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Relationship between arrival date, hatching date and breeding success of the white stork (*Ciconia ciconia*) in Slovakia

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Abstract: Changes in the spring arrival dates of migrant birds have been reported from a range of locations and many authors have focused on long-term trends and their relationship to temperature and other climatic events. Perhaps more importantly, changed arrival dates may have consequences for the breeding dates of birds which strongly influence breeding success. In this paper we take the opportunity provided by a monitoring scheme of the white stork (*Ciconia ciconia*) to examine several features of the timing of arrival and breeding in relation to chick production in Slovakia during the period 1978–2002. First arrival dates ranged from 5th March to 30th April, and hatching dates varied between 26th April and 8th July. Generally, early arriving pairs started breeding earlier and a shorter interval between the arrival of the first partner and breeding, expressed here as hatching date, resulted in higher breeding success.

Key words: white stork; breeding success; phenology; migration; hatching time; volunteers' records

Introduction

In migratory birds, individuals that are the earliest to arrive on their breeding grounds typically occupy the best territories and consequently have the highest reproductive success (Forstmeier 2002; Tryjanowski et al. 2004). Early arrival also provides the opportunity for an earlier start to egg laying (Møller 1994; Brown & Brown 2000; but see Both & Visser 2001). Laying date and, after incubation, hatching date may be crucial to understanding which part of the avian annual cycle is under strongest natural selection (Møller 1994; Both & te Marvelde 2007). The timing of hatching influences the speed of chick development and their food and energy requirements (Deeming 2002). Therefore only after an analysis of arrival dates and timing of breeding (e.g., hatching date) is it possible to understand how changes in weather and climatological conditions (or even environmental conditions in a broader sense) affect bird populations (Deeming 2002; Both & te Marvelde 2007). Obviously, to show this potential pattern, long-term data covering both arrival and hatching dates are necessary.

One of the species in which long-term changes in both timing of arrival and breeding have been described in detail is the white stork (*Ciconia ciconia* L., 1758) (Ptaszyk et al. 2003; Tryjanowski et al. 2004). Moreover, previous papers have clearly indicated a link between arrival date and timing of breeding (Tryjanowski et al. 2004), suggesting a strong evolutionary pressure on earlier migration in the species. However, in the previous analyses, the volume of data on breeding date were limited because the timing of breeding is assessed by back-calculation from bill length measurements taken during ringing of chicks (for details on the method see Kania 1988). Therefore, data were only available for nests accessible to ringers, for example avoiding electricity pylons or old trees because of inherent dangers, and the results that were obtained may be biased to more accessible nests. Despite this it was possible, during a long-term monitoring scheme of the white stork in Slovakia, to obtain data not only on breeding success (as traditionally recorded by white stork researchers, see Creutz 1985; Schulz 1998) but also on arrival dates as well as hatching date for a proportion of the nests (for details on methods see below, but for a general description of the scheme see Štollmann 1987; Fulín 2000).

In this paper we consider some aspects of the arrival and breeding phenology of the white stork, and in particular how these may affect breeding success.

Material and methods

The study was conducted in 18 years during the period 1978–2002 (data were not collected in all years) in the agri-

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cultural landscape of Slovakia, and covered the whole country. In Slovakia the white stork builds nests mainly on electricity posts, chimneys, the roofs of farm buildings and trees, thus making the nests extremely conspicuous (Kalivodová et al. 1993; Štollmann 1987; Fulín 2000).

The dates of arrival of white storks to their nests were recorded by observers living near occupied nests or who visited sites on a near-daily basis. These records were sent directly to the principal author (M.F.). Breeding timing is here assessed as the date of hatching of the first egg in the nest and has been estimated from observation of female storks on the nest. Once the first egg is hatched the female bird markedly changes her behaviour, and has a tendency to stay more often at the nest although not just sitting and incubating the eggs (Bocheński & Jerzak 2006). Because hatching is asynchronous within a stork nest the growth of individual nestlings may well be different and breeding timing is typically estimated from information on the oldest chick. Data on hatching date were only available for pairs with breeding success, and therefore breeding success should be interpreted as the number of chicks per successful nest. The breeding success (numbers of chicks) of the nest was established in the middle of July using standard methods used during the International Census of White Storks (Creutz 1985; Schulz 1998).

