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The White Stork *Ciconia ciconia* in the Legnica-Głogów copper industry district (SW Poland) – population density and breeding results

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Abstract The population density and brood results of the White Stork were studied between 1984 and 1991 in Legnica voivodeship (4037 km^2), where a large copper industry centre has been developed for over 30 years. A total of 2217 data items, concerning nest occupation and brood results, were collected in relation to ca. 350 nests in the study area. The density of breeding pairs was 6.7/100 km^2. The copper industry was not found to have any direct negative impact on population dynamics and breeding parameters. In the 640 km^2 former administrative district ("powiat") of Legnica, where a metalworks has been operating since 1959, the density of the White Stork population has been increasing since 1922. In Legnica voivodeship as a whole, the population density increased by about 35% between the years 1974 and 1984 or by more then in the majority of the adjacent voivodeships. The mean numbers of young per breeding pair (JZa) – 1.98 and per successful pair (JZm) – 2.54 as well as the proportion of unsuccessful pairs (%HPo) – 19.4% were similar to the values recorded in the other regions of Poland. Brood results around the metalworks – the most heavily polluted areas – revealed no negative impacts on JZa, JZm or %HPo, in relation to distance from the metalworks or wind direction.

Key words: White Stork *Ciconia ciconia*, copper industry, environmental changes, population density, brood results.

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INTRODUCTION

The White Stork is one of the species whose number are seen to be falling and whose range is contracting out of areas which had formerly been long-occupied (Dallinga & Schoenmaker 1984, Rheinwald 1989). A decline has also been reported in Poland, with the breeding population down 10% between 1974 and 1984 (Profus *et al.* 1989). It is considered that this phenomenon is a consequence of the decrease in that part of the landscape comprising meadows and pastures – the availability of which is one of the most important factors regulating the size of breeding population of the White Stork (Bogucki & Ptaszyk 1986, Ptaszyk 1991, Randik 1989). Research in Poland has confirmed that these biotopes are the most important foraging grounds for the species (Pinowski & Pinowska 1989). However, research has not previously considered the influence of heavy industry on the state of the population of this species.

The voivodeship province of Legnica is one of the regions of Poland where the environment has changed radically in a short time. Between 1960 and 1980, this area was transformed from a typical agricultural region into a great centre for the extraction and processing of copper. The mines, metalworks and other works which appeared in the Legnica-Głogów district have contributed to a marked degradation of the environment and to its contamination with a wide range of harmful chemical compounds. Attesting to this are the results of evaluation of water quality (Florczyk *et al.* 1979), soil studies (Pacyna *et al.* 1981, Roszyk 1978) and studies of crops (Roszyk 1978, Szerszeń *et al.* 1978).

The work described in this paper is based on the results of research into breeding of the White Stork which was carried out in Legnica voivodeship between 1984 and 1991. One of the aims has been to define the influence of the copper industry on the size of breeding population of the White Stork, and the effectiveness of its reproduction.

THE STUDY AREA

The voivodeship of Legnica

The voivodeship of Legnica covers 4037 km^2 and includes all or parts of some 14 physiographic units (Fig. 1). Lying in the warmest south-western region of Poland, the voivodeship has a mean temperature of 8.5°C for the year as a whole, and means of 2.0°C and 18.5°C for January and July respectively. The growing season lasts for between 220 and 230 days. At 500–600 mm, mean annual precipitation is close to that reported for the greater part of Poland (Kondracki 1981). Land-use is also typical for the country's agricultural regions, with arable land accounting for 49%, forests for 24%, meadows for 7% and pastures for 5%. There is a well-developed pattern of human settlement, with 14 settlements per 100 km^2, and the density of the population is 123/km^2 (W.U.S. 1987).

