 58 (covering 152 ha) were the industrial reservoirs as defined henceforth. Individual reservoirs of this type have areas of between a few ares and 15 ha; with the majority up to 5 ha. In most cases, the industrial reservoirs have an extensive fringe of bulrushes, and mine waters and other industrial, or communal, effluents are often drained into them.

The reservoirs on which research into breeding ecology was conducted are situated in a suburban landscape, mainly in Bytom-Rozbark. The remainder are found in the nearby city of Chorzów. The oldest date from the 1930s, and the majority came into being in the 1950s. In the period during which research was carried out, the total area of reservoirs was about 35.8 ha, of which about 7.6 ha (21%) was comprised of areas with emergent aquatic vegetation. Put another way, its share in the total area of the reservoirs was about four times higher than at Wielikąt. About 70% of this vegetation consisted of *Phragmites communis*, and the remainder of *Typha angustifolia* and *T. latifolia*. In contrast to Wielikąt, the fringes of bulrushes were extensive and many years old; i.e. vegetation had been accumulating there for many years. The majority of the reservoirs are used by anglers. One reservoir is given over to bathing in the summer period, and another to the extensive culture of fish without supplementary feeding. In times of hard winters, only the largest reservoirs had areas – of about 0.15 ha – that were not frozen. The remaining reservoirs were frozen completely

METHODS

The proportion of Moorhens in the breeding *Non-Passeriformes* water – and marsh bird community was determined in accordance with the method for counting birds described by Borowiec *et al.* (1981) and Cempulik (1985).

Research at Wielikąt area was carried out in the years 1982-89. In the years 1982-86, an attempt was made to find all the pairs and nests, and in the remaining years to discover all the pairs. Every two weeks from April to mid August, inspections of the whole area were made, during which the taped calls of the species under study were played.

In Bytom-Rozbark, research was carried out in the years 1983, 1987 and 1989. Attempts were made there to find all the nesting pairs and nests, by making a systematic search of the reeds and of patches of bulrushes. The adoption of such a method was a consequence of the high density of breeding pairs of the species in this habitat.

A total of 87 nests were found in the "Wielikąt" area and 118 nests in "Bytom-Rozbark". Nests found were marked on maps and monitored on average every 7–10 days until the last chicks had hatched. As each was laid it was numbered successively. The flotation test (Mayer-Gross 1972) was applied in order to determine the advancement of incubation. The majority of the eggs were measured (Cempulik 1991).

The criterion which permitted breeding to be defined as "successful" was the presence of chicks in, or in the vicinity of, a nest. The presence of numerous small fragments of egg shell under a layer of nest

material was also evidence of the hatching of chicks. A lack of shell fragments, or the presence of large shell fragments with traces of egg contents (yolk, blood, part of the embryo) testified to the destruction of a clutch. Successful broods included those in which at least one chick hatched. The calculated total number of eggs destroyed was probably lower than the real number, because single eggs may already have been destroyed before the discovery of a nest in the course of monitoring, and some at the time of hatching.

Some research into breeding ecology was carried about at Wielikąt only. In the years 1985-86, all the sites discovered in previous years were visited at intervals of 7–10 days. The taped Moorhen call was played in those places, and their spatial structure was described. The purpose was to investigate the speed with which particular sites were occupied. Sites were assumed to be potentially suitable if their spatial structure (water level, state of vegetation and appearance of the surroundings) was the same as that prevailing in the season in which the site had been occupied. In 1986, the size of 12 breeding territories was measured. Measurements were made of the distances in meters from the nest to the furthest place in which a bird still reacted to the playing of the taped call. This distance was measured along embankments. In order to analyze thoroughly the habitat distribution, habitat fragments (sites and patches) in which Moorhens were nesting, were compared with those in which breeding was not recorded. To do this, the banks of the ponds and channels (in which Moorhens were not recorded) were divided into fragments of 180 m in length. This approximately matched the length of a breeding territory along an embankment, in habitat fragments which had narrow belts of reeds.

In 1987, the total breeding population in Bytom was estimated. Between June and mid July a single monitoring was carried out on all the reservoirs, using vocal stimulation. An estimate of the detectability of breeding pairs: males and females of the species under study respond with similar calls, hence their vocal response to stimulation by the tape does not allow for distinction according to sex. In a marked majority of cases only one individual from a pair responded – probably the male (Engler 1980). Where both members of a pair did respond they were at a distance of not more than 20 m from each other. The error in the estimation of the population with its considerable dispersion may therefore have been insignificant. In the case of the Bytom-Rozbark population, the difficulties in counting breeding pairs – resulting from the high population density – were to a great extent eliminated by the search for nests. A larger error could have been made only in the estimate of the breeding population in the whole city of Bytom. Here the stimulation of vocalization was used only for birds hidden in bulrushes. Such a population could have been underestimated. With high densities, two individuals from different pairs calling close to each other (up to 20 m) could have been recorded as a single pair.

HABITAT DISTRIBUTION OF THE MOORHEN

Research in the Wielikąt area showed that the Moorhen preferred channels. About 30% of this migratory population nested there. Moorhens also bred in ponds with an area of between 1 and 40.6 ha. Moorhens more often occupied small ponds (of 1–6.5 ha); sites dominated by *Typha sp.*; belts of fringing vegetation of more than 3 m in width (narrower belts occupied were almost exclusively in channels) and those habitat fragments where the depth of water was less than 80 cm (Tab. 1). In addition, for reasons that are unclear, Moorhens distinctly more often occupied the sites near which regular human activity was taking

Table 1. Potentially suitable and actually occupied Moorhen breeding sites in the Wielikąt fish-pond complex.
All differences are significant at $p < 0.001$ (χ^2 test).

[Tabela 1. Charakterystyka stanowisk potencjalnych i zasiedlanych w Wielikącie.]

Habitat parameters		Potential	Occupied	
		n	n	%
Habitat type	channels	83	23	28
	ponds	484	52	11
Size of ponds (ha)	1 – 6.5	32	12	38
	>6.5	452	40	9
Water depth (cm)	70 – 80	38	18	47
	>80	519	57	11
Human presence	yes	131	36	28
	no	436	39	9
Width of reed-beds (m)	≤3	383	22	6
	>3	107	37	35
Dominant plant *spp.*	*Typha sp.*	42	12	29
	Ph. communis	472	51	11

place (the sites bringing in of equipment and fodder, angling, and the collection of *Lemna sp*). The preponderant distribution in habitat fragments with this attribute may have resulted from the role of man as a "protective umbrella" against predators.

