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Brief report

Does the White Stork *Ciconia ciconia* reflect farmland bird diversity?

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The White Stork (*Ciconia ciconia*) is an icon of nature protection and one of the easiest birds to monitor, particularly in Central Europe. Here avian biodiversity was compared between sites (territories) occupied by nesting White Storks and sites that were formerly occupied but were unoccupied during the two study years, and often for several preceding years. The study was conducted in Western Poland during two breeding seasons, 2007 and 2008, involving 43 and 54 territories, respectively. Moreover, information on nest occupancy and breeding success of White Storks since 2005 was used as a measure of habitat quality. Breeding bird diversity was significantly higher in occupied than in unoccupied White Stork territories. Bird diversity was also higher in territories with better White Stork chick productivity in the period 2005–2008. Even greater differentiation in bird diversity might have been achieved between occupied White Stork territories and random sampling points in similar habitat.

1. Introduction

The abundance or presence of particular bird species may reflect the ecological value of a given area (Gilroy *et al*. 2008). Whether diversity of a group of closely-related bird species can reflect richness of other bird species (Drever *et al.* 2008) or ecosystem condition (Fresman Broder *et al.* 2002, Paillisson *et al.* 2002) has been the subject of research. Some authors have suggested that one species group cannot be a good indicator of wider animal diversity (Billeter *et al.* 2008, Larsen *et al.* 2009). However, a number of studies have recently been done, particularly in farmland areas to identify good bio-indicators (e.g., Browder *et al.* 2002, Gilroy *et al.* 2008, Naccari *et al.* 2009, Aydin & Kazak 2010 Hvenegaard 2011, Pimentel *et al.* 2011, Tisher 2011). Birds have been suggested as a group with high indicator potential (Billeter *et al.* 2008). They have been used as indicators of, for example, environmental pollution (Gilroy *et al.* 2008, Naccari *et al*. 2009), general ecosystem condition (Martínez-Fernández *et al.* 2005, Mistry *et al.* 2008) and biodiversity (Carignan & Villard 2002, Gregory *et al.* 2003, Hvenegaard 2011). It has been suggested that effective bio-indicators must be quantitative, simple to use and easy-to-detect keystone, flagship or umbrella species (Carignan & Villard 2002).

Among farmland bird species, the White Stork is an icon of nature conservation in Europe and elsewhere (Creutz 1985, Kosicki *et al.* 2007) and data on population size, and even breeding success, have been collected in some regions since 1890 (Bairlein 1991). Establishing population size and breeding success is relatively easy in the field, using standard international methods, and therefore data are of a good quality (Creutz 1985, Dallinga & Schoenmakers 1987, Schulz 1998, Tryjanowski *et al.* 2005). It builds huge, easily located nests (Creutz 1985, Kosicki *et al.* 2007, Vergara *et al.* 2010) and it is easy to find a reasonable sample size, at least in Poland where 20% of the global population lives (Schulz 1998).

Moreover, the White Stork is a top predator; up to 80% of prey biomass in the study population are *Microtus* voles (Creutz 1985, Schulz 1998) but also fish, amphibians and reptiles are eaten (Kosicki *et al.* 2006). Sergio *et al.* (2008) suggested that top predators may reflect species richness for two reasons: (a) predators may directly cause high biodiversity, or (b) they may be spatio-temporally associated with it and thus act as indicators. The White Stork is valuable for breeding House Sparrows (*Passer domesticus*; Kosicki *et al.* 2007). Thus, conservation measures taken to protect the White Stork may also help other farmland birds. Furthermore, the species is charismatic and easy to detect.

These arguments lead us to hypothesize that the White Stork may be associated with sites of higher biodiversity in farmland. Although this idea has been suggested in previous work (e.g. Creutz 1985, Dallinga & Schoenmakers 1987, Schulz 1998, Kosicki *et al.* 2007) it has never been explicitly tested. Therefore our main goal was to study avian diversity in White Stork territories and to check whether higher stork occupancy and success were related to higher diversity of other bird species.

2. Material and methods

The study was conducted in Western Poland near the small towns of Gostyń (51°52’ N, 17°00’ E) and Kościan (52°05’N, 16°39’ E). This is an area of arable fields interspersed with meadows, pasture, human settlements, small river valleys and woods. The White Stork here builds isolated nests mainly on electricity poles, chimneys and roofs of buildings (Tryjanowski *et al.* 2009). White stork population size and productivity were established by standard methods used for the International Census of White Storks (Creutz 1985, Schulz 1998).

