The breeding ecology of the Mute Swan *Cygnus olor* in central Poland

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This paper describes the breeding performance of the Mute Swan in central Poland. Population size, productivity and possible factors affecting hatching success are discussed. During a four-year study (1997-2000), between 75-101 breeding pairs were found within the study area. Fishponds were the habitat most frequently used by swans in all seasons, and birds preferred small water bodies (5-25ha) to large ones (>25ha). The mean clutch size was 6.02 eggs, and the average number of cygnets fledged per pair was 4.42. Pairs that bred on small ponds had higher breeding success. Food availability within a territory was not correlated with productivity and the number of fledged cygnets did not appear to depend on the intensity of human activities at the site. However, the level of contact with non-territorial birds within breeding territories had a significantly negative effect on the breeding success of a pair.

Key Words: Mute Swan, breeding success, territory quality, intraspecific relationships.

The Mute Swan is one of the most intensively studied wildfowl, with a large volume of literature on general ecology, migration and behaviour (see reviews by Birkhead & Perrins 1986, and Bart *et al.* 1991). However, these studies have mainly been conducted in western Europe where the Mute Swan populations live in relatively close proximity to humans. Few studies have been based on populations from the eastern part of its range in Europe and where these have occurred, they have generally been confined to small study areas (eg Czapulak & Wieloch 1991).

The Mute Swan became a regular breeding bird in central Poland in the late 1960s (Wieloch 1984) but first successfully bred at Walewice fishpond complex (52°06'N, 19°43' E) in 1963

(Wieloch 1984). A census between 1976 and 1979 covered an area of five 'voivodships' in central Poland (approximately 21,500 sq km), revealed the presence of 50 breeding pairs (Wieloch 1984). Since then the species has colonised all main water bodies in the region and stabilised at about 80-90 breeding pairs (Wlodarczyk 1999). The aim of this paper is to describe the Mute Swan's breeding performance following its population expansion in central Poland, and to assess factors that influence the breeding success within the region.

Study area

The study area was situated in central Poland (51°15'-52°06'N, 18°38'-20°00'E) and covered 1,040 km^2. River valleys surround the area from the north, the west and the east, although the region consists mainly of agricultural land that lacks large water bodies. Fishpond complexes are the only common type of water habitat and these are concentrated in the northern part of the study area. Large fishponds are rare and the average size of a pond does not exceed 25 hectares. There are two large reservoirs, Jeziorsko (4,200 ha) and Sulejowski (2,200 ha), within the study area. The western region is rich in small peat bogs and ponds, situated in the River Ner valley. The valley is flooded each spring. Three large cities occur in the study area: Lódz, Piotrków Trybunalski and Tomaszów Mazowiecki.

Methods

The study was conducted during four breeding seasons between 1997 and 2000 inclusive. During the first two years, the whole area was surveyed between the beginning of June and the end of September. In 1999-2000 the survey was started at beginning of March in order to collect data on clutch size and hatching success, and finished in September. 1:50000 maps were used to identify waterbodies in the survey area potentially suitable for swans as breeding grounds. In all years, breeding pairs were visited in late May or early June in order to check the number of hatched cygnets. In 1999-2000, it was possible to assess the hatching date and each pair was visited up to one week after hatching occurred. Additionally, during this visit the nest was checked in order to find any unfertilised or damaged eggs. In cases where the number of observed cygnets was lower that the number of eggs, the number of protein membranes left after hatching in the nest were counted. A second survey of the breeding pairs was made in late August or early September, just before the cygnets were able to fly. At that time the number of fledged cygnets was counted. The studied population consists mainly of pairs that breed alone on the waterbody. In places where two or more breeding pairs occupied the same water body, they avoid each other and so there were no problems with brood mixings at the end of the breeding season. The first two years of the study

were started late in the breeding season so pairs that had lost their nest during laying or incubation were not detected. The results relating to cygnets' mortality, clutch size and hatching success are therefore based on data only from years 1999-2000. Laying and hatching dates were estimated to within one week. To assess factors influencing the breeding performance of a pair, each waterbody occupied by swans was described in relation to the following variables:

Habitat type

Size of water body, type of habitat (four categories: fishpond, river, reservoir, pond, peat bog), percentage of water covered with reeds and with floating vegetation;

Human impact

Number of peopleat a site rated as three types: 1. absence of people; 2. small number of people or visited only during weekend; 3. permanent presence people. Cases of humans feeding swans and distance from the nearest built-up area were also recorded.