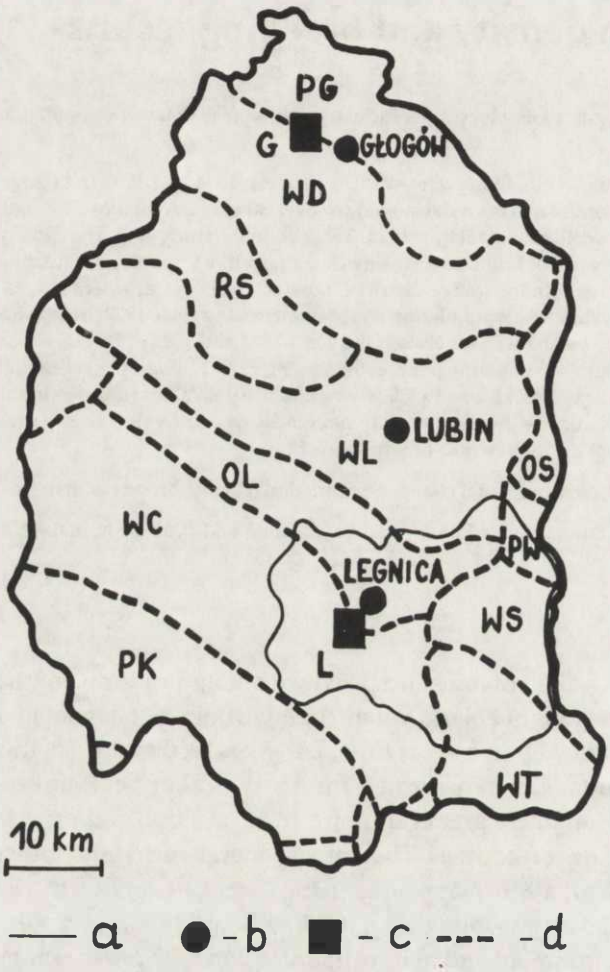

Fig. 1. The physiographic units in the voivodeship of Legnica. a – borderline of the former administrative district ("powiat") of Legnica, b – towns with over 25000 inhabitants, c – localisation of the metalworks "Głogów" (G) and "Legnica" (L), d – physiographic units.

[Ryc. 1. Województwo legnickie – podział na jednostki fizjograficzne. a – granice dawnego powiatu legnickiego, b – miasta powyżej 25 tys. mieszkańców, c – lokalizacja hut "Głogów" (G) i "Legnica" (L). Jednostki fizjograficzne: OL – Obniżenie Legnickie, OS – Obniżenie Ścinawskie, PG – Pradolina Głogowska, PK – Pogórze Kaczawskie, PW – Pradolina Wrocławska, RS – Równina Szprotawska, WC – Wysoczyzna Chojnowska, WD – Wzgórza Dalkowskie, WL – Wysoczyzna Lubińska, WS – Wysoczyzna Średzka, WT – Wzgórza Strzegomskie.]

The Legnica-Głogów Copper District

The beginning of the 1960s saw the onset of the development of the copper extraction and processing industry in the Legnica-Głogów District. The environment of Legnica voivodeship has changed considerably as a consequence. Tomaszewski (1974) grouped these changes into the following categories:

1) Morphological changes – the appearance of mineworkings, spoil heaps and settling ponds;

2) Hydrographic changes – pollution of watercourses, drying up of wetlands, excessive damming of rivers and streams and lowering of the water table;

3) Atmospheric changes – pollution by particulates and gases released as a results of the activities of the metalworks, evaporation from the surfaces of settling ponds and the drying of copper concentrate;

4) Biological changes – e.g. the disappearance of forests, falling harvests, declines in the nutritional value of crops and the disappearance of certain groups of plants and animals.

Almost the whole of Legnica voivodeship is at present classified as a zone of ecological threat. Of particular significance in the contamination of the environment are the emissions from metalworks of considerable amounts of SO_2 and CO, as well as of particulates containing the toxic compounds of the heavy metals Cd, Pb, Zn and Cu. It should be stressed, that these metalworks are localised close to the areas with high density of breeding population of the White Stork.

MATERIALS AND METHODS

The main method by which data on the breeding of the White Stork was obtained was direct monitoring in the field. In some cases, this was supplemented by

interview given by the inhabitants of villages. Further sources of data were surveys sent to the head of each village ("sołtys"), in 1984 and 1989, and directly to the owners of farms with storks'nests, in 1990. Obtained in total were some 2217 items of data concerning the nest occupation and brood results in particular years of around 350 nests within the study area. Complete counts (involving the monitoring of all settlements) were carried out in 1984 and 1991.

The text employs abbreviations which are commonly accepted in works on the White Stork (e.g. Jakubiec 1985):
JZa – average number of nestlings per nest occupied by a breeding pair;
JZm – average number of nestlings per nest with brood;
%HPo – proportion of nests with unsuccessful broods among those occupied by breeding pairs for which breeding has been determined.

RESULTS

The state of the population and indices of reproduction

In the years 1984–1991, the density of breeding pairs in Legnica voivodeship was 6.7 per 100 km^2. In individual physiographic units it ranged from 0 to 23 pairs per 100 km^2 (Fig. 2.). The density was higher in lower-lying areas (such as OL and PG, see Fig. 2). This fact was connected with the greater representation in these areas of meadows and pastures – the main feeding grounds of storks.

There were considerable variations in the values obtained for the whole voivodeship for the main indices of reproduction (Tab. 1) – JZa, JZm and %HPo (see "Material and methods"). However, geographical variation in JZa and JZm was slight: values of the coefficients of variability for individual physiographic units were 5.6 and 4.9% respectively. Only %HPo was more variable, with a c.v. of 23.9% (see Fig. 3).

