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Short research contribution

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SELECTION OF NESTING AND FORAGING HABITAT BY THE LESSER SPOTTED EAGLE *AQUILA POMARINA* (BREHM) IN THE KNYSZYŃSKA FOREST (NE POLAND)

ABSTRACT: To manage conservation issues, it is essential to recognize the factors determining the occurrence of endangered species. This study examined the foraging habitat and nest site preferences of the Lesser Spotted Eagle *Aquila pomarina* (Brehm) in the Knyszyńska Forest (NE Poland). This is a large (839 km^2) protected (Landscape Park Puszcza Knyszyńska, NATURA 2000) forest complex composed mainly with coniferous and mixed wood stands with meadows in river valleys inside the complex and arable lands outside it. The research was carried out on a study plot of 440 km^2, in the breeding seasons of 2006 and 2007. Nest site characteristics, such as distance to open areas, settlements and watercourses were measured and compared with random points. The habitat composition of hunting territories was recorded and compared to habitat availability on the whole study plot, and the birds' hunting effort was assessed. The eagles showed a preference for nesting close to open spaces (potential hunting grounds) and watercourses (like rivers and streams), but avoided proximity to human settlements. As hunting grounds, the birds highly preferred grasslands and avoided arable lands. Time spent hunting on grasslands comprised over 95% of the observed hunting activities and grasslands were significantly positively selected both in the whole study plot and within a 2 km-radius from nest. The results suggest that the conservation of the Lesser Spotted Eagle should focus especially on meadows and pastures adjacent to large forest complexes.

KEY WORDS: Lesser Spotted Eagle, *Aquila pomarina*, habitat selection, nest sites, raptors conservation

The recent changes in agricultural management and farmland habitats in the European Union have become a serious threat to farmland birds, especially habitat specialists (Birdlife International 2004, Atkinson *et al.* 2005, Buckingham *et al.* 2006). Particularly susceptible to habitat loss are birds of prey, which require large hunting areas of appropriate habitat.

A decline of raptors population due to foraging habitat loss has already been documented (Donázar *et al.* 1993, Šálek and Schröpfer 2008). In general, decline of a species can be arrested using knowledge of its habitat preferences, which allows application of appropriate conservation measures (Onti-veros *et al.* 2004, Giralt *