Intraspecific relationships

Distance between the nearest reservoirs occupied by swans, distance between two breeding pairs, presence of non-breeding swans in the same waterbody and their number. Four categories were used: 1. Absence of non-breeding swans, 2. Up to 10 birds, 3. Up to 50 birds, 4. More than 50 birds. The degree of contact with non-breeding birds was also recorded in three categories: 0= absence of non-breeding birds, 1= non-breeding birds separated from breeding pair by reed belts or dikes, 2= unlimited visual contact between breeding pair and non-breeding birds.

All data were collected during two visits within a territory. When a territory was part of a larger area (eg a complex of fishponds), the same variables were collected for the whole complex. The association between the variables and the number of fledged cygnets was tested using a one-way ANOVA. It was not possible to use a paired-sample test in the analysis because the number of pairs that were included across a number of years was small. Only 16 pairs were ringed and there was little correlation between years (r_1=0.08, P=0.77, R^2=0.14, P=0.67). The differences among the territories belonging to different categories were tested using t-test and post-hoc HDS Tukey test. To check the significance of using data obtained from the same pairs during four years of studies, the correlation between pair number and number of fledged cygnets was calculated.

Results

During the study period, between 75-101 pairs of swans bred within the study area. The most common type of habitat used by swans in both seasons reflected habitat availability, ie fishponds (**Figure 1**). Birds preferred small

water bodies of up to 25 ha to those exceeding 25 ha (**Figure 2**). Usually only one pair occupied each water body and places where more than two pairs bred in the same place were rare (n=5). There were only eight territories that were occupied temporaility and all of them were abandoned due to human activity within the territory.

The mean clutch size was 6.02 (n=121). The reduction in brood size during incubation was caused by infertility of eggs (7.4% of all eggs, n=500) and loss of eggs due to predation or human activity (22.5% of all nests were destroyed during that time, n=120). The number of cygnets that hatched per pair with at least one cygnet was 5.26 (n=257). The mean size of family at the end of breeding season was 4.42 (n=257). The most frequent were broods with five and six cygnets. The mortality of cygnets during their first three months of life was different between breeding seasons: 15.4% (n=312) in 1999 and 30.4% (n=306) in 2000. The mean number of fledged cygnets for pairs occupying different habitat types differed significantly (ANOVA $F_{4,270}$=2.53, P=0.041), **Figure 3**. The pairs that bred on small ponds had higher breeding success than pairs from large reservoirs (**Figure 4**), and the difference between these two groups was statistically significant (t=2.36, df=190, P=0.019). The number of cygnets fledged did not depend on the intensity of human activity

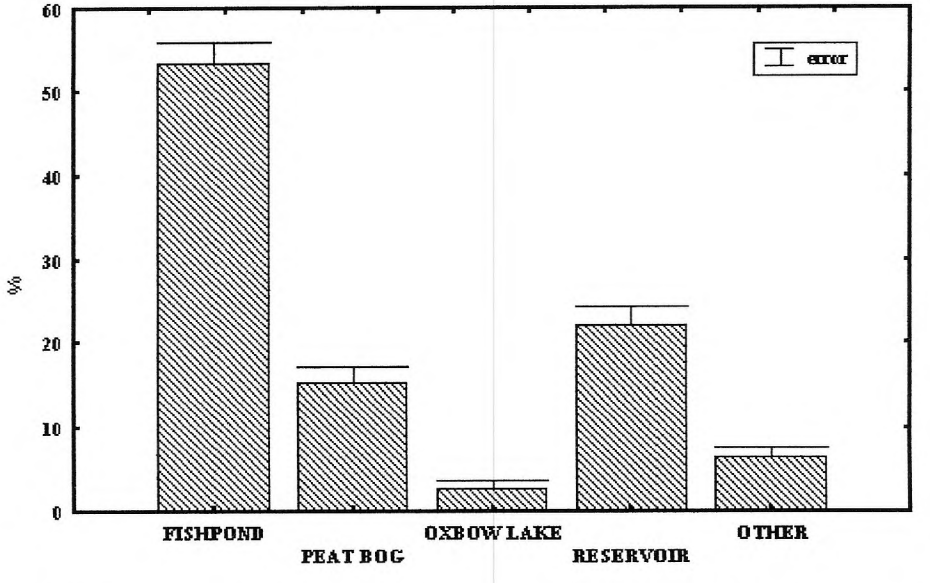

Figure 1. The percentage of nests situated on five main habitat types in central Poland (data for years 1997-2000).