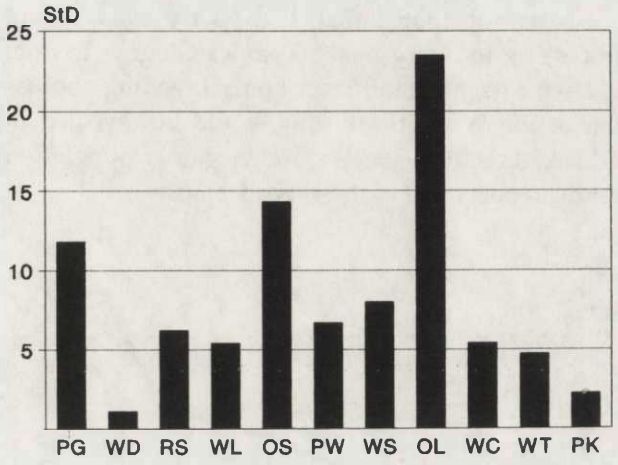

Fig. 2. Density of nests ocuppied by breeding pairs per 100 km^2 (StD) in 1984 in those physiographic units of the voivodeship of Legnica (Fig. 1) in which the White Stork was nesting.

[Ryc. 2. Zagęszczenie gniazd zajętych przez pary lęgowe na 100 km^2 (StD) w roku 1984, w tych jednostkach fizjograficznych województwa legnickiego (ryc. 1), w których bocian gnieździł się.]

Table 1. Variability in the average number of nestlings per breeding pair (JZa), and per successful pair (JZm), and proportion of unsuccessful pairs (%HPo) in Legnica voivodeship (1984–1991); c.v. – coefficient of variability.

[Tabela 1. Zmienność średniej liczby młodych na parę lęgową (JZa), na parę z sukcesem (JZm) i udziału par lęgowych bez sukcesu (%HPo) w województwie legnickim (1984–1991); c.v. – współczynnik zmienności.]

	x	min.-max.	c.v.
JZa	1.97	1.59-2.55	15.7
JZm	2.51	2.14-3.00	12.7
%HPo	20.0	14.9-28.1	25.6

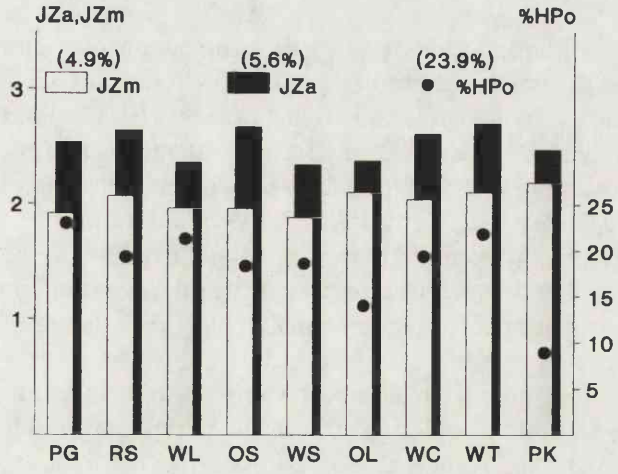

Fig. 3. Average long-term (1984–1991) indices for the reproduction of the White Stork in physiographic units. JZa, JZm, %HPo – see Table 1.

[Ryc. 3. Średnie wieloletnie (1984–1991) wskaźniki rozrodu bociana białego w jednostkach fizjograficznych. JZa, JZm, %HPo – patrz Tab. 1.]

The dynamics of the population studied

It was anticipated that, if copper extraction and processing industry in the Legnica-Głogów District had had a negative influence on the breeding population of the White Stork, this would be revealed in reduced breeding success and negative population trends in part or all of the voivodeship.

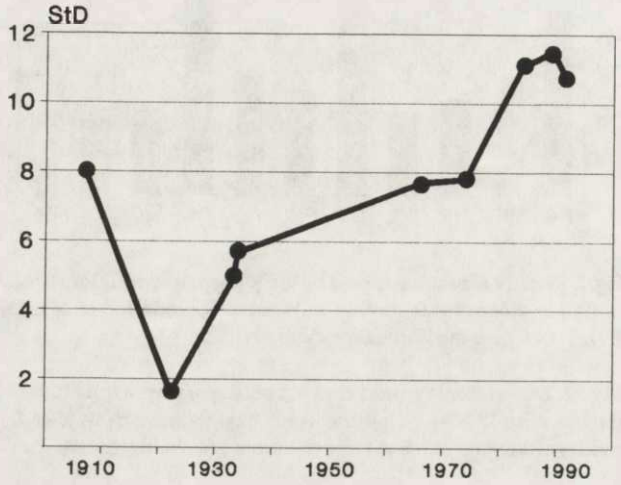

Fig. 4. Changes in the numbers of White Storks in the 20th century in the former administrative district ("powiat") of Legnica. StD – nests occupied by breeding pairs per 100 km^2.