In the study area, White Stork occurrence and population productivity have been recorded since 1973, therefore all nest locations were known a priori (Tryjanowski *et al.* 2009). We worked on two groups of territories based on occupied and unoccupied (empty) White Stork nests. Unoccupied nests may, in practice, have also been empty for several preceding years. We defined the territory as the area where foraging birds were observed in previous years; up to 2,000 m from the nest (see also Nowakowski 2003, Olsson & Rogers 2009). In 2007 we used 11 unoccupied and 32 occupied territories, and in 2008 added another 11 territories to produce 14 unoccupied and 40 occupied nest sites. For all occupied nests the number of White Stork chicks fledged was counted.

Bird species were recorded in the early morning at three points per territory, with a minimum separation of 200 m, in good weather (not in rain or strong wind) using the 5-min point count method (Surmacki & Tryjanowski 1999). Counts were carried out between 30 minutes before and 4.5 hours after sunrise, three times at each point, i.e., in the middle of March, April and May. All counts were made by the lead author (MT) and a maximum of 27 5-min point counts made on any one day. In 2007 one of the census points was at the nest site and the other two were random points within the territory. With the benefit of hindsight, the count at the nest site may have reflected more the birds of the human settlement in which most storks nest rather than the farmland in which they

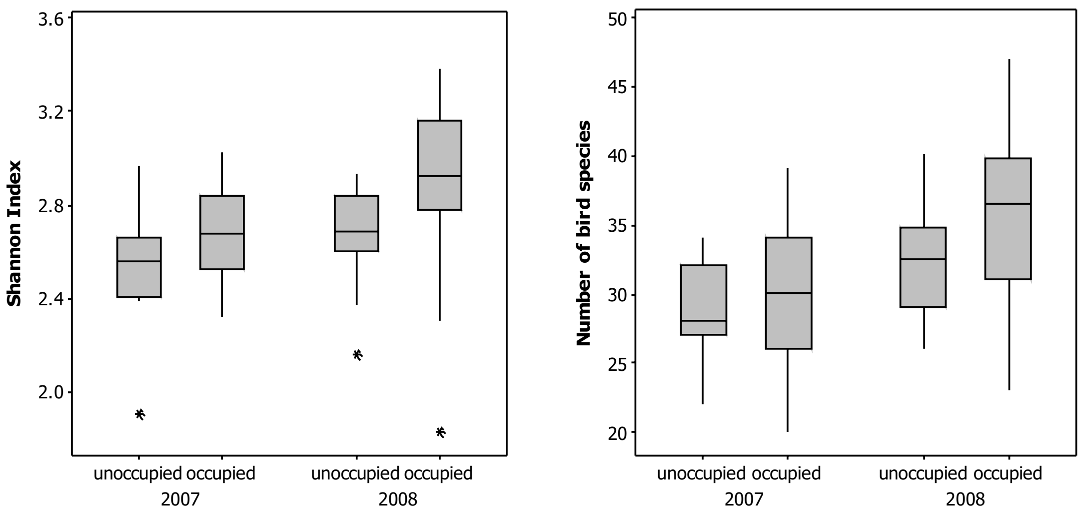

Fig. 1. Box plots of Shannon-Wiener index (left panel) and number of bird species (right panel) in unoccupied and occupied territories of the White Stork in 2007 and in 2008. The box represents the interquartile range with the median indicated by a horizontal line, whiskers extend vertically to maximum and minimum values, unless an outlier (represented by an asterisk) is present.

forage. Hence, in 2008 three random points within the territory were used. We consider the 2008 records to be a more reliable estimate of the territorial diversity and have thus focussed on this year rather than combine estimates between years. The density of individuals of each bird species in the stork territories was estimated as the maximum number recorded during any one visit. For each year, data were summarised as the total number of breeding species and a Shannon-Wiener index of diversity (based on density estimates) for each territory.

Moreover, among the studied sample of White Stork nests, 35 had been visited each year from 2005–2008. For each site the total number of White Stork chicks produced over the four years and the number of years the nest site was occupied by White Storks was calculated. For each territory, CORINE LAND COVER (2000) variables were obtained. Here, we only consider the percentage of pasture *versus* that of non-irrigated arable land, the major land-cover types in the study area.

In each year, breeding bird species richness and Shannon-Wiener index for unoccupied and occupied White Stork territories were compared using two sample *t* tests, and Pearson correlations used to compare these variables with stork occupancy and productivity. The land-cover variables were compared between occupied and unoccupied territories (2008 data only) using two-sample *t* tests and were correlated with stork occupancy and productivity. Residuals from all tests were checked for normality, only that for Shannon-Wiener index in 2008 and the pasture-occupancy correlation failed and hence the test results were confirmed using a Mann-Whitney test and Spearman correlation respectively. All statistical analyses were carried out using the software MINITAB v.15.