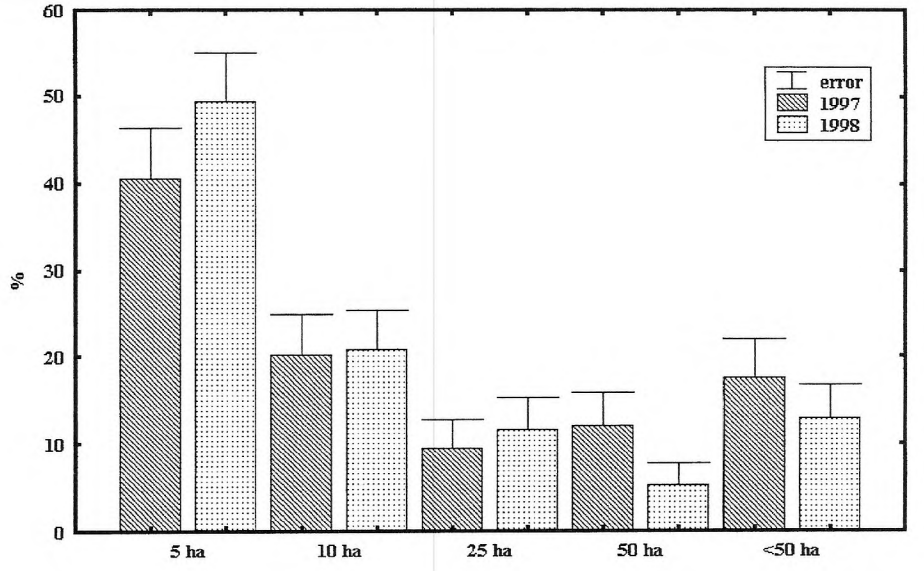

Figure 2. Percentage of nests situated on waterbodies of different size in central Poland (data from years 1997-98).

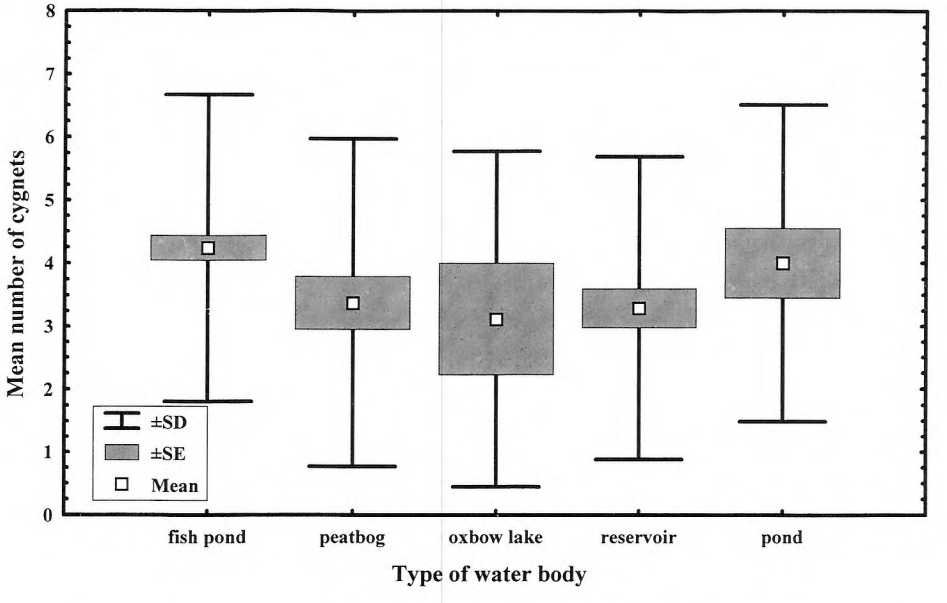

Figure 3. Number of fledged cynets for pairs from different type of habitat. (Square = mean value; box = mean + standard deviation; lines = standard error).