[Ryc. 4. Zmiany liczebności bociana białego w XXw. w dawnym powiecie legnickim. StD – zagęszczenie gniazd zajętych przez pary lęgowe na 100 km^2.]

Although there is a lack of complete historic data on the size of the studied population in the voivodeship as a whole, it is known that numbers have tended to increase since 1922 in part of it – the former administrative district ("powiat") of Legnica (Brinkmann 1935, Pax 1925, Tomiałojć 1972, 1985, author's data) – as Fig. 4 presents. An apparent slight decrease in the number of breeding pairs in 1991 was the results of the occupation of an exceptionally high percentage of nests by non-breeding birds. In 1974 and 1984, nationwide counts showed that the voivodeships in southwest Poland varied greatly in the population trends observed (Profus *et al.* 1989). However, as Fig. 5 shows, there was a clear rise in the density of breeding pairs in the adjacent voivodeships of Legnica and Wałbrzych. Thus the influence of the copper extraction and processing industry in the Legnica-Głogów District has not been strong enough to prevent a rapid increase in the population of the White Stork which

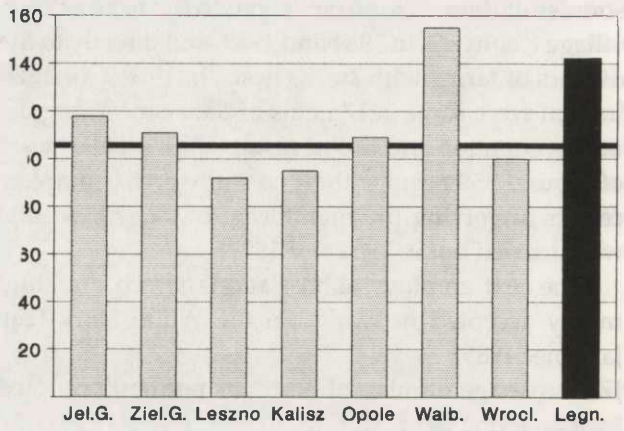

Fig. 5. Changes in the numbers of White Storks in the voivodeships of south-west Poland in the years 1974 to 1984 – as a percentage of the state in 1974 (after Profus et al. 1989).

[Ryc. 5. Zmiany liczebności bociana białego w województwach płd.-zach. Polski w latach 1974–1984 – jako % w stosunku do stanu w roku 1974 (wg Profusa et al. 1989).]

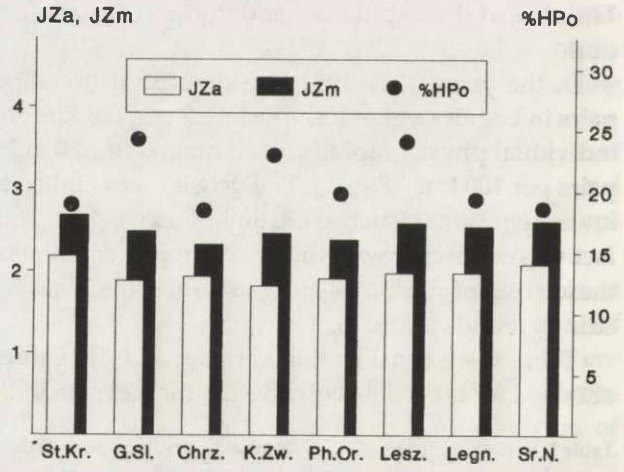

Fig. 6. Long-term averages for indices of reproduction in various regions of southern and western Poland, after Jakubiec et al. (1986) and author's own data. JZa, JZm and %HPo – see Table 1. Abbreviations for geographical names explained below.

[Ryc. 6. Wskaźniki rozrodu (średnie wieloletnie) w różnych rejonach Polski zachodniej i południowej wg Jakubca et al. (1986) i danych własnych. JZa, JZm i %HPo – patrz Tab. 1. Skróty nazw geograficznych: Chrz. – dawny powiat Chrzanów, G.Sl. – Górny Śląsk, Jel.G. – woj. Jelenia Góra, K.Zw. – Kotlina Żywiecka, Legn. – woj. Legnica, Lesz. – woj. Leszno, Ph.Or. – Podhale i Orawa, St.Kr. – powiat Strzelce Krajeńskie, Śr.N. – Środkowe Nadodrze, Walb. – woj. Wałbrzych, Wrocl. – woj. Wrocław, Ziel.G. – woj. Zielona Góra.]

runs counter to the trend in most of the voivodeships in south-west Poland, where the number of breeding pairs has remained constant or even declined. Examples of the latter trend are given by the voivodeships of Leszno and Kalisz (Fig. 5).