For pairs breeding at Wielikąt, a marked constancy of distribution was noted from year to year. Of the 47 sites discovered, 72% were occupied for between three and five seasons. Of these 47 sites, 29 had a spatial structure over the period of five years, which was the same as that at the time when breeding was recorded. It was shown that as many as around 90% of such sites were occupied for between three and five seasons (Fig. 1). In the ponds they were occupied for a minimum of two seasons, and in the channels for not less than three.

The occupation of sites by breeding pairs occurred between April and July. The existence of a considerable number of unoccupied, potentially-suitable sites was recorded in successive months of the breeding season (Fig. 2). The results presented suggest a decided preference for certain habitat fragments and a lack of saturation of the Wielikąt study area by the breeding population, e.g. in 1986 there was the theoretical possibility – taking into consideration the analyzed features of the spatial of habitat – of a further increase in the population of 43%.

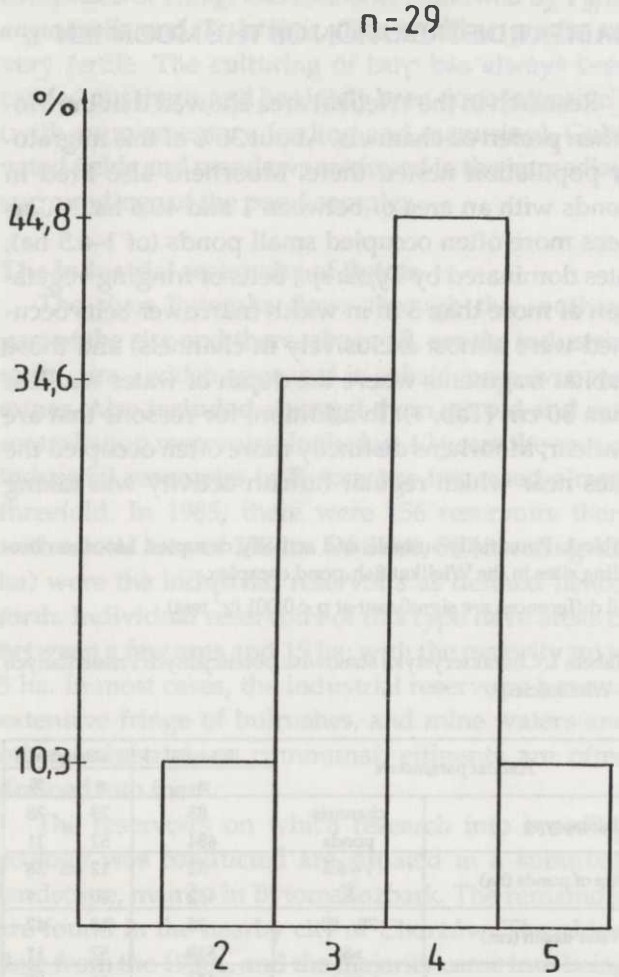

Fig. 1. Percentage distribution of Moorhen sites occupied by breeding pairs for two to five seasons. Only sites potentially suitable through all five years of the study have been analyzed.

[Ryc. 1. Procentowy rozkład stanowisk zajmowanych przez pary lęgowe, przez dwa do pięciu sezonów. Uwzględniono tylko stanowiska, które przez pięć sezonów były potencjalnie odpowiednie.]

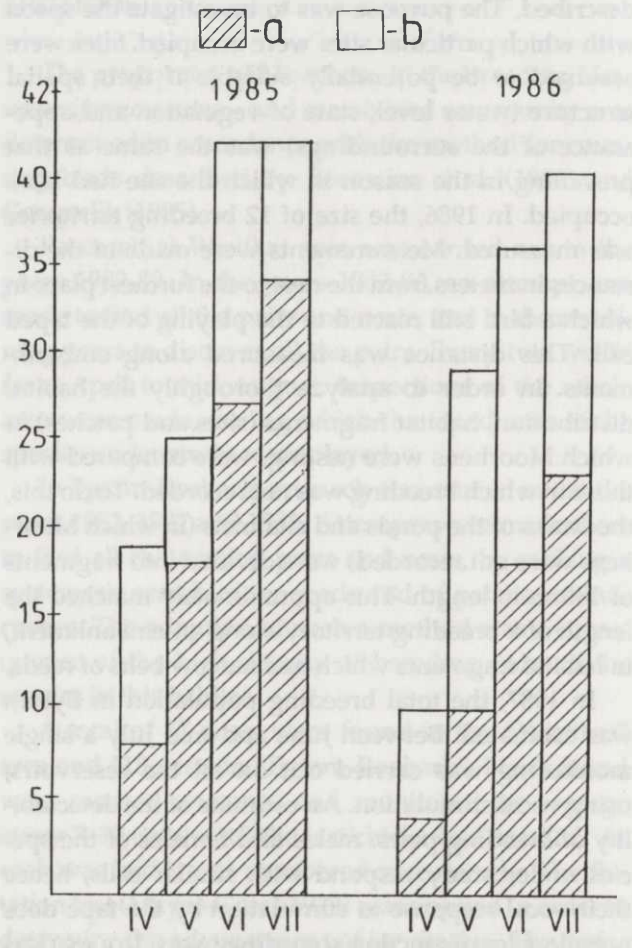

Fig. 2. Saturation of potential sites (numbers) by pairs of Moorhens in months of the breeding seasons (Wielikąt). a) occupied, b) unoccupied.

[Ryc. 2. Stan wypełnienia potencjalnych stanowisk przez kokoszkę wodną w kolejnych miesiącach sezonu lęgowego w Wielikącie a) zajęte, b) niezajęte.]

THE SIZE, DENSITY AND SYNANTHROPIZATION OF BREEDING POPULATION

In the Wielikąt area, the species under discussion constituted 3–4% of the total number of breeding pairs, in the bird community (Cempulik 1985). However, in the industrial reservoirs the Moorhen was a distinct dominant and accounted for 16% of the studied breeding bird community (Cempulik & Krotoski 1987).

In 1983, 33 pairs were recorded in Bytom-Rozbark, and in 1989 as many as 71 breeding pairs. At Wielikąt, smaller changes in the size of the populations were noted in consecutive seasons (Fig. 3). Extreme densities of breeding pairs were about 18–22 times higher in the industrial reservoirs than in the ponds and channels of Wielikąt combined. However, in counts per area of emergent aquatic vegetation, densities were only 3–4 times higher in the industrial reservoirs. Still higher densities were noted in the Wielikąt channels (Tab. 2) in spite of the fact that total occupation of all potential sites was not recorded there. In this case, the model of population buffering by territoriality proposed by Fretwell and Lucas (1969) was not confirmed. This phenomenon was not confirmed in research on the Woodpigeon *Columba palumbus* either (Tomiałojć 1980).

