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THE IMPACT OF LANDSCAPE STRUCTURE ON OCCURRENCE OF WHITE STORK'S NESTS

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Влияние структуры ландшафта на встречаемость гнезд белого аиста. - К. Латус, К. Куява. - Беркут. 8 (2). 1999. - Целью работы было определение показателей структуры ландшафта, влияющие на встречаемость гнезд белого аиста. Исследования проведены на участке в 660 km^2 в Восточной Германии (долина р. Одер), где плотность гнездования достигает 4 пар на 100 km^2. Предпочтение местообитаний белым аистом определялось путем исследования структуры ландшафта в радиусе 1 км от гнезда. В населенных пунктах было случайным образом выбрано 56 "гнездовых участков" и 34 "контрольных участка" (без гнезд). Структура ландшафта (соотношение местообитаний, индекс разнообразия Шеннона H', плотность границ и т. д.) измерялись по аэрофотоснимкам (1:10000). "Гнездовые участки" характеризовались более высокой долей травянистых биотопов и водоемов и большим значением H': 1,37 по сравнению с 0,95 на "контрольных участках" (P < 0,01). Аисты явно предпочитали более разнообразные местообитания – 80 % "гнездовых участков" имели высокую степень разнообразия (0,81-1,70), в то время как 80 % "контрольных участков" в намного более низком классе разнообразия (0,21-0,80). Травянистые биотопы также имели значительное влияние. Аисты предпочитали для гнездования прилегающие и умеренно фрагментированные участки.

Abstract. The objective of the study was to determine the landscape structure indices influencing the occurrence of White Stork's (*Ciconia ciconia*) nests. The analyses were performed for the MOL-district (660 km^2) in East Germany (Oder valley) where the density of breeding pairs as high as to 4 per 100 km^2. White Stork habitat preferences were determined by investigating landscape structure within a 1 km radius of nesting locations, 'breeding sites' (N = 56), within and for 'control sites' (N = 34), randomly selected points in the villages without stork's nests. The landscape structure (habitat proportions, Shannon's diversity index H', density of edges, etc.) was measured by evaluating aerial photographs (1:10000). Breeding sites were characterised by a higher proportion of grasslands and inshore waters as well as by a significantly higher (P < 0,01) value of H' 1,37 compared to 0,95 for 'control sites'. Storks clearly preferred more differentiated landscapes – 80 % of 'breeding sites' were localised in very high diversity classes (0,81-1,70), while 80 % of 'control sites' were in much lower diversity classes (0,21-0,80). Also grasslands were found to have a strong influence. Storks preferred contiguous and moderately fragmented grasslands as nesting habitats.

Key words: White Stork, East Germany, habitat preference, landscape structure.

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Introduction

Intensive land-use management affects the structural arrangement of agricultural landscapes and influences the occurrence of species leading to change or serious loss of biodiversity (Mc Laughlin, Mineau 1995). Additional information is needed concerning abiotic (physical and chemical) landscape features and connections between landscape and the biota to help forecast ecological threats and support efforts to protect biodiversity. The White Stork (*Ciconia ciconia*) was selected for an investigation of the integration of a species into a landscape due to its large area-habitat preferences and ability to adapt to farmland. The objective of our study was to determine the landscape parameters strongly associated with the occurrence of White Stork's nests and, therefore those which should be considered as essential for effective protection of the species.

Study area

The study was carried out on a 660 km^2 area in the district MOL (Brandenburg), located in the Oder river valley. In the 1990s, the density of White Stork reached as high as 4 pairs/100 km^2 (Mitteilungsblatt..., 1995). The district MOL has a typical land use composition for agricultural regions: agricultural use (62 %) (92 % crop fields and 7 % grasslands), woodlands (24 %), inshore waters (3 %), settlements (9 %) and other land uses (2 %) (LDS Brandenburg, 1995). Fifty-one percent of the crop fields is used for grain. The land is intensively cultivated: the annual applications of NPK reach 200 kg per ha, the wheat yield is 45-55 dt/ha and pesticides are sprayed from 2-6 times/year (Amt für Landwirtschaft, 1995). The district MOL has 82 inhabitants/km^2. The density of human settlement is 6/100 km^2. The annual mean precipitation is approx. 500 mm; the mean temperature is +18 °C in July and –1 °C in January (LDS Brandenburg, 1995).