Arrival and hatching dates were converted to Julian days (days post December 31) prior to analysis. Because arrival and hatching dates differed between years, the median for each year was subtracted from both dates (standardized) so that the investigation focuses on relative, rather than absolute, timing in each year. In this paper we used only data on nests with all three items of information i.e. arrival date, hatching date and breeding success. In total, data were analysed from 226 nests, between one and 41 nests annually (mean ± SE = 12.6 ± 3.1).

Throughout the text, values are reported as means ± SE or medians (with interquartile range). To avoid the lack of independence between single nest values, some of the analyses have been undertaken on annual average values and, due to the great differences in sample sizes between years (see above), weighted by annual sample size. Calculations were conducted using the SPSS for Windows package, and all statistical analyses were applied according to the recommendations of Zar (1999).

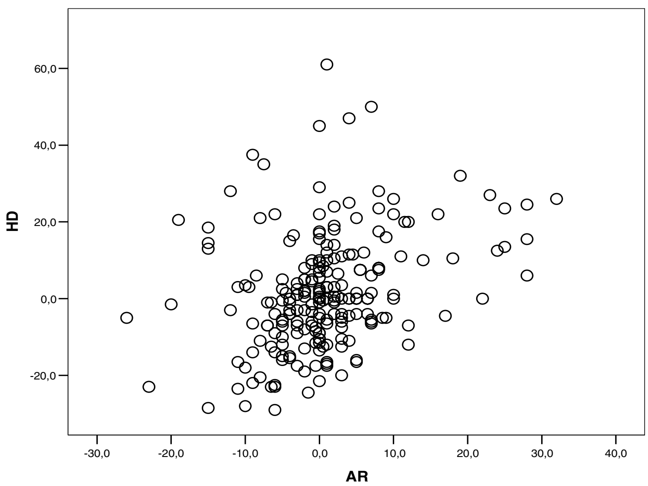

Fig. 1. Relationship between arrival and hatching dates. Abbreviations: AR – arrival date of the first bird to the nest; HD – hatching date (in standardized Julian date, 0 – median date in each year).

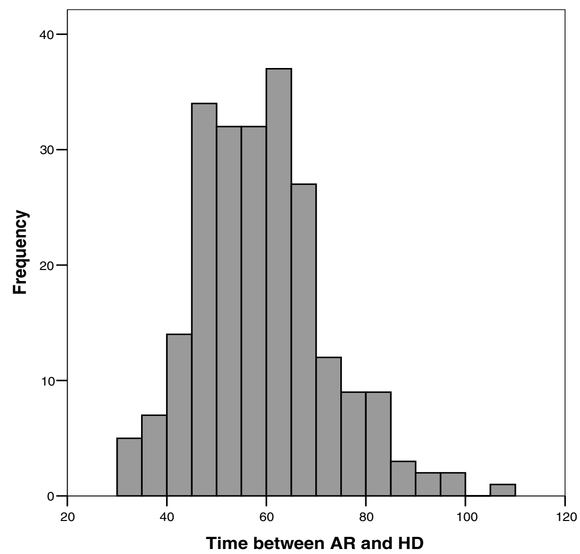

Fig. 2. Histogram of the interval between dates of arrival (AR) and hatching (HD).

Results

Arrival and hatching dates

Arrival dates ranged from 5th March to 30th April (median 31st March, IQ range 26 March to 5 April). Arrival dates differed significantly between years (Kruskal-Wallis ANOVA, $\chi^2 = 41.79$, df = 17, $P = 0.001$), but no directional change was found (regression weighted by annual sample size, $t = 0.974$, df = 16, $P = 0.344$).

Following arrival at the nest, time is spent on repairing the nest, egg laying and incubation. Hatching dates varied between 26th April and 8th July (median 29th May, IQ range 21 May to 8 June). A positive significant relationship was found between standardized arrival and hatching time ($r = 0.330$, df = 224, $P < 0.001$, Fig. 1). The interval between arrival and hatching was between 31 and 106 days (mean ± SE = 58.6 ± 0.9 d, Fig. 2), with no significant differences between years (Kruskal-Wallis ANOVA, $\chi^2 = 14.21$, df = 17, $P = 0.652$). Evidence for an advance in hatching date was nearly significant ($t = 1.995$, df = 16, $P = 0.063$) and the interval between arrival date and hatching date had decreased in recent years ($t = -3.123$, df = 16, $P = 0.007$).