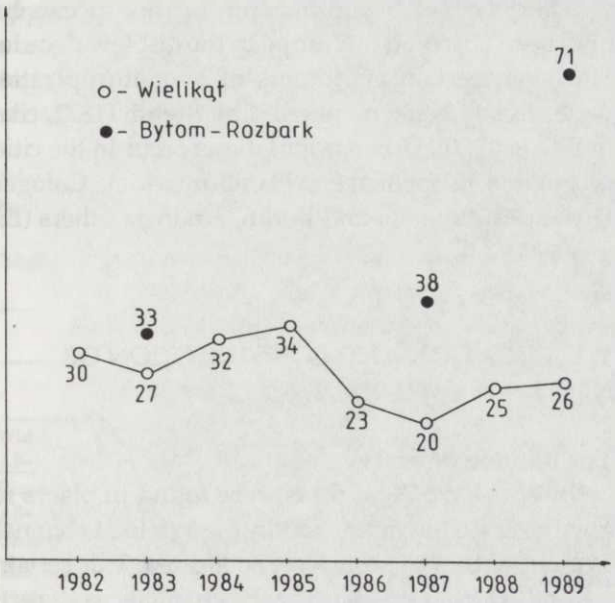

Fig. 3. Numbers of breeding pairs in years of study.

[Ryc. 3. Liczba par lęgowych w kolejnych latach badań.]

In Europe, the highest densities of Moorhens have been noted in small, highly eutrophic bodies of water (Harengerd 1968, Klemetsen 1970, Engländer & Kuhn 1975). In comparison with data contained in the work by Dyrcz *et al.* (1991), it follows that the Moorhen nests at exceptionally high densities in Upper Silesia, particularly in industrial reservoirs (Tab. 2). This density is one of the highest of those demonstrated from Europe.

Table 2. Density of breeding Moorhens in the Wielikąt and in the Bytom-Rozbark.

[Tabela 2. Zagęszczenie par lęgowych kokoszki wodnej w Wielikącie i w Bytomiu Rozbarku.]

	Pairs/10 ha in relation to:	
	total area within embankments	emergent aquatic vegetation only
Wielikąt – fish-ponds (260.4 ha)	0.5 – 0.9	12.6 – 20.1
Wielikat – channels (0.9 ha)	100	180
Bytom-Rozbark industrial reservoirs (35.8 ha)	9.2 – 19.8	46.1 – 93.3

Expressed as the length of the sector along an embankment which was defended, the sizes of 12 breeding territories at Wielikąt varied from 60 to 180m. In about 60% of those territories, the length of these sectors came to 140–180 m, or 0.14 to 0.18 ha. A similar results was obtained by Wood (1974a) for the ponds in the middle of fields. The sizes of territories in Bytom-Rozbark were not measured, owing to the character of the reservoirs and the high density of breeding pairs. From population densities it may, however, be calculated that the average size of a breeding territory there was about 0.1 ha and was therefore similar to the sizes given by Gibbons (1986) near Cambridge.

Totally 133 breeding Moorhen pairs were recorded within the administrative boundaries of the city of Bytom in 1987. About 95% of this population was nesting in industrial reservoirs. This universality of occurrence, high density and numerical dominance, of the Moorhen appears to result from the fact that certain features of the habitat shown to be preferred in the detailed studies of the Wielikąt area, were present in still greater concentration in the industrial reservoirs. These features are: the small size of the reservoir, shallowness, a broad fringe of emergent aquatic vegetation and a higher rate of occurrence of

Typha sp. (Tab. 1). In addition, the impoverished composition of biocoenoses characteristic of suburban and urban habitats certainly had an influence on the state of the population. An example of this is the sporadic occurrence in this habitat of predatory birds capable of limiting the numbers of Moorhens. Hence, resulting from the character of this habitat was the high breeding success, and most probably, the low mortality of parents in the breeding season. For example, the interruption of incubation for reasons other than the destruction or abandonment of the clutch was not recorded in either studied habitat.

In the industrial reservoirs there were distinctly fewer Coots *Fulica atra* (Cempulik 1985, Cempulik & Krotoski 1987). This was not therefore an effective, dominating competitor in this habitat. Similarly, this species did not occupy the Wielikąt channels, which made them even more suitable for Moorhens.

The Moorhen is also commoner than the Coot in some other regions of Europe with strong anthropopressure, for example in North Rhine Westphalia (Engler 1980). The extension of the European breeding range of the Moorhen in the last 100 years, and its increasing density in some regions, may be explained mainly by the increasing area of anthropocenoses. The local causes could have been various e.g. on the one hand, the eutrophication of lakes and the creation of new culture ponds, marl pits, reservoirs created by subsidence, sewage settling ponds and city centre ponds, and on the other hand the simplification of the composition of biocenoses – for example by a reduction in the representation of predators and a lessening of inter-specific competition. An extension of breeding range has also occurred in other continents e.g. Ilyicev & Flint (1987) emphasized the influence of rice cultivation on the broad expansion of this species in central Asia i recent decades.

In Upper Silesia, breeding sites of this species are rarely found amongst heavily built-up urban areas. Of reservoirs monitored in the years 1982-89 and colonized by this species, only two were reservoirs located at the edges of large residential estates with blocks of flats. In addition, the breeding of a wild pair was recorded in the nearby Silesian Zoological Gardens. The nest was located in a tree (of 3.3 m) growing on an island in a small pool. A few data concerning the nesting of single pairs of Moorhens in cities are also found in the Avifaunistic Data-bank of the Upper Silesian Museum in Bytom:
– in the 1950s, in a former city park in Siemianowice, at a distance of about 50 m from a building, in a pond covering about 1.5 ha (E. Imiołczyk);
– in 1986, in a city park in Tychy (I. Oleksik);
– in two ponds covering about 0.03 and 0.04 ha in the Różanka estate in Chorzów on pair in 1989 and 1990, 2 pairs in 1991, and 3 pairs in 1992 (J. Betleja);
– in a pool covering about 0.05 ha in the Tysiąclecia housing estate in Katowice – 1 pair in 1991 and 1992 (J. Kasperek). These data show that synurbization (colonization of urban habitats and adjustment to urban conditions) is just beginning in the Moorhen, though its synanthropization (occurrence in broadly anthropogenic habitats) is already in progress in Upper Silesia. This process is certainly retarded because of the peripheral location, and therefore the non-urban character, of reservoirs in this region. These reservoirs are, in the great majority, surrounded by wasteland which is visited by people relatively rarely. On the other hand, reservoirs in parks or within estates occur only sporadically and are poor in, or completely devoid of, emergent vegetation. The sharp structural difference between the aquatic habitat of the periphery and that in the centres of cities in Upper Silesia is certainly one of the main reasons for the retardation of the process of synurbization by the Moorhen in this area (in comparison with in Western Europe).