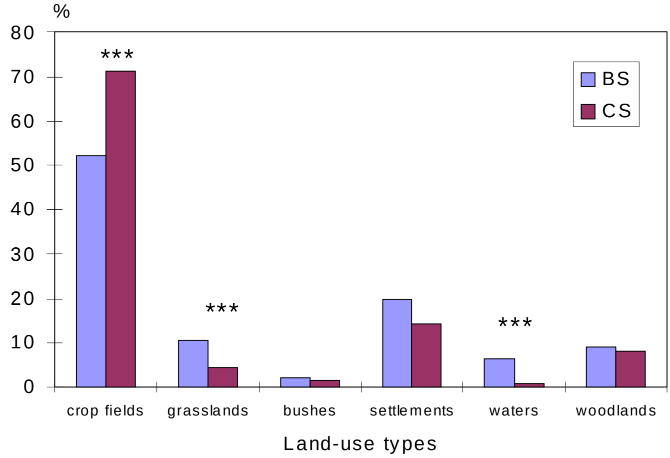


Fig. 1. Land-use of the area around breeding sites (BS) and control sites (CS).

Рис. 1. Использование земель вокруг гнездовых (BS) и контрольных (CS) участков.

Methods

The landscape structure in the proximity of nests occupied by breeding pairs within last five years ("breeding sites": BS, N = 56) was compared to the landscape structure of areas without White Stork's nests ("control sites": CS, N = 34). Because nearly all of the nests are localised in the settlements (Ranner, Tiefenbach 1994), CS were taken as randomly selected points in settlements without White Stork's nests, close to the border of the settlements. The landscape structure was investigated within a 1 km radius around BS and CS, based on a finding by Creutz (1988) who noticed that during the earliest stage of fledgling development their parents need view-contact with the nests. The landscape structure was measured with the aid of black and white aerial photographs at a 1:10 000 sale. The measurements were focused on the patches and boundaries between patches. A "patch" was defined as a homogeneous area of land (according to photograph sensitivity) and classified according to six land-use classes: woodlands, crop fields, grasslands, inshore waters (seas, ponds etc.), bushes (cemeteries, gardens etc.), settlements.

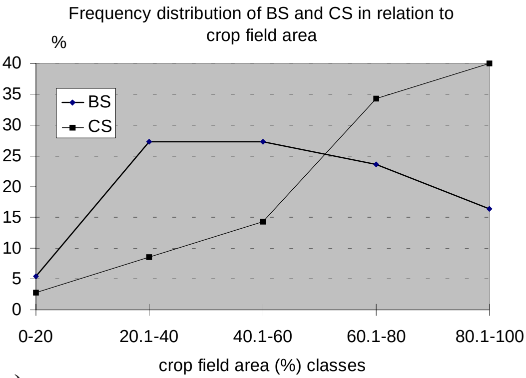
The chosen variables can be split into three groups:

1. Variables based on the main land-use classes proportions: a) the percentages of crop fields, woodlands, grasslands, inshore waters, bushes, settlements, b) landscape diversity index defined as Shannon's diversity index

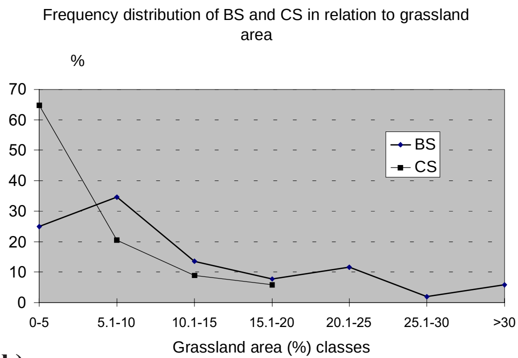
$$H' = -\sum_{i=1}^{n} p_i \ln(p_i)$$, in which p_i is the proportion of i-th habitat and c) the openness of a landscape. The openness of landscape is a good indicator for birds to determine a free view of the nest surroundings to recognise possible feeding areas as well as dangers. We defined an open land as covered by crop fields and/or grasslands (Andries, 1984), thus the openness of landscape is the percentage of open land.