3. Results

In 2007 between 20 and 39 bird species were recorded on each territory. In 2008 the numbers ranged from 23 to 47 species. In total we observed 19,486 birds from 119 species. In neither year was a significant relationship found between the number of bird species and White Stork breeding success (the number of chicks fledged). In 2007 there was a statistically significant difference in Shannon-Wiener index between occupied and unoccupied territories (two sample *t* test: $t_{41} = -2.19$, $p = 0.034$; Fig. 1) but not in bird species number ($t_{41} = -0.62$, $p = 0.538$; Fig. 1). The Shannon-Wiener index also differed significantly between occupied

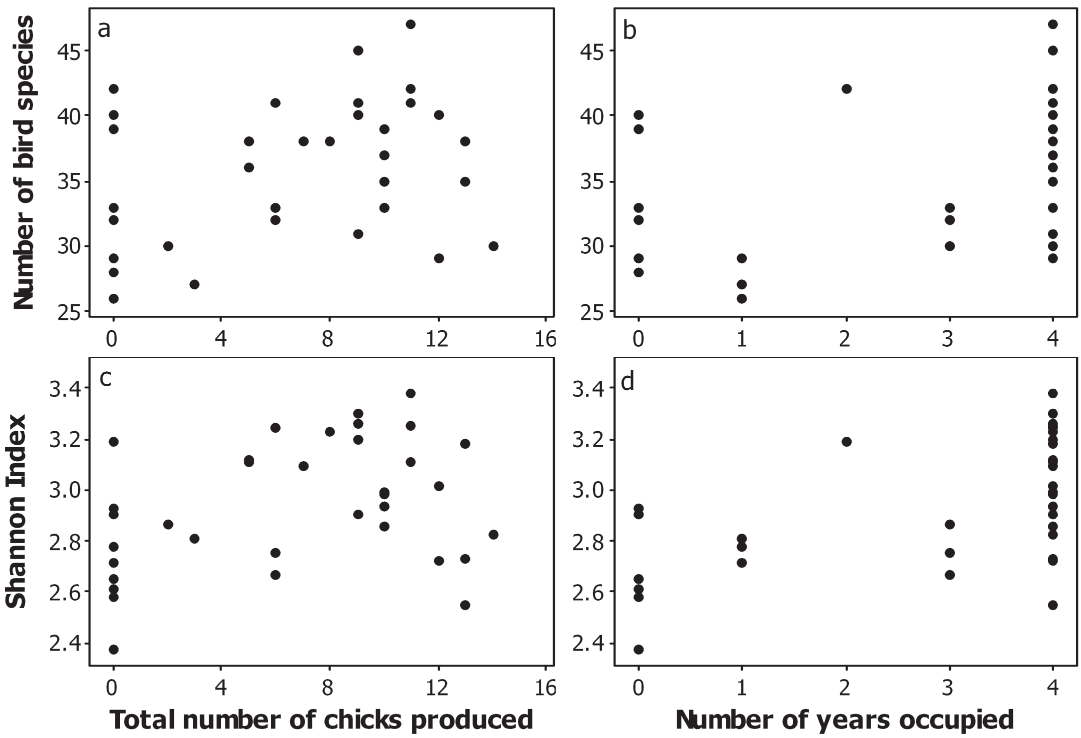

Fig. 2. The relationship between the number of bird species in 2008 and (a) the total number of White Stork chicks produced over the four years and (b) the number of years a territory was occupied by the White Stork during 2005–2008; and between the Shannon-Wiener index of bird diversity in 2008 and (c) chick production of the White Stork and (d) territory occupancy (n = 35 territories).

and unoccupied territories in 2008 ($t_{52} = –2.54$, p = 0.014; confirmed by Mann-Whitney test: W = 239, p = 0.004; Fig. 1) and marginally so for the number of bird species (t_{52} = –1.97, p = 0.054; Fig. 1).

The number of bird species in 2008 significantly and positively correlated with the total number of White Stork chicks in the years 2005–2008 (r_{33} = 0.341, p = 0.045, Fig. 2a) and with the number of years a site was occupied during 2005–2008 (r_{33} = 0.431, p = 0.010, Fig. 2b). Furthermore, the Shannon-Wiener index for 2008 significantly and positively correlated with the total number of White Stork chicks in the years 2005–2008 (r_{33} = 0.355, p = 0.037, Fig. 2c) and with the number of years a site was occupied during 2005–2008 (r_{33} = 0.573, p <0.001, Fig. 2d).