The process of synurbization of this species has only been observed in Europe in the last few decades. However, certain symptoms of synanthropization were already being mentioned by Brehm (1822, cited in Engler 1980). Urban populations occur in the cities of London, Copenhagen, Hamburg, Kiel, Cologne, Düsseldorf, Munich and Berlin, amongst others (Engler 1980).

THE LOCATION AND CONSTRUCTION OF NESTS

The location of nests

In Wielikąt 54% of nests were found in places regularly visited by man, and in the Wielikąt channels as many as 86% of nests were so located. This certainly resulted from the fact that the channels were regularly visited by people and the ponds less so. In the reservoirs in Bytom-Rozbark, nests were found above

Table 3. Numbers of nest sites in relation to some environmental factors: presence of humans, presence of trees within 50 m, presence of patches of *Typha sp.* * numbers of sites, ** numbers of nests Differences statistically significant at $p < 0.001$, or (the first pair) – at $p < 0.05$.

[Tabela 3. Zależność usytuowania gniazd od czynników: regularnej obecności człowieka, występowania drzew w odległości do 50 m, umieszczania gniazd w zaroślach palki *Typha sp.*]

Factors	Wielikąt		Bytom-Rozbark
	ponds	channels	industrial reservoirs
Human presence* – regular	23	25	26
– sporadic	36	4	85
Trees * – present	81		40
– absent	7		70
Nests in ** – *Typha sp.*	7		64
– other vegetation	75		45

all (77%) in places where people appeared only sporadically (Tab. 3). In Wielikąt, almost all of the nests (92%) were found near trees (at up to 50 m). In the reservoirs in Bytom-Rozbark, this kind of situation occurred only in the cases of 36% of nests (Tab. 3) because there is less tree cover and there are fewer single trees there. Moreover, in the industrial reservoirs it is most probable that the presence or absence of trees does not have a great protective significance because a very extensive fringe of aquatic vegetation occurs there. However, in Wielikąt, the tree cover supplemented the emergent aquatic vegetation and gave some possibilities for the establishment and hiding of nests even in narrow and sparse fringes of bulrushes. On the other hand trees increase the possibility of the destruction of broods by Hooded Crows *Corvus c. cornix* and Magpies *Pica pica*. However, these places were often reached by people, and there this factor could have constituted protection against predators. In the habitats studied, a total of about 92% of nests were located amongst *Phragmites communis* and *Typha spp*. The remainder were constructed by birds amongst *Iris pseudacorus*, *Carex spp*, *Juncus spp* and in branches of *Salix alba* trailing into the water.

It was shown in Wielikąt that communities overgrown by *Typha spp*. were distinctly preferred by Moorhens (Tab. 1). In Bytom-Rozbark as many as 59% of nests (Tab. 3) were located amongst these plants. Nests were also located there in broader fringes of vegetation than in Wielikąt. The distance of the nest from land was also greater on average in the industrial reservoirs (Tab. 4). Moreover, there was a marked difference in the number of nests located at distances of up to 2 m from land – 54% in Wielikąt and 8% in Bytom-Rozbark. This resulted mainly from the fact that about 30% of the Wielikąt population was nesting in channels and these are narrow. The location of nests on dry sites was recorded in only two cases. It occurred at Bytom-Rozbark. This fact suggests that the predation pressure from mammals is of great significance for the location of nests. Differences in the distance of nests from the surface of the water (Tab. 4) attest to the fact that nests in the Wielikąt ponds were protected to a lesser extent from waves than those built in the industrial reservoirs.

The average height of the vegetation in which a nest was located varied in particular habitats (Tab. 4).

Table 4. Location of nests in relation to several habitat features. Statistical significance: + $p < 0.05$, ++ $p < 0.01$, +++ $p < 0.001$ (Student's t- test).

[Tabela 4. Zależność usytuowania gniazd od czynników środowiskowych.]

Factors	A Wielikąt-ponds			B Wielikąt-channels			C Bytom-Rozbark reservoirs		
	x	n=48-49 (min-max)	SD	x	n= 22-23 (min-max)	SD	x	n= 106-108 (min-max)	SD
Width of vegetation fringe (m) AB++ AC+++ BC+++	7.7	(1-25)	6.1	3.5	(0.3-24)	5.0	12.5	(2-80)	10.7
Distance to the bank (m) AB+ BC++	5.1	(1-25)	4.9	3.1	(0.2-20)	4.2	6.1	(1-30)	5.7
Distance to the water (m) AB+++ AC+++ BC+++	2.5	(0.1-15)	3.5	0.5	(0.1-4)	0.9	5.7	(0.1-25)	5.9
Vegetation height (m) AB+++ AC++ BC++	170	(10-300)	44.5	116	(20-200)	61.2	150	(45-200)	36.8
Water depth (cm) AC+++ BC+++	52	(5-100)	19.1	45	(10-90)	24.6	26	(5-100)	16.8

This height depended on the species of plant and on whether, and to what degree, the vegetation from previous growing seasons had been preserved. In the industrial reservoirs, *Typha spp.* and vegetation accumulated from the previous seasons fulfilled an important role. Nests located there were better hidden from predators moving close to the surface of the water, that is to say jumping from clump to clump or swimming to the nests. Differences in the average depth of water near nests were also recorded (Tab. 4). In Wielikąt, water surrounding the nests was usually deeper – which probably made access difficult for terrestrial predators. In Bytom-Rozbark the water was shallower, but a thick layer of ooze usually occurred there, and this – in association with the large expanse of bulrushes – certainly made access to the nests even more difficult for such species as the fox *Vulpes vulpes* and *Mustelidae* predators.

The construction of nests

Nests were built from pieces of plants which were found in their immediate surroundings. The essential building materials were the leaves of *Phragmites communis* and *Typha spp.* In the ponds, the height of the nest was on average greater and the immersion deeper than in the reservoirs of Bytom-Rozbark (Tab. 5). Some of the nest was not immersed in the water at all. In Bytom-Rozbark such nests made up 76% of the total (n = 108), whilst in the ponds in Wielikąt only 38% of the total (n = 47, statistically significant difference, $\chi^2 = 19.9$, $p < 0.001$). However, in the channels, non-immersed nests made up as much as 61% of the total (n = 23). In addition, nests in the Bytom-Rozbark reservoirs were of smaller diameter (Tab. 5). Such nest construction undoubtedly resulted from the fact that they had been established in shallower water, and this above all in *Typha Spp* and in vegetation accumulated over many seasons. All this limited slipping (as a results of waves), and immersion of the nest, and this in turn limited the necessity for additional building up of them.

Table 5. Nest measurements and their immersion in the water
Differences are significant at: + $p < 0.05$, ++ $p < 0.01$, +++ $p < 0.001$ (Student's t-test).

[Tabela 5. Rozmiary i zanurzenie gniazd.]