Breeding success

The mean number of fledglings per successful white stork pair was 3.05 ± 0.07, with significant differences between years (Kruskal-Wallis ANOVA, $\chi^2 = 29.70$, df = 17, $P = 0.029$) and no significant change over time was found ($t = 0.228$, df = 16, $P = 0.823$). Breeding success was not significantly correlated with standardized arrival date or standardized hatching date, both for individual nests ($r = 0.039$, df = 224, $P = 0.559$ & $r = -0.117$, df = 224, $P = 0.080$, although the latter is

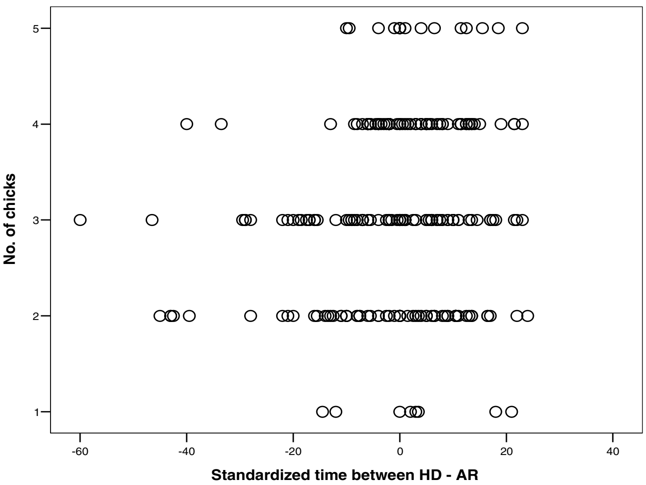

Fig. 3. Relationship between standardized period (in days, 0 – median date in each year) between arrival date (AR) and hatching date (HD) and number of chicks.

close to significance) and for annual mean values, where the relationship was closer to statistical significance ($r = -0.413$, df = 16, $P = 0.089$ & $r = -0.375$, df = 16, $P = 0.125$, respectively). However, birds which had a relatively shorter period between arrival date and hatching date had higher breeding success ($r = 0.143$, df = 224, $P = 0.032$, Fig. 3).

Discussion

We did not find a significant negative relationship (early = more productive) between arrival timing and the number of chicks as suggested in studies on the white stork in Poland (Kosicki et al. 2004; Tryjanowski et al. 2004). A similar lack of relationship was also noted in Spain (Vergara et al. 2007). We suspect this may be the consequence of generally higher chick productivity in Slovakia and Spain, for example compared to an average 1.8 chicks per nest in Poland (Tryjanowski & Sparks 2008). Higher chick production may be the consequence of a relatively low breeding density (thus a lack of competition between neighbouring storks for resources), and greater food resource availability generally. In Poland, there is a strong pressure on storks with regard to the timing of migration and breeding; the earlier individuals are in better condition and re-occupy better nests located in better territories (Tryjanowski et al. 2005). The relationship in our data between the timing of breeding and breeding success was marginally significant providing some evidence that storks hatching relatively earlier (and in reference to their arrival timing) had greater breeding success. Confirmation of this result when more data become available is recommended. This suggests that it is not only the timing of arrival that is important but also how quickly the first partner finds the second partner and starts breeding. In the white stork males generally arrive earlier, and therefore occupy better territories, find females earlier, reproduce earlier and in consequence have higher fitness (Tryjanowski & Sparks 2008). It is clear that there should be a strong positive correlation between timing of migration and breeding/hatching dates as suggested in some papers (Møller 1994; Brown & Brown 2000). In our study arrival dates were correlated positively with hatching dates, and the minimum interval between the two was 31 days, equating exactly to the incubation period of the white stork (Creutz 1985; Schulz 1998; Profus 1991). A longer interval between arrival at the nest and hatching was associated with lower breeding success.

We believe that another important aspect of this paper should be emphasised here. For those species well known to the general public data collected by (well trained) local people can provide a valuable resource in monitoring bird populations, as also shown for an earlier study published on the white stork by Ptaszyk et al. (2003).

To conclude, in this paper we provide evidence of a link between the timing of return to breeding grounds and the timing of breeding, measured by egg hatching. Earlier hatching and a reduced arrival-breeding interval appear to enhance breeding success. Therefore, natural selection may favour both earlier migrants and earlier breeders simultaneously, but the cost-profit ratio for individuals could differ according to their condition (e.g., Forstmeier 2002) and to provide more detailed answers we need manipulative experimental studies.

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