Effect of Water Level and Livestock on the Productivity and Numbers of Breeding White Storks

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Abstract.—We studied numbers and productivity of the European White Stork (*Ciconia ciconia*) during 1968-2002 at Kłopot village colony (in the Odra River valley, Poland) and their response to water level and livestock farming. The number of nesting pairs (range 19-33) fluctuated independently of the April and June water level, but correlated with the presence of a local livestock farm. The average number of chicks fledged per pair was negatively correlated with the water level in April, when White Storks choose the breeding area. The White Stork appears to use farming activity rather than water level in making a decision as to where to a settle. This result suggests that changes in management practices, which are relatively easily made, may improve demographic parameters of local breeding White Storks. *Received 10 January 2004, accepted 15 December 2004.*

Key words.—*Ciconia ciconia*, White Stork, Poland, floods, dairy farm, population fluctuations.

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Some authors have suggested that population dynamics and nest productivity of the European White Stork (*Ciconia ciconia*) are affected by water levels on the breeding grounds (Dallinga and Schoenmakers 1987; Creutz 1985; Schneider 1988; Bairlein 1991, Goriup and Schulz 1991). Water conditions are thought to influence changes in food resources, but this has been rarely tested (but see Dziewiaty 2002). In years with higher spring water level in rivers, local White Stork numbers were higher and had better breeding success (Creutz 1985; Schneider 1988; Dziewiaty 2002). Increasing local water levels has been suggested as a means to improve breeding densities and breeding success in the White Stork (Dziewiaty 2002).

Vegetation changes along river valleys are caused by a combination of river water level, seasonal flooding regime, meteorological conditions and by the intensity of grazing and mowing (Benstead *et al.* 1999). Thus farming practice can affect the habitat for the White Stork, since they forage on the ground, feeding in shallow water and from food on low plants (Creutz 1985; Sackl 1997; Schulz 1998). Moreover, the presence of grazing animals is known to affect the abundance of insects, mainly large dung beetles associated with cattle faeces (Benstead *et al.* 1999). There is also a positive correlation between the degree of use of pastures and large beetle abundance (Bunalski 1999).

We predicted that in years when cattle intensively grazed pastures located in the Odra River valley that both the number and productivity of the local White Storks would be greater. Recent changes in farm management practices in the Odra valley have altered the habitat for storks. Since the collapse of communism, many of the large livestock farms have been broken up. More recently, with impending accession to the European Union, problems with marketing cattle from farms has led to the abandonment of livestock farming, especially in western Poland. These changes have the potential to influence the Polish avifauna (Denisiuk 1992). Since Poland is host to about a quarter of the total European White Stork population (Jakubiec and Guziak 1998; Schulz 1998), management changes could have major influence on storks in Europe.

In this paper, we consider whether fluctuations in numbers and reproductive success of the White Stork are related to water level and/or the presence of livestock in foraging areas along the Odra River.

STUDY AREA AND METHODS

Study Area

The study was conducted between 1968-2002 in Kłopot village, located in the Odra River valley, western Poland (52°07'N; 14°43'E). It is one of the largest White Stork colonies in Poland (Jakubiec and Guziak 1998) and probably also in Europe (Schulz 1998). The study area includes ca. 50 small farms located in the river valley, an area partly used as pastures, meadows and rarely as arable fields (for further details, see Radkiewicz 1992).

White Stork Census

White Storks built nests mainly on roofs, with increasing numbers nesting on poles. The numbers and productivity of the storks in the study area were determined using the standard methods recommended for the International Census of White Stork (Creutz 1985; Schulz 1999). All nests were located and breeding success was determined by counting the fledglings when well grown in the nests during the first half of July.

Environmental Variables

Information on cattle grazing for each year was obtained from the local administration. Data were coded as 0 (no farming, no pasture in the river valley) and 1 (cows grazed in river valley), because more detailed data were not accessible.

The average daily water level in the Odra River was obtained from a hydrological station at Słubice, 12 km north of the study area.

Statistical Procedures

Number of breeding pairs in the colony, and average fledgling productivity per breeding pair were used as dependent variables in the models with water level and farming activity treated as independent variables. Because, temporal changes in water level and its subsequent influence on the environment is complicated (Chiew and McMahon 1993; Wyżga 1997; Radziejewski and Kundzewicz 1999) two measures were selected for analysis. These were water levels in April—when the majority of the local breeding storks return from the African wintering grounds and make a decision where to breed (Radkiewicz 1984; 1992); and in June—the period of maximum chick growth when parental feeding activity is at its highest (Profus 1986; Johst *et al.* 2001). Water level data and dichotomous information on farming activity were analyzed together using general linear modeling. Basic statistical tests were applied according to Sokal and Rohlf (1995). Data are presented as mean ± SD. Analyses were conducted using the statistical package SPSS for Windows.