	A			B			C		
	Wielikąt – ponds n = 48			Wielikąt – channels n = 23			Bytom-Rozbark reservoirs n = 106		
	x	(min-max)	SD	x	(min-max)	SD	x	(min-max)	SD
Nest height (cm) AC++	18.0	(4-38)	7.3	17.0	(8-27)	5.4	15.0	(4-29)	4.3
Diameter (cm) AC+++ BC+	20.8	(16-26)	1.9	20.6	(17-25)	1.8	19.7	(14-25)	1.9
Depth (cm) of immersion AC++ BC+	8.0	(1-24) n=29	6.1	8.1	(2-14) n=9	5.0	4.1	(1-13) n=26	2.8

PHENOLOGY AND CLUTCH SIZE

Phenology of breeding

In Wielikąt, a similar number of first brood clutches were initiated in both halves of the breeding season. On the other hand, in Bytom-Rozbark, di-

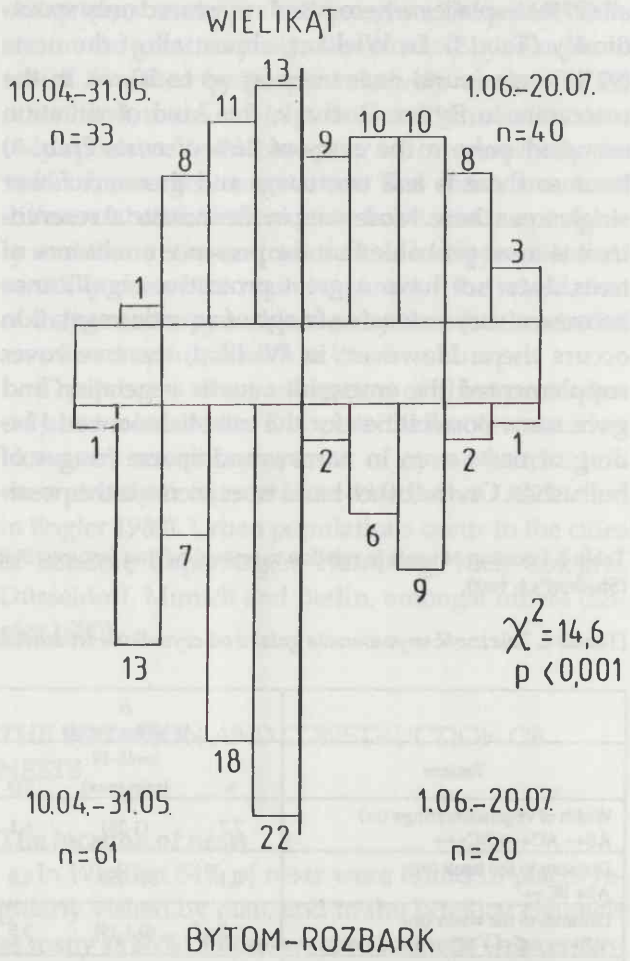

Fig. 4. Numbers of 1-st broods initiated during a particular ten-day period.

[Ryc. 4. Liczba pierwszych lęgów rozpoczętych w kolejnych dekadach.]

stinctly more first brood clutches were initiated in the first half of the season (Fig. 4). This undoubtedly resulted from the migratory habit of the first population, and the probably resident nature of a considerable part of the second (Cempulik 1991). Furthermore, of the first brood clutches initiated in the first half of the breeding season, 70% were in the channels at Wielikąt and only 35% in the ponds ($\chi^2 = 6.71$, $p < 0.01$). As optimal habitat, the channels were occupied more quickly and probably by older birds. At the same time the later occupation of territory by some breeding pairs in Wielikąt was not the result of an absence of suitable potential nesting places (Fig. 2).

In the Upper Silesia habitats studied, the earliest breeding began in the middle third of April. The earliest incidences of breeding in Hess (Hoehl 1939), Belgium (Neyt 1961) and Switzerland (Glutz *et al.* 1973) come from the middle third of March. According to Havlin (1970), only 0.5% of 269 cases of breeding in an area of Czechoslovakia began in the first third of April, and the majority began in the middle third of May.

Amongst the pairs studied at Wielikąt (n = 52), only two cases of second broods were recorded. On the other hand, in the reservoirs at Bytom-Rozbark as many as 18 such cases were recorded amongst the 59 pairs studied. This difference is statistically significant ($\chi^2 = 12.1$, $p < 0.001$). In Wielikąt, the initiation of second broods was recorded in the last third of June and in the first third of July. On the other hand, in Bytom-Rozbark it occurred from the last third of May to the middle third of July (last third of may – 3 broods, first third of June – 5 broods, middle third of June – 3 broods, last third of June – 4 broods, first third of July – 1 brood and middle third of July – 2 broods). As many as 61% of these broods were initiated in the period from the last third of May to the middle third of June. In reality, it is probable that even more pairs in the industrial reservoirs went on to have a second brood. Attesting to this is the discovery of broods which were defined initially as first, but in the neighborhood of which was subsequently found evidence that first breeding had already happened (e.g. nests with shell fragments under layers of nest material, and "helpers at the nest" feeding chicks). The fact that at least 30% of the Bytom-Rozbark population went on to have second broods may be explained by (among other things) the fact that about 75% of first broods in this population were initiated in the first half of the breeding season (Fig. 4).

Clutch size

The sizes of the first clutches ranged from 3 to 14 eggs (Fig. 5). In both habitats about 76% of clutches contained 6 to 9 eggs. Larger clutches were recorded in the Wielikąt channels than in the ponds there or than in the industrial reservoirs (Tab. 6). There was a tendency for larger clutches to occur in the industrial reservoirs in comparison to the Wielikąt ponds. Eggs laid at the industrial reservoirs were also larger than at Wielikąt – with the exception of the channels (Cempulik 1991).

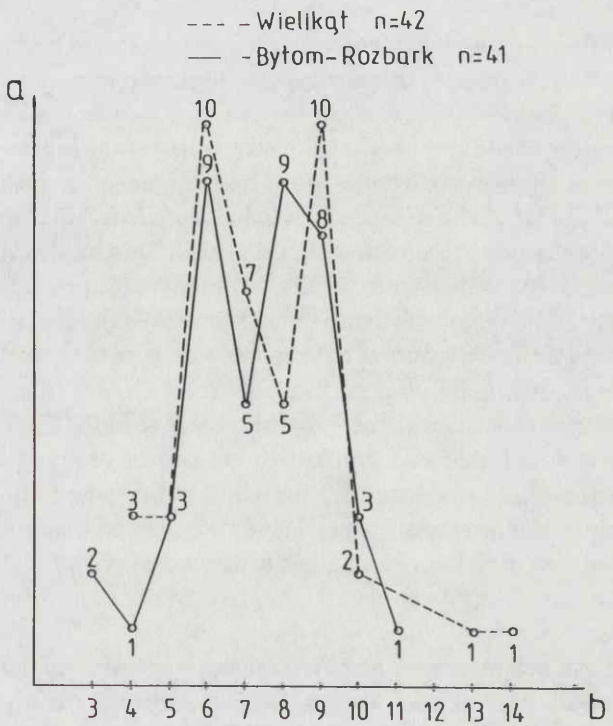

Fig. 5. Distribution of first clutch sizes. a) clutches, b) egg numbers.