Similarly, indices for the reproduction of the population (JZa, JZm and %HPo) were within the range reported for other areas (Fig. 6). Thus, on the scale of the voivodeship as a whole, there was no evidence that the presence of the copper industry had had an influence on the state of the White Stork population, or on the indices describing its reproduction.

The influence of the distance from the metalworks

Analysis was carried out to investigate variations in the indices of reproduction within the population studied. It was felt that part of the population could have been located within some zone of negative influence around individual works in the Copper District. Consideration was given to the work of Pacyna *et al.* (1981), who showed that, at a distance of 8 km from a metalworks, soil concentrations of Cu, Pb and Cd had decreased to a "background" level typical of very distant sites (the equivalent figure for Zn was as little as 4 km). Similarly, a study of concentrations of heavy metals in lichens has indicated a zone of strong atmospheric contamination extending to 11 km from emission sources at a copper processing works (Bielecki *et al.* 1978). Kabata-Pendias (1979) showed that the influence of particulates from metalworks on the contents of copper and lead in cereals remained distinct at a distance of up to 12 km.

On the basis of these studies, it was considered that the part of the White Stork population most endangered by emissions was that nesting within 10 km of copper works. Comparisons were therefore made between the indices of reproduction for populations nesting near to, and far from, metalworks – e.g. in RS (Fig. 1). These comparisons (Fig. 7) did not reveal any effect of distance where JZa and JZm were concerned. Indeed, in the case of %HPo, the results completely defied expectations by being significantly lower near metalworks (χ^2 test, $p<0.05$).

The influence of a gradient of distance from the metalworks was studied by reference to a sample of 140 nests within 15 km of the "Legnica" metalworks. Nests with data items from less then 5 years were omitted, but correlations analysis was performed on the remaining 71 nests, using distance, and the long-term averages of JZa, JZm and %HPo for a number of years. No statistically significant correlations were found for JZa or JZm ($r = -0.12$, $p = -0.32$ and $r = 0.12$, $p = 0.31$ respectively). Expectations were again defied by %HPo, which was found to rise with distance from the metalworks ($r = 0.30$, $p = 0.0093$).

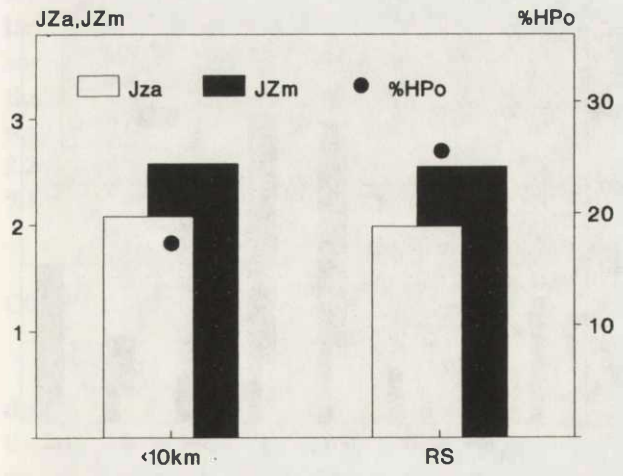

Fig. 7. Long-term averages for indices of reproduction in the proximity of (km from) copper works and at a distance from them – in the RS subdivision (see Fig. 1), JZa, JZm and %HPo – see Table 1.

[Ryc. 7. Wskaźniki rozrodu (średnie wieloletnie) w pobliżu hut miedzi (km) i z dala od nich – na Równinie Szprotawskiej (Ryc. 1). JZa, JZm i %HPo – patrz Tab. 1.]

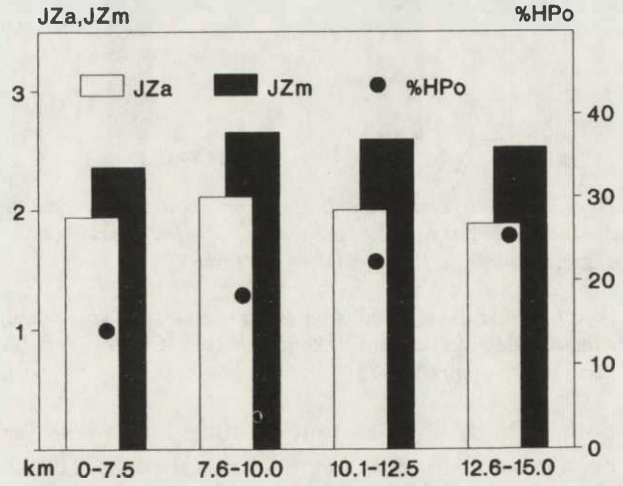

Fig. 8. Long-term averages for indices of reproduction in the km distance zones distinguished around the "Legnica" metalworks. JZa, JZm and %HPo – see Table 1.