2. Variables based on the linear structures: the densities of different types of boundaries (between crops and grasslands, woodlands and grasslands, etc.) as well as their total.

3. Variables based on the distances: a) the



a)



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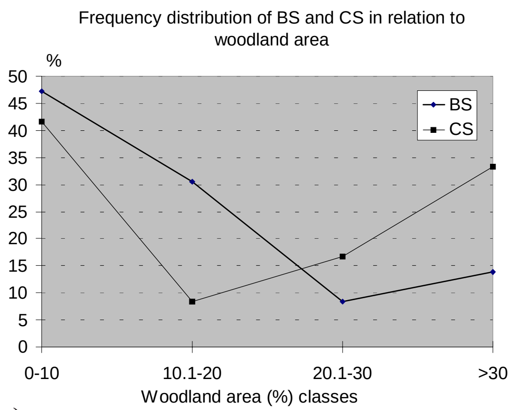

c)

Fig. 2. Frequency distribution of breeding sites and control sites.
Рис. 2. Частотное распределение гнездовых и контрольных участков:
a) – в зависимости от площади полей;
b) – в зависимости от площади лугов;
c) – в зависимости от площади лесов.

distance from BS (CS) to the nearest patch determined separately for all land-use classes, b) the distance between the same type of land-use patches.

Results

Impact of land-use types composition

The land-use of the area at BS and CS differed markedly. BS's area was characterised by a smaller percentage of crop fields (52 % and 71 %, respectively), and much higher percentage of grasslands (11 % and 4 %) as well as inshore waters (6 % and 1 %). According to Chi-square test the differences are statistically significant at P<0,001 (Fig. 1). The difference in landscape diversity between BS and CS (1,37 and 0,95, respectively) is statistically significant at P<0,01 (Poole, 1979). In addition, the difference in the frequency distribution between BS and CS in relation to the H' index is statistically significant (cc^2 test, P<0,001). Eighty percent of BS were localised in high diversity classes of 0,8-1,7 while 80 % of CS were found in lower diversity classes of 0,2-0,8.

Special consideration was given to some types of land-uses important for White Storks for nesting and feeding purposes. Crop fields and grasslands may be regarded as potential feeding areas but woodlands as a possible indicator for disturbance. The frequency distributions of BS and CS varied (cc^2 test, P<0,001) in relation to crop field coverage (Fig. 2a) as well as to grassland percentage (Fig. 2b). Sixty percent of BS were localised in places characterised by crop fields covering areas in a range of 20-60 %, while up to 80 % of CS were surrounded by areas covered by 60-100 % of crop fields. Seventy-five percent of BS were found in the places where grasslands cover from 5 % to more than 30 % of the land surface, while about 85 % of CS were found in areas with a very low percentage (0-10 %)