[Ryc. 5. Rozkład wielkości pierwszych zniesień: a) liczba zniesień, b) liczba jaj w zniesieniu.]

At Wielikąt (ponds + channels), the average clutch size (Tab. 6) and average length of eggs (Cempulik 1991) was distinctly smaller in the second half of the breeding season than in the first. This may have resulted from the increasing representation of younger birds coming to the breeding site later on. According

Table 6. Average clutch size and production of chicks (pull/pair/year)
Statistical significance of differences indicated as: + $p < 0.05$, ++ $p < 0.01$, +++ $p < 0.001$ (Student's t-test).

[Tabela 6. Średnia wielkość zniesień i produkcji piskląt.]

Parameters	A Wielikąt-ponds			B Wielikąt-channels			C Bytom-Rozbark			D Wielikąt-ponds+channels		
	x	(min-max)	SD	x	(min-max)	SD	x	(min-max)	SD	x	(min-max)	SD
1-st brood clutches AB+++ BC++	6.8	(4-10) n=30	1.6	9.2	(6-14) n=12	2.4	7.3	(3-11) n=41	1.9	7.4	(4-14) n=42	2.1
1-st brood clutches from period of: 20.IV–31.V (a)							7.4	n=40	1.9			
1.VI–20.VII (b) D (ab) ++							6.8	n=23	1.5			
Clutch in replacement broods	7.0	(5-9) n=5	1.9	8.2	(6-13) n=4	3.3	6.0	(5-7) n=3	1.0	7.6	(5-13) n=9	2.5
2-nd-brood clutches							7.1	(5-10) n=10	2.0			
Production of chicks (per pair with known production)	6.3	(4-10) n=22	3.3	10.3	(6-20) n=12	17.1	7.8	(2-20) n=40	7.3	7.7	(4-20) n=34	11.6

to Perrins (1970), more and more young females go on to breed as the breeding season progresses, and Schaffer (1974) as well as Pianka and Parker (1975) were of the opinion that the size of parental investment increases through life. The later onset of breeding by young birds has been recorded in the Moorhen by Huxley and Wood (1976). This has been noted for other water birds by many authors e.g. Mendall (1958), and Baillie and Milne (1982). Moreover, parents beginning to breed at a later period, and young hatched in this period, may have a lower chance of survival into the next breeding season. They have less time to accumulate the resources of energy necessary to undergo the moult and to migrate to the wintering grounds. Fretwell (1969) suggested that young hatching later can have a lower social position at the wintering grounds and hence a lower chance of survival.

In the channels at Wielikąt, as opposed to the ponds, the initiation of first broods occurred mainly in the first half of the season. They were preferred markedly (Tab. 1) and were most probably occupied by older birds i.e. the ones arriving earliest at the breeding site, and producing the largest clutches and the biggest eggs (Cempulik 1991). A tendency towards the production of the greatest number of chicks was also found there (Tab. 6), thus enabling them to be defined as the optimal habitat. Differences in average clutch size between the first and second halves of the breeding season were not demonstrated in the industrial reservoirs. This was because that population is most probably predominantly resident (Cempulik 1991).

The highest average clutch size in replacement broods was recorded in the channels at Wielikąt (Tab. 6). Going on to have these broods in Wielikąt were certainly mainly the older birds, which is to say the ones arriving more quickly at the breeding site and occupying the optimal habitat of the channels. Hence the sizes of clutches and of eggs laid in this category of brood were greater there (Cempulik 1991). On the other hand, in the habitats at Bytom-Rozbark, birds of various ages may have gone on to have replacement broods, on account of their presence from the beginning of the breeding season. The number of eggs in second clutches at Bytom-Rozbark was as follows: 5 eggs – 3 clutches, 6 eggs – 2 clutches, 7 eggs – 1 clutch, 9 eggs – 3 clutches, and 10 eggs – 1 clutch, and the average size of clutches in this category was 7.10 (Tab. 6).

BREEDING LOSSES AND BREEDING SUCCESS

Within the studied population, the size of, and reasons for, breeding losses in the periods of laying and incubation were varied. Distinctly higher losses were recorded in Wielikąt (Tab. 7): 50% of total losses there were caused by predators, and the remainder were the results of the inundation of nests by waves – 27%, a change in water level – 11.5%, and as a result of the activities of man (including the researcher) –

Table 7. Nesting success
Statistical significance between pairs of parameters compared ($\chi 2$ test) at: + $p<0.05$, ++$p<0.01$, * - when at least one young hatched per brood.

[Tabela 7. Sukces lęgowy.]

		A Wielikąt		B Bytom-Rozbark	
		n	%	n	%
Broods:	– successful*	60	70	82	85
	– unsuccessful AB+	26	30	14	15
Pairs:	– successful*	59	76	79	92
	– unsuccessful AB++	19	24	7	7

11.5%. No statistically significant differences were found between the ponds and channels at Wielikąt, in terms of the size of, and reasons for, losses. Within the studied population the sizes of, and reasons for, losses were equal throughout the course of the breeding season. The level of losses caused by predators was also similar in the studied areas (about 15%). In Wielikąt, nests located amongst current season 's vegetation (n = 19), were destroyed more often -58%; nests located amongst vegetation derived predominantly from the previous season's growth (n = 22) suffered destruction in only 9% of cases – ($\chi^2 = 11.2$, $p < 0.001$).