[Ryc. 8. Wskaźniki rozrodu (średnie wieloletnie) w wyróżnionych strefach odległości (km) wokół huty "Legnica". JZa, JZm i %HPo – patrz Tab. 1.]

A different method of investigating relationships between the distance of a nest from a metalworks and indices of reproduction was to identify distance zones. Such an approach did not require that nests with small numbers of data items be excluded because long-term averages from a number of years were calculated for all the nests within a given zone. In spite of this, there was once again no evidence of any influence of the distance of a nest from the metalworks on JZa and JZm (Fig. 8), while %HPo again defied expectations by increasing with distance. The difference between the nearest and farthest zones came close to achieving statistical significance (χ^2 test, $0.05<p<0.1$).

In the case of the Głogów I and II metalworks, the smaller number of nests around the complex and the shorter series of data for some nests made it impossible to calculate the correlation between the distances of nests from the metalworks and indices of reproduction, or to distinguish four distance zones – as had been possible for the "Legnica" metalworks. Two distance zones were compared, but there was again no demonstrable link between distance from the source of emission and reproductive indices (Fig. 9). In this case, %HPo did conform to expectations by being higher closer to the metalworks, but this differences was not statistically significant (χ^2 test, $p>0.2$).

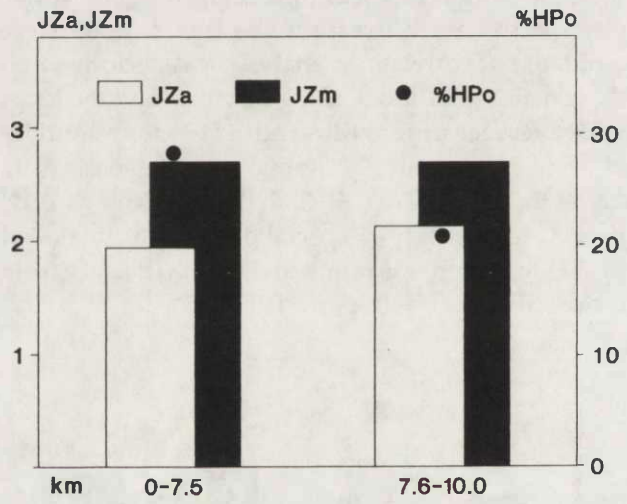

Fig. 9. Long-term averages for the indices of reproduction in the km distance zones distinguished around the "Głogów" I and II complex of metalworks. JZa, JZm & %HPo – see Table 1.

[Ryc. 9. Wskaźniki rozrodu (średnie wieloletnie) w wyróżnionych strefach odległości (km) wokół kompleksu hut "Głogów" I i II. JZa, JZm i %HPo – patrz Tab. 1.]

In the case of "Legnica" metalworks, further analysis was carried out which eliminated the influence of wind direction. The 4 sectors of wind rose with the largest numbers of nests were considered, and analysis was carried out to determine if there was any correlation between the three indices of reproduction for nests in given sector and the distance from the metalworks. A total of 12 correlation analyses were performed, but none of these gave a statistically significant result.

The influence of the frequency with which the wind blows in particular directions was also eliminated in comparison of data from the N and NW sectors around the "Legnica" metalworks. As is seen below, the wind blow in these two directions with very similar regularity, and the distribution of nests in relation to the emission source is different in these two sectors. 66% of nests in the N sector were less than 9 km from the metalworks, while 95% of nests in the NW sector were at distances greater than 9 km. In spite of this, the sectors did not differ significantly where indices of reproduction were concerned. Values of JZa were 2.0 and 1.9 respectively, values of JZm – 2.4 and 2.5 and values of %HPo – 16.2% and 25.0%.

The influence of wind direction

The search for a link between the location of nests on the wind rose around the "Legnica" metalworks,

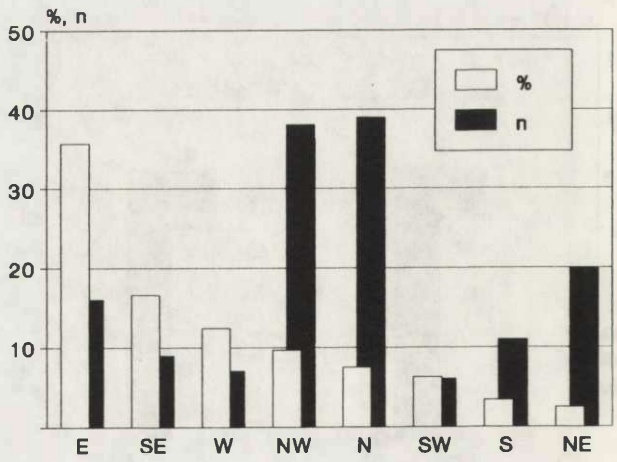

Fig. 10. Frequency (percentage of days in a year on) with which winds blow towards sectors of the wind rose around the "Legnica" metalworks, and the number of nests in sectors (n)

[Ryc. 10. Częstotliwość wiatrów (% dni w roku) wiejących w kierunku sektorów róży wiatrów wokół huty "Legnica" i liczba gniazd w sektorach (n).]

and indices of reproduction, was complicated by the unfavourable distribution of nests between sectors (Fig. 10). The lack of any such link is indicated by the very low level of statistical significance between the long-term averages for indices of reproduction in a sector and the frequency with which wind blow in that direction (r ranged from -0.08 to 0.50 and p ranged from 0.085 to 0.21). Also insignificant was the correlation between the frequency with which wind blows in the direction of a given sector and the number of nests in that sector.