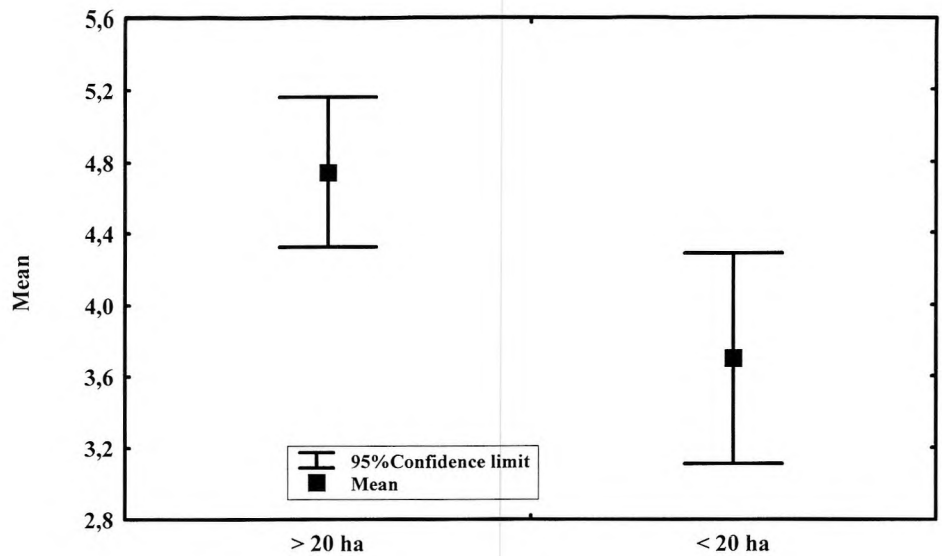

Figure 4. Mean number of cygnets fledged for pairs that breed in two groups of territory size.

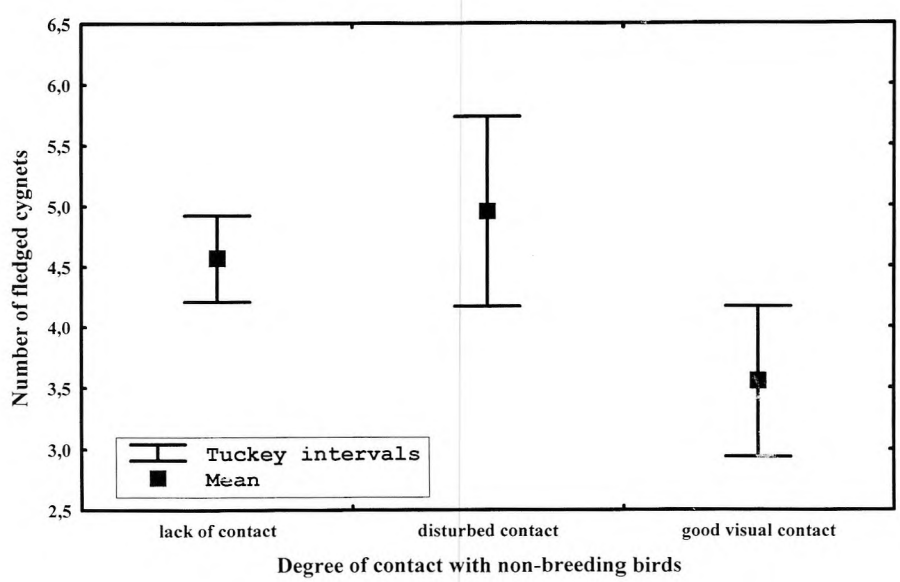

Figure 5. Mean number of cygnets fledged for pairs with different degree of contact with non-breeding birds.

($F_{3,277}$=1.144, P=0.33), or the availability of extra food from humans (bread, fish fodder etc.) ($F_{3,278}$= 1.166, P=0.32). Also the food supply available to birds within the territory, measured separately as the percentage of area covered by emerged and afloat vegetation did not have any impact on the breeding success ($F_{9,194}$= 0.94, P=0.49, $F_{10,141}$=1.42, P=0.176). The intensity of contacts with non-territorial birds that stayed within a territory had a statistically significant effect ($F_{2,247}$=9.783, P=0.001). Such relationships depended on the type of contact with moulting birds. The pairs in good visual contact with non-breeding birds had lower brood size in September than those with partial or no contact with non-breeders (**Figure 5**). Seven sites where the "polish morph" of the Mute Swan bred were recorded during the two years of the study. The percentage of cygnets that belonged to that morph was 3.8. All occurrences were in the northern part of the study area.

Discussion

The Mute Swan has colonised the central part of Poland successfully and its population is now stable. Given the first brood in central Poland occurred 30 years ago, the region now can be regarded as a part of the Mute Swan's main breeding range. There was no

Table 1. Mean number of young Mute Swans reared by a pair.

Country	Brood size	Source of data
Central Poland	4.42	This study
Whole Poland		
Year 1959	4.42	Zajac 1963
Years 1978-79	4.31	Wieloch 1984
Years 1981-89	4.1-4.3	Czapulak & Wieloch 1991
Eastern Germany 1971-74		
Founder population	4.8	Rutschke 1982
Stabalised population	3.9	
Denmark 1966-75	1.9-3.8	Andersen-Harild 1980
Estonia	3.4	Paakspuu 1974*
England 1961-78	3.7	Coleman & Minton 1980
Ireland 1983-89	3.5	Collins 1991
Finland 1969-71	1.4	Happanen 1976
USA 1982-90	2.5-3.9	Conover & Kania 1999