In the areas studied, the loss attributable to predators was lower than that determined by Amat (1982) for water birds of medium size. The Wielikąt area was penetrated on average by 5 pairs of Magpie *Pica pica* and by between 5 and 7 pairs of Hooded Crow *Corvus corone cornix* as well as by groups of between 20 and 70 non-breeding Hooded Crows. The destruction of Moorhen nests by birds of both species was also recorded. In addition, on average 5 pairs of Marsh Harrier *Circus aeruginosus* nested at the ponds. The Bytom-Rozbark area was penetrated by only 1 to 2 pairs of Magpie and birds of this species probably destroyed only 1 Moorhen nest. Furthermore, Hooded Crow and Marsh Harrier *Circus aeruginosus* were not present in the area. It is certain that the main predators in this habitat were *Mustelidae*, Muskrats *Ondatra zibethica* and rats *Rattus spp.*

According to the literature, Moorhen clutches are plundered mainly by *Corvidae, Rattus spp., Mustelidae, Vulpes vulpes* and some feral dogs (Engler 1980, Ilicev & Flint 1987), and by *Circus aeruginosus* (Hauri 1960 and Ilicev & Flint 1987). Cases are also known of the destruction of Moorhen broods by Water Rails *Rallus aquaticus* (Mylne 1963) and Mute Swans *Cygnus olor* (Berndt 1968) and perhaps also by Coots (Heyder 1969). Huxley and Wood (1976) stated that in the agricultural, urban and suburban habitats of Great Britain, the greatest of the known losses resulted from the activities of man. At the same time 56% of total losses in these habitats had unknown causes. Anderson (1965) noted that from amongst 34 Moorhen nests in an agricultural landscape with small ponds, 15% suffered destruction. Moreover Havlin (1970) showed that 15% of 65 broods on fish ponds suffered destruction.

Waves and changes in water level can be a serious cause of breeding losses (Anfinnsen 1961). In Wielikąt, inundation of nests as a consequence of waves or changes in water level, was the cause of about 40% of recorded losses. On the other hand, in Bytom-Rozbark, losses caused by these factors did not occur. This resulted from differences in the characters of the studied habitats and differences – occurring for this reason – in the location and building of nests (see above). In the larger reservoirs (large waves combined with small areas of emergent vegetation) as well as where it comes to changes in water level, the inundation of nests can be as important a factor limiting reproduction as predation. Up to now this factor, limiting the breeding success and even the habitat distribution of the Moorhen, has been appreciated insufficiently in the literature.

More pairs enjoyed breeding success in Bytom-Rozbark than in Wielikąt (Tab. 7). Within the studied habitats there was a distinct tendency towards the highest average production of chicks in the Wielikąt channels and the lowest in the ponds themselves (Tab. 6). Of 388 eggs (52 clutches) at Wielikąt, 267 chicks hatched (69%). However in the industrial reservoirs in Bytom-Rozbark, 402 chicks hatched from 455 eggs in 63 clutches (88%). Wood (1974b) monitored 53 nests (267 eggs) in agricultural countryside in England. Only 47 chicks hatched from these (18%). The presence of "helpers at the nest" was observed once in Bytom-Rozbark. Gibbons (1987) recorded the positive influence of their presence on breeding success in extremely saturated habitat.

On the assumption that the Bytom-Rozbark population was in great measure resident (Cempulik 1991), it is worth recalling here the theses put forward by

O'Connor (1985) and concerning the influence of the migratory or sedentary habit on population dynamics:
a) in comparison with a migratory population, a resident one produces more flying young;
b) the production of fledglings decreases along with the diversity of the nesting habitat, as a result of the lower survival rate in such a habitat.

In the studies presented here, Wielikąt had habitat with a more mosaic-like character, and was that with which a population undertaking migration in the post-breeding period was associated. Hence both theses put forward by O'Connor supplement the explanation for the higher density of the breeding population in the industrial reservoirs as compared to the Wielikąt population (Tab. 2).

Pitt (1918) touched upon the problem of the location and height of nests as factors able to influence the survival of chicks in the first days of life. This may have great significance when the young are forced to leave the nest shortly after hatching, e.g. to escape from predators, and when their return to the higher-placed nest cup is made difficult. The prolonged time outside the nest gives a threat of cooling, which is a cause of increased mortality. Such a situation may have arisen in Wielikąt where on average higher nests were recorded than in Bytom-Rozbark (see Tab. 5). Moreover, nests in Wielikąt were located amongst less dense vegetation, which certainly increased the detectability of chicks to predators.

It is probable that the resident Moorhens – wintering in the industrial reservoirs (Cempulik 1991) – are killed more rarely as a result of collisions with aerial obstacles (Heynis 1980) or vehicles (Engler 1980) than those which undertake migration – such as the Wielikąt birds. This is certainly an additional factor in the occurrence of a population density about 20 times higher in the industrial reservoirs than in Wielikąt.

CONCLUSIONS

1. In Wielikąt (fish ponds and channels) the migratory population of Moorhens nested at moderate density. In this community of aquatic *Non-Passeriformes* it was an accompanying species (accounting for about 4% of the population of this community).

2. It was shown that Moorhens prefer channels, and then small, shallow ponds with a broad fringe of emergent vegetation in which there is a high representation of *Typha spp.* The preference for the channel habitat at Wielikąt as best for breeding performance, was expressed in terms of the rapid occupation of territories and the greater number of pairs initiating breeding in the first half of the season. In the studied habitats, the greatest number of eggs per clutch and the greatest egg sizes were associated with the channels.

3. The Wielikąt habitat was not saturated by this species: e.g. in 1986 there was the possibility for an increase in the size of the population of about 43%.

4. In Wielikąt, the number of pairs initiating first broods was similar in the designated earlier and later periods of the breeding season. The later occupation of territories by some of the pairs from this population was not the result of an absence of suitable places for nesting in the initial period of the breeding season, but was probably the result of later return from the wintering grounds. A lower average number of eggs in clutches in the second half of the breeding season was recorded there. This may have resulted from the later arrival of young females at the breeding site. Also, only a single case of second brood was recorded there.

5. In Wielikąt, breeding losses amounted to 30%, of which half resulted from predation (mainly by *Corvus c. cornix* and *Pica pica*). The remaining losses were mainly the result of waves.

6. In Bytom-Rozbark, a probably resident population of Moorhens nested in industrial reservoirs in a suburban landscape. Densities of breeding pairs amongst the highest in Europe for this species were recorded there (46.1 – 93.3 pairs/10 ha of reedbed). The Moorhen was a decided dominant within the community of waterbirds there. The high density and decided dominance of the Moorhen amongst waterbirds in Bytom-Rozbark was favoured by such features of the habitat as: the small size and limited depth of the reservoirs, the broad fringe of emergent water vegetation and a higher representation of *Typha spp.* These features were also preferred at Wielikąt, but occurred to a greater degree in Bytom-Rozbark. In addition , more vegetation from the previous seasons occurred in the latter habitat.

7. In Bytom-Rozbark, about 75% of first broods were initiated in the first half of the breeding season. Probably in connection with this, as many as 30% of the studied pairs (n = 59) went on to a second brood. There was a tendency towards the laying of a larger number of eggs, and eggs of larger size, than in the Wielikąt ponds (excluding the channels). The average clutch size in this habitat was similar in the first and second halves of the breeding season.

8. In Bytom-Rozbark (in comparison to in Wielikąt), nests were located in shallower water, in broader fringes of bulrushes and more often amongst *Typha spp.* These differences resulted from the character of the reservoirs, their surroundings, the pressure and character of predation and human activities. All of the losses there were the result of predation, and amounted to only about 15%.