Data from the nests around the "Głogów" I and II complex also gave no indication of an influence of wind direction on two of the indices of reproduction. Expectations were again defied in the case of the proportion of nests with unsuccessful breeding, which was smaller the more often winds blew in a particular direction. Statistically significant differences were noted for this index when the E sector (in whose direction winds blew most often) was compared with the SE+NE and N+S sectors (sectors with similar frequency of winds were combined), and with the W sector (χ^2 tests, $p<0.05$, $p<0.001$ and $p<0.05$ respectively).

Analysis of the influence of wind direction on indices of reproduction in the E and NE sectors allowed for the elimination of the disruptive influence of distance from the metalworks. As Fig. 10 shows, these two sectors differed maximally in the percentage of winds blowing in their direction, but had a very similar distribution of nests in relation to distance from the source of emission. In spite of this, the values for the three indices of reproduction were not found to differ significantly. In the two sectors, the values of JZa were 2.2 and 2.1, values of JZm – 2.8 and 2.7, and values of %HPo – 18.2 and 20.0, respectively.

CONCLUSIONS

1. The area's copper extraction and processing industries were not found to have a demonstrable negative influence on the numbers, or the effectiveness of reproduction, of White Stork in the voivodeship as a whole. Indeed, along with that of Wałbrzych, it was the voivodeship of Legnica which showed the greatest increase in numbers to be noted among the eight voivodeships of south-west Poland. Long-term averages for the main indices of reproduction (the average number of young per breeding pair (JZa), the average number of young per pair with young (JZm) and the percentage of unsuccessful broods (%HPo)) were within the range of values reported from other regions of Poland.

2. No negative influence was determined for the breeding results of pairs nesting in the vicinity of the most environmentally-burdensome copper works of the Legnica-Głogów Copper District. The mean numbers of young reared by breeding pairs (JZa) or pairs with young (JZm) was not related to the distance of nests from the metalworks. Indeed, the average proportion of unsuccessful broods (%HPo) fell with the increasing proximity of individual nests to the "Legnica" metalworks. This is to say that the relationship was contrary to expectations.

3. Wind direction did not give rise to any variations in the indices of reproduction in nests located around metalworks.

4. The following factors may help to explain the fact that the population dynamics and effectiveness of reproduction of the species showed no visible reaction to the extensive transformations of the environment and to the presence of great amounts of pollutants in it:
– population studied remain in the contaminated areas for a relatively short period (from April to August);
– storks will take a wide range of food, allowing a fall in numbers of some potential prey species to be compensated for with more intensive exploitation of others;
– storks often forage in feeding grounds at considerable distances from the nest and therefore from the metalworks.

5. The methodology applied allowed for the evaluation of the influence of the copper extraction and processing industries on the effectiveness of breeding, and not on the course of breeding. It is, for example, possible, that in areas which are strongly contaminated and transformed, a reduction of breeding success occurs at the hatching stage as was reported for the Marsh Harrier *Circus aeruginosus* by Witkowski (1989) when analysing the influence of pesticides on the reproduction. Furthermore, it may be that, in spite of the more limited food resources in such areas, it may be possible for storks to rear a relatively large number of young, as a result of decreased competition for food between the smaller number of young. In uncontaminated areas, the average number of young hatching

may be greater, but the reduction in breeding success may result from the stronger competition for food in the nest. This may lead to evening-out of breeding success between pairs nesting in areas strongly degraded and beyond.

Translated by dr. James Richards.

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STRESZCZENIE

[Bocian biały *Ciconia ciconia* L. w Legnicko-Głogowskim Okręgu Miedziowym – zagęszczenie populacji i wyniki lęgów]

Celem badań było określenie wpływu przemysłu wydobycia i przetwórstwa miedzi, skoncentrowanego na obszarze Legnicko-Głogowskiego Okręgu Miedziowego, na liczebność i wskaźniki rozrodu populacji lęgowej bociana białego. Badania prowadzono na obszarze województwa legnickiego (4037 km^2) w latach 1984–1991. Łącznie zebrano 2217 informacji o efektach lęgów dla 350 znajdujących się na obszarze badań gniazd. Główną metodą była kontrola terenowa gniazd, a uzupełniającą – ankieta.