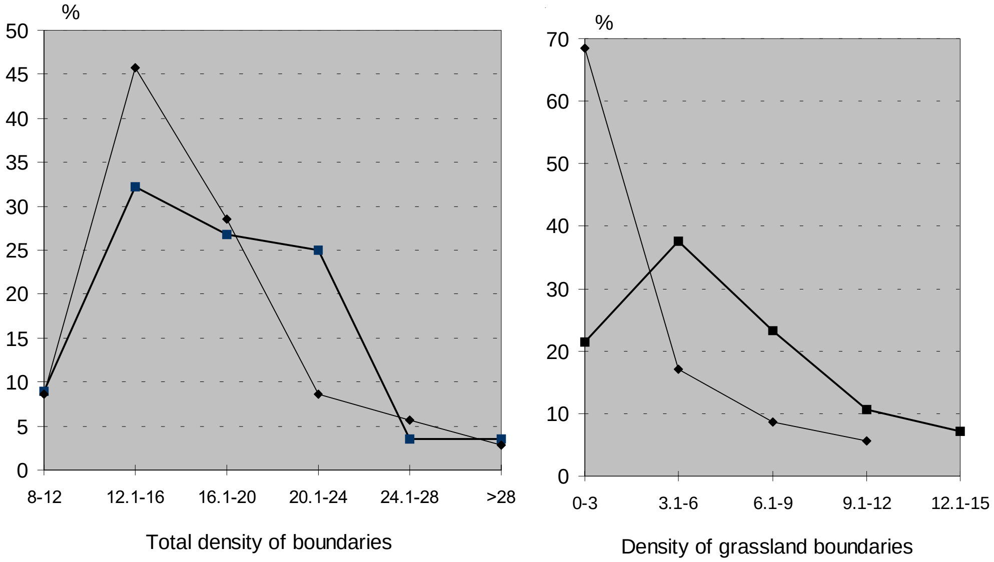

Fig. 3. Frequency distribution of BS (thick line) and CS (thin line) in relation to density of boundaries (in km/circle).
Рис. 3. Частотное распределение гнездовых (толстая линия) и контрольных (тонкая линия) участков в зависимости от плотности границ (в км на круг).

of grasslands. These results correspond with the grassland/open land rate analyses which showed a significantly higher value of the rate (U-test, P<0,001) for BS. Regarding woodlands, 80 % of BS were found in the areas with 0-20 % woodland coverage, while 60 % of CS were surrounded by 10 % to more than 30 % woodland coverage (Fig. 2c). The differences are statistically significant (cc^2 test, P < 0,001).

Impact of boundaries

BS were more frequently localised in the range of 12,1-24 km of all boundaries per circle while CS were found to be markedly most frequent in the range of 12,1-16 km per circle (Fig. 3). The difference reported here is statistically significant (cc^2 test, P < 0,01). Special attention was focused on the fragmentation of grasslands the main feeding areas for White Stork. Nests were found more frequently in the areas characterised by significantly higher density of grassland boundaries (cc^2 test, P < 0,001) (Fig. 3).

Discussion

Most studies on the distribution of White Stork's nest were based on singular habitat analyses, for example on the influence of grassland percentage on the density of breeding pairs (Thomsen, 1995, Schneider, 1988). The results reported here show much more complicated relationships between the species and preferred habitat and support previous findings that investigations of the species must be carried out in landscape contexts as other authors have already noticed (Flather, Sauer 1996).

The main factors responsible for survival of a given species are the possibility for nest building and sufficient food supply for its brood. The importance of food supply for White Stork in his breeding region was showed e. g. by Pinowska et al. (1989) and the influence of food supply on breeding success has been analysed by Löhmer et al. (1980), Profus (1986), Struwe and Thomsen (1991). Although results are based on the analysis of landscape structure characteristics, clear preferences for special landscape features outside of the one km radius can be easily recognised. The landscape structure around BS and CS differed depending on the percentages of crop fields, grasslands and woodlands as well as on the diversity of landscape. Indeed variables based on distances are of less importance within 1 km around nest, but variables based on linear structures are significant different and provide more comprehensive information about the degree of landscape fragmentation determined by the density of boundaries. These preferences are surely linked with the feeding biology of White Stork. The species is a generalist in food intake. As Lakeberg (1995) described, this species changes its food during the breeding season from earthworms and amphibians in the first phase to small mammals preferred later during breeding older fledglings, probably because of a higher energy content (Profus, 1986). But decisive role for White Stork is played not by the potential food supply by itself, but food availability (Alonso et al.,1991). The species as a stepper bird with quick sight reacts on small moving animals (Creutz, 1988). White Stork looks for mice and other animals in open land, especially with low vegetation, harvested crop fields and grasslands, which can be found much more easily (and on the average closer to the nest) in diversified landscape compared to unified one. So, it seems that diversified, mosaic-like landscapes consisting of many patches of different land-use types (incl. small woods, small water bodies etc.) but with some minimum area of grasslands (10-20 %) as main feeding area and moderate density of all boundaries as well as boundaries of grassland patches are an optimal breeding habitat for White Stork in intensively used farmland in Europe.

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