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STRESZCZENIE

[Ekologia lęgów kokoszki wodnej *Gallinula chloropus* na Górnym Śląsku]

Celem pracy było poznanie przyczyn wysokiego zagęszczenia populacji lęgowej kokoszki wodnej na zbiornikach przemysłowych Górnego Śląska, w porównaniu z liczebnością tego gatunku na stawach rybnych tego regionu. Badania objęły niektóre aspekty ekologii rozrodu w środowisku stawów rybnych i kanałów w Wielikącie (gm. Lubomia k. Raciborza) i na zbiornikach przemysłowych w krajobrazie podmiejskim w Bytomiu-Rozbarku. Powierzchnia stawów z wodą w Wielikącie wynosiła od 222,7 do 260,4 ha, a roślinność wodna wynurzona stanowiła w tym 4-5% powierzchni. Kanały przy stawach miały łącznie około 3 km długości, 2–4 m szerokości i były w znacznej części zarośnięte. Wypełnione wodą zbiorniki przemysłowe w Bytomiu-Rozbarku posiadały powierzchnię 35,8 ha, w tym około 21% stanowiła powierzchnia roślinności wynurzonej. W Wielikącie w latach 1982-86 dążono do wykrycia wszystkich par i gniazd, jak i prowadzono dokładny opis wszystkich stawów i kanałów wielikąckich. W latach 1987-89 dążono tylko do wykrycia wszystkich par. W Bytomiu-Rozbarku w latach 1983, 1987 i 1989 dążono do wykrycia wszystkich par lęgowych i gniazd. W 1987 roku dokonano oceny liczebności całej populacji w Bytomiu. Prowadzono również badania mające ustalić udział kokoszki wodnej w ugrupowaniu lęgowym wodnych *Non-Passeriformes* w tych środowiskach.

Spośród stanowisk (n = 29), które były dogodne do lęgów przez pięć sezonów, najwięcej (około 45%) było zajmowanych przez cztery sezony (ryc. 1). Stwierdzono istnienie znacznej liczby nie zajętych, potencjalnie dogodnych stanowisk (ryc. 2). Kokoszka wodna preferowała w Wielikącie kanały i małe, płytkie stawy o szerokich pasach roślinności wodnej, wynurzonej gdzie dominowała pałka i regularnie przebywał człowiek (tab. 1). W Bytomiu-Rozbarku miały miejsce większe zmiany liczebności (ryc. 3). Na zbiornikach przemysłowych wykazano 18–22 razy wyższe zagęszczenie badanego gatunku niż łącznie na stawach i kanałach w Wielikącie (tab. 2).

W Wielikącie (w porównaniu z Bytomiem-Rozbarkiem) gniazda były umieszczane głównie tam, gdzie regularnie przebywali ludzie i w tych fragmentach środowiska, gdzie w otoczeniu rosły drzewa (tab. 3). W Bytomiu-Rozbarku gniazda były umieszczane na małych zbiornikach, w szerokich pasach roślinności wodnej – rosnącej w płytkiej wodzie i z dużym udziałem pałek (tab. 3 i 4) i roślinności nagromadzonej przez wiele lat. Na zbiornikach przemysłowych gniazda były mniejsze i rzadziej zanurzone, a jeżeli występowało zanurzenie, to było ono mniejsze niż w Wielikącie (tab. 5). W środowisku tym w odróżnieniu od Wielikąta, zdecydowanie więcej lęgów pierwszych odbyło się w pierwszej połowie sezonu lęgowego (ryc. 4). Na zbiornikach przemysłowych około 30% spośród badanych par przystąpiło do lęgów drugich, a w Wielikącie tylko około 4%. Największą średnią wielkość pierwszych zniesień stwierdzono na kanałach wielikąckich (tab. 6). W Wielikącie występowała różnica średniej wielkości pierwszych zniesień między pierwszym a drugim okresem sezonu lęgowego. Takiej różnicy nie stwierdzono w Bytomiu-Rozbarku (tab. 6). W obu środowi-

skach około 76% pierwszych zniesień zawierało od 6 do 9 jaj (ryc. 5).

Wyraźnie wyższe straty w lęgach stwierdzono w Wielikącie (tab. 7). W tym środowisku 50% strat spowodowały drapieżniki, a pozostałe były wynikiem zatapiania gniazd przez falowanie i sporadycznie przez zmiany poziomu wody i działalność człowieka. W Bytomiu-Rozbarku wszystkie straty wynikały z drapieżnictwa. Na badanych powierzchniach wysokość i przyczyny strat były zbliżone w wyróżnionych okresach sezonu lęgowego. Poziom strat spowodowanych przez drapieżniki w badanych środowiskach był zbliżony (około 15%). W Wielikącie gniazda umieszczane wśród roślinności z bieżącego sezonu były niszczone częściej niż gniazda umieszczane wśród roślinności pochodzącej głównie z poprzednich sezonów wegetacyjnych.

Wykazano, że dla kokoszki wodnej kanały między stawami Wielikąta były środowiskiem optymalnym. Terytoria były tam zajmowane wcześniej niż na stawach i więcej par przystępowało do lęgów w pierwszej połowie sezonu lęgowego. Tam też stwierdzono największą w badanych środowiskach średnią liczbę jaj w zniesieniach i największe rozmiary jaj. Wysokie zagęszczenie par lęgowych na zbiornikach przemysłowych było zapewne wynikiem wielu przyczyn. Przyczyny te tkwiły głównie w strukturze przestrzennej środowiska lęgowego (występowało tam nagromadzenie cech, co do których udowodniono, że są preferowane przez kokoszkę wodną) i prawdopodobnie w zachowaniu tych ptaków w okresie polęgowym. Na zbiornikach bytomsko-rozbarskich większa liczba lęgów zakończyła się sukcesem, jak i większa liczba par osiągała sukces lęgowy (tab. 7). Podczas badań na powierzchni wielikąckiej wykazano, że zatapianie gniazd jest na stawach przynajmniej tak samo ważnym czynnikiem ograniczającym rozród kokoszki wodnej, jak drapieżnictwo. W Wielikącie istniały odpowiednie warunki struktury przestrzennej środowiska, aby liczebność populacji lęgowej była tam znacznie większa. Brak wysycenia tego środowiska był prawdopodobnie skutkiem wielkości produkcji potomstwa przez tamtejszą populację i jej przeżywalności w sezonie polęgowym, w tym podczas wędrówek i zimowania. Stwierdzono, że synantropizacja kokoszki wodnej na Górnym Śląsku jest powszechna, lecz proces urbanizacji tego gatunku dopiero się rozpoczyna.

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