Zagęszczenie populacji lęgowej w woj. legnickim wynosiło 6,7 par na 100 km^2, a w poszczególnych jednostkach fizjograficznych – od 0 do 23 par na 100 km^2 (ryc. 2). Wskaźniki rozrodu – średnia liczba młodych na parę lęgową (JZa), na parę z sukcesem (JZm) i udział par lęgowych bez sukcesu (%HPo) – wahały się

w okresie badań znacznie, ale zmienność geograficzna średnich wieloletnich dla JZa i JZm była mała (c.v. odpowiednio 5,6% i 4,9%). Bardziej zmienny był %HPo – c.v. = 23,9% (ryc. 2). W skali całego województwa wpływ przemysłu miedziowego na liczebność populacji oraz wskaźniki rozrodu był niewidoczny. W latach 1974–1984 spośród ośmiu województw Polski południowo-zachodniej, największy wzrost zagęszczenia populacji stwierdzono w Wałbrzyskiem i właśnie w Legnickiem – o 37% (ryc. 5). W dawnym powiecie legnickim (ryc. 1) trend wzrostu zagęszczenia populacji utrzymuje się już od około 70 lat (ryc. 4). Wskaźniki JZa, JZm i %HPo dla woj. legnickiego mieściły się w zakresie wartości podawanych z innych regionów Polski (ryc. 6).

Przeanalizowano także wewnątrzpopulacyjne zróżnicowanie wskaźników rozrodu badanej populacji. Zbadano wpływ odległości od hut miedzi k.Legnicy i k.Głogowa na JZa, JZm i %HPo. Na podstawie innych badań (Bielecki *et al.* 1979, Kabata-Pendias 1979, Pacyna *et al.* 1981) przyjęto, że najbardziej zagrożona emisjami z hut część populacji gniazduje w odległości 10 km od nich. Jednak JZa, JZm na tych obszarach było bardzo zbliżone do notowanych na Równinie Szprotawskiej – z dala od hut, a %HPo był istotnie niższy w pobliżu hut (test χ^2, $p<0,05$), czyli odwrotnie, niż oczekiwano (ryc. 7). Podobny wynik dała analiza korelacji średnich wieloletnich JZa, JZm i %HPo w poszczególnych gniazdach z odległością od huty "Legnica". Dla JZa i JZm współczynniki korelacji były nieistotne statystycznie (odpowiednio $r = -0,12$ przy $p = 0,32$ i $r = 0,12$ przy $p = 0,31$), a %HPo nieoczekiwanie wzrastał wraz z odległością ($r = 0,30$ przy $p = 0,0093$). Ten sam rezultat uzyskano przy analizie średnich wieloletnich JZa, JZm i %HPo w strefach odległości wokół huty "Legnica" (ryc. 8) i huty "Głogów" (ryc. 9). Nie stwierdzono także istotnych korelacji pomiędzy wskaźnikami rozrodu a odległością od hut w poszczególnych sektorach róży wiatrów wokół huty (co pozwoliło wyeliminować wpływ czynnika kierunku wiatru).

Analizie poddano także wpływ kierunku wiatru na wskaźniki rozrodu. W sąsiedztwie huty "Legnica" nie stwierdzono korelacji pomiędzy częstotliwością wiania wiatrów a wskaźnikami JZa, JZm i %HPo. W okolicach kompleksu hut "Głogów" I i II kierunek wiatru nie wpływał na JZa i JZm, natomiast nieoczekiwanie %HPo był tym mniejszy, im częściej wiały wiatry. Różnice dla tego wskaźnika pomiędzy sektorami E (w którego kierunku wiatry wieją najczęściej) a SE+NE i N+S (sektory o podobnej częstości wiania wiatrów połączono) oraz W były istotne statystycznie (test χ^2, przy odpowiednio $p<0,05$, $p<0,001$ i $p<0,05$). W sektorach E i NE, skrajnie różniących się procentem wiatrów wiejących w ich kierunku (ryc. 10), rozkład odległości gniazd od huty "Legnica" był podobny, co pozwoliło wyeliminować jej wpływ. W sektorach tych JZa wynosiło odpowiednio 2,2 i 2,1, JZm – 2,8 i 2,7, a %HPo – 18,2% i 20,0%.

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BOOK RECEIVED

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The atlas covers the period 1985 to 1989. The data were collected by the Aves Ornithological Centre in cooperation with 80 ornithologists. Maps, presenting semi-quantitative data of 110 bird species breeding in the area, are based ona fine grid system (1x1 km). Over and above the atlas itself, the book deals with the occupation by bird communities of main habitats of the region. It also sumarizes the recent transformations of the avifauna, and presents the regional context of wildlife conservation.

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