The percentage of arable land did not differ significantly between unoccupied and occupied White Stork territories in 2008 (67.4% vs. 63.9%, respectively; t_{52} = –0.71, p = 0.48) but it did for pasture (9.2% vs. 17.0%, respectively; t_{52} = –2.76, p = 0.008). Furthermore, there was a significant and positive correlation between pasture% and number of years a site was occupied in 2005–2008 (r_{33} = 0.445, p = 0.007; confirmed by Spearman correlation $r_{s(33)}$ = 0.524, p = 0.001) and between pasture% and the total number of White Stork chicks in 2005–2008 (r_{33} = 0.458, p = 0.006).

4. Discussion

We found a co-occurrence of nesting White Storks and greater-than-average diversity of other bird species. This could be due to the presence of better-quality habitats around occupied nests, as indicated by the greater proportion of pasture within occupied than in unoccupied territories and the tendency of stork productivity to increase with more pasture. It should be noted that in Poland a loss of pasture land reflects the general tendency of traditional, extensively-managed fields to become more intensively managed. Our findings are not a simple trophic relationship between White Stork and other birds, since small birds, and especially their chicks, only occasionally occur in the stork diet (Creutz 1985, Kosicki *et al.* 2006).

We found that higher chick production in the White Stork (using breeding success records from four years) was associated with a higher number of other bird species, as well as with greater avian biodiversity. The modification of the census method in 2008 produced an estimate of diversity which may be more reliable than the one applied in the previous year (for reasons, see Material and methods); hence, we focused on results from 2008. Correlations did not exceed a magnitude of 0.6 but were only based on three counts and did not take into account the diversity of other groups. The lack of a significant relationship between bird-species diversity and the breeding success of the White Stork (in terms of number of offspring) in a given year (2008) may be due to the generally low variability in annual chick production (Tryjanowski *et al.* 2005).

Our study agrees with other works (Dallinga & Schoenmakers 1987, Tryjanowski *et al.* 2005) that had no empirical data but suggested the usefulness of the White Stork to identify spots of high bird-species diversity in farmland. Moreover, it is worth noting that we only compared occupied *versus* unoccupied White Stork territories, which will be a conservative test relative to a comparison with random locations. The mere presence of an unoccupied nest suggests that the territory once used to be capable of providing the energy necessary for nest construction (Tryjanowski *et al.* 2009).

To further assess the value of the White Stork as an indicator of habitat quality, we recommend an examination of whether a declining biodiversity in intensive agricultural areas (or with land-use changes from pasture to arable) is associated with White Stork decline over a longer time frame. A rapid assessment of White Stork population size and land-use changes over the last 40 years suggests a strong correlation between these parameters (Kosicki & Kuźniak 2006), which has also been noted elsewhere in their geographical range (Dallinga & Schoenmakers 1987, Bairlein 1991, Tryjanowski *et al.* 2005) and is supported by our brief comparison with the cover of pasture land.

Through constant monitoring of White Stork populations we may be able to estimate the value of natural ecosystems occupied by them. Therefore, this type of research should be continued, but enhanced by both improved methods for estimating biodiversity (including non avian taxa) and by increased sample size. This may translate into broader observed changes in agricultural landscapes. We hope the results and conclusions from such research can be used in practice to both assess the value of diversity in agricultural landscapes and to protect White Storks.

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Heijastaako kattohaikara maaseutulinnuston monimuotoisuutta?

Kattohaikara (*Ciconia ciconia*) on luonnonsuojeluikoni ja yksi helpoimmin seurattavista lintulajeista eritoten Keski-Euroopassa. Tässä tutkimuksessa verrattiin lintudiversiteettiä asutuilla ja asumattomilla (vanhoilla) kattohaikaran pesäpaikoilla kahtena vuotena. Työ tehtiin Keski-Puolassa pesimäkausina 2007 ja 2008, käsittäen vastaavasti 43 ja 54 reviiriä. Kattohaikaran pesimämenestystä vuodesta 2005 lähtien käytettiin ympäristön laadun mittarina. Pesimälinnusto oli merkitsevästi rikkaampaa asutuilla kuin asumattomilla haikarareviireillä. Diversiteetti oli myös sitä korkeampi, mitä parempi oli haikaroiden pesimämenestys vuosina 2005–2008. Luultavasti erot olisivat olleet vielä suurempia, jos asuttuja haikarareviirejä olisi verrattu satunnaisesti valittuihin pisteisiin samanlaisessa ympäristössä.

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