*Recalculated data after Wieloch 1984

marked change in the number of breeding birds during four years of study. The average breeding density based on data from years 1999-2000 gave range from 9.5 to 10.8 breeding pairs per 100 sq. km. This figure is similar to results observed in other parts of central Europe. Wieloch (1984) estimated the breeding density of Mute Swans in central Poland to be 1-10 breeding pairs per km^{-2}. in years 1976-79. In the Netherlands and northeast Germany, the density ranges from four to eight pairs (Hagemeijer & Blair 1997). The tendency for Mute Swans breeding in central Poland to occupy fishponds and reservoirs and to avoid oxbow lakes, is typical for the species in other parts of Poland (Wieloch 1984). A preference for small water bodies as breeding territories has also been described (Wieloch 1984). From the 1970s onwards, Mute Swans in central and eastern Europe started to breed in close proximity to humans, choosing small ponds up to 25 ha in size (Wieloch 1991). This feature of habitat selection has enabled Mute Swans to colonise new areas close to human habitation (Strawinski 1971).

Although earlier studies allude to a shift in breeding behaviour, they did not investigate correlations between the size of breeding area and the number of cygnets fledged (Wieloch 1991). The lower breeding success of pairs with large territories, observed in central Poland, can perhaps be explained in terms of habitat and food availability. Small water bodies are mainly shallow, with dense vegetation, and they serve as excellent feeding grounds while the dense reed belts provide shelter for cygnets. Intraspecific competition in terms of food depletion or territory defence may also be a contributing factor because it is more possible for two or more breeding pairs to occupy the same large water body. Unfortunately, other studies compared only the breeding success between pairs occupying territories that differed in the level of available food but not using the size of territory as a variable (Scott & Birkhead 1983; Collins & Whelan 1990; Spray 1991; Collins 1991). Also in central Poland, there was a significant difference between breeding success for pairs occupying different habitats. The highest values of breeding success were found on fish ponds, the lowest on oxbow lakes and reservoirs (**Figure 3**). This difference could be the result of relatively stable levels of water at fishponds that protects nests from predation. Nests on oxbow lakes and reservoirs were vulnerable to fox or dog predation in dry seasons, as evidenced in 2000 when all nests in these habitats were destroyed.

The observed clutch size during the present study was similar to values observed in other European countries where different populations revealed values from 4.8 to 6.9 eggs per clutch (Smiddy & O'Halloran 1991). Also swans from other parts of Poland had similar clutch size: 6.1-6.2 in southern Poland and 5.8 in the northern part of the country (Czapulak & Wieloch 1991).

The mean number of fledged cygnets was relatively high, but similar to fledging success recorded in other parts of Poland and Europe, especially in expanding populations (**Table 1**). The results are similar to the data for the whole of Poland from the 1970s (Wieloch 1984). The mortality, between 17% and 30%, is similar to a pattern observed in Western Europe (eg the mortality of cygnets from south Staffordshire, England in years 1966-85 was 20-31.4% (Coleman & Minton 1980; Coleman *et al.* 1991) and Swans in Ayrshire, Scotland had a mortality rate between 52.2-25% (Leach 1988). The observed differences in mortality between the two years of study were probably caused by an extremely dry spring in 2000 when many natural water bodies dried out.

There is no example of studies in literature which reveal negative influences of other birds on the pairs of breeding swans except colonial swans (Andersen-Harild 1980). However, this study showed that intraspecific relationships can be crucial for a pair during the time of breeding. Lack of such a negative correlation in territories with reduced visual contact suggests that mainly direct interactions are responsible for the observed situation. Food depletion caused by a large number of birds occupying the same waterbody does not seem to be a key factor in explaining reasons for increasing cygnet mortality. There was no correlation between the number of cygnets and the number of non-breeding birds within territory which could reduce the food availability of the waterbody. Also Conover (1994) did not observe negative impact of the Mute Swan on the food supplies of the waterbody. However, studies from Scotland (Meek 1993) revealed sharp reduction in the number of breeding swans followed by the increase of birds in previous years and connected with this decrease in food supplies. This is why these data need further behavioural studies to test whether there is a difference in behaviour between pairs occupying territories with moulting birds and those that breed in isolation.

The percentage of the "polish morph" within the total number of cygnets (3.8%) was similar to results obtained in other parts of Poland, such as the Barycz valley - 4.0%, and the Lublin region - 2.1% (Wieloch & Czapulak 1991). According to the data on distribution of this morph in Poland, the location of pairs rearing cygnets of "polish morph" in central Poland should be restricted to the southern part of the study area (Wieloch & Czapulak 1991), which differed from the pattern observed in this study. Concentration of pairs with white cygnets in the north is probably caused by a high fidelity of birds to their breeding grounds, but more research is needed on this phenomenon.

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