RESULTS

Changes in Environmental Conditions

Grazing by farm animals at the State farm in Kłopot village stopped in 1990 due to changes in Polish agriculture after communism. From that year, meadows were not mowed and pastures ceased to be grazed. Consequently, both vegetation height and density were mainly determined by the water level.

Water levels from March 1968 to June 2002 varied from 391cm (values at the standard river stratum above the riverbed) in April 1970 to 156cm in April 1974 and from 346cm in June 1968 to 109 cm in June 1994 (Fig. 1). Water levels in the April and June within years were not significantly correlated (r_{33} = 0.068, n.s.). However the water level in June decreased significantly over the study period (r_{33} = -0.427, P < 0.01).

Number of Breeding Pairs

The number of breeding White Stork pairs varied from 19 to 33 between 1968-2002 (mean 25.7 ± 3.6; Fig. 2). The annual number of breeding pairs without fledgling(s) varied from 1 to 13 (mean 3.9 ± 2.5), which was between 4% and 42% of all breeding pairs in any year. Only a small number of non-breeders (mainly in flocks up to 10) were recorded in the central part of the Odra River valley. These birds never foraged in the same places as the breeders.

Production of Young

The mean number of young produced per pair in a year ranged from 1.83 to 3.60 between 1968-2002 and decreased signifi-

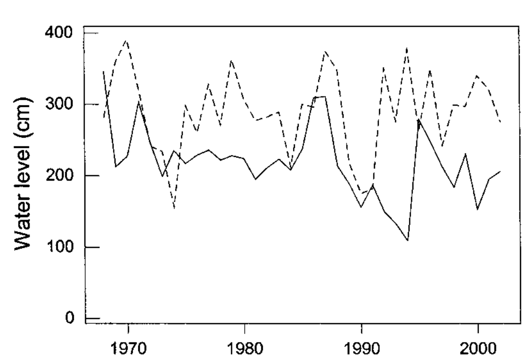

Figure 1. Changes in water level (cm) in the Odra River at Słubice hydrological point, 1967-2002. Broken line - level in April, solid line—level in June.

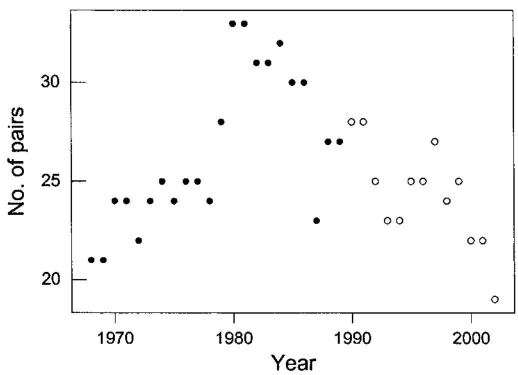

Figure 2. Number of breeding pairs of the European White Storks at Kłopot, 1967-2002. Closed circles indicate years with farming practice in the Odra River valley, open circle years with no farming.

cantly during the study (r_{34} = -0.407, $P < 0.02$, Fig. 3). The average productivity per pair was not correlated with the number of breeding pairs in the study area (r_{33} = 0.143, n.s.).

Relationship of the Numbers of Adult Pairs and Productivity to Water Level and Livestock Farming

The number of breeding pairs in the study area was related to the presence of livestock in the Odra River valley. When the livestock farm existed, local White Stork numbers increased over time (y = 0.382(±0.102)×, t = 3.74, R^2 = 41.2%, $P < 0.001$), and the situation reversed when livestock farming finished (y = -0.473(±0.138)x t = 3.42, R^2 = 51.6%, $P < 0.01$) and both regression slopes differed significantly ($F_{1,32}$ = 15.3, $P < 0.001$). The number of fledglings per pair was inversely related to water level in April (Table 1; r_{34} = -0.418, $P < 0.02$) (Fig. 4).

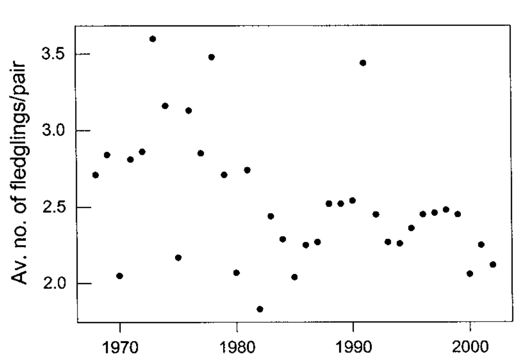

Figure 3. Changes in average numbers of fledglings per pair of the European White Stork at Kłopot 1967-2002.

DISCUSSION

Although this study was limited to one area, we believe that the results have wider significance. The study group of storks is one of the largest in Europe (cf. Jakubiec and Guziak 1998; Schulz 1998).

The density change from year to year was similar to that in other areas where White Stork numbers were counted over long periods (Creutz 1985; Schulz 1998; Tryjanowski and Kuźniak 2002). However, contrary to prediction, we did not find a positive effect of water level in early spring and summer on the number of breeding pairs. Moreover, river water levels in April were negatively correlated with the average productivity per pair. However, it should be taken into account that the effect of water level on flood intensity is often non-linear (Chiew and McMahon 1993; Wyżga 1997; Radziejewski and Kundzewicz 1999). Some authors (Dallinga and Schoenmakers 1987; Schneider 1988; Dziewiaty 2002) linked high water levels with a potential positive effect on White Stork food resources, thus reducing the energy cost of foraging. In years of high water levels there were larger changes in vegetation structure, because the water stopped or retarded the vegetation succession and provided good foraging patches (Kajak 1985; Sera and Cudlin 2001). Also, water level can positively modify potential food resource available to storks, such as fish, amphibians and small passerine bird densities (Holčik and Bastl 1976; Dyrcz *et al.* 1984; Ogielska 1999; Osiejuk *et al.* 1999). On the other hand, flooding can negatively affect earthworm (Kajak 1985) and small mammal numbers (Raczyński *et al.* 1984), which frequently feature in the diet of the White Stork in Poland (Pinowska and Pinowski 1989; Antczak *et al.* 2002; Tryjanowski and Kuźniak 2002).

The hypothesis that food availability affects local numbers of White Stork is further supported by the positive influence of graz-

Table 1. General linear model analysis of a productivity parameter of the Klopot White Storks in relation to water level in April and June and livestock farming on the state farm. N = 35 years.

Source	Type III SS	F	P
Productivity per pair ($R^2 = 0.396$)			
April water level	1.12	7.08	0.012
June water level	0.01	0.01	0.979
Farming activity	0.21	1.32	0.260

ing within large dairy farms. We found a sharp decrease in the numbers of storks after cessation of dairy farming. Møller (2001) reported that the numbers of breeding Barn Swallows (*Hirundo rustica*) decreased for several years after farming ceased though the rate of decrease slowed over time (Ambrosini *et al.* 2002). The presence of livestock farming is important not only for small insectivorous passerines, like the Barn Swallow (Møller 2001), but also for storks. This effect is mainly due to changes in their foraging areas. In our case, farming activity did not, completely explain the variation in breeding numbers or productivity, but we only suggested that it could be an important factor. It can affect White Stork numbers with a time lag, because it has a delayed effect on food availability. Other potential explanatory variables, such as the conditions in African wintering grounds, or during migration and breeding (Creutz 1985; Schulz 1998), were not considered by us. On the other hand the decline of the local numbers of storks started before grazing activity ceased. During the last years of communism, intensive farming was much reduced compared to earlier years and before farming finally ceased. Clearly, the potential impact of changes in farming practice needs further investigation.

There was a close association of White Storks with livestock farming, and this may have implications for the conservation of the species. Livestock farming practices may change radically in the future as a consequence of accession to the European Union (see also predictions in Ambrosini *et al.* 2002) with concomitant negative effects on the farmland avifauna in Poland.

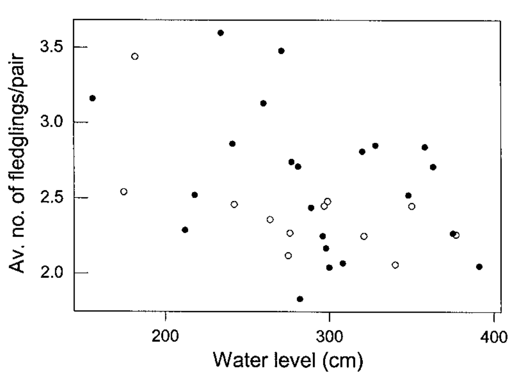

Figure 4. Bivariate plot showing average fledglings per pair of European White Stork at Klopot as a function of water level in April and farming activity in the river valley. (Closed circles indicate years with farming practice in the Odra valley, open circle years with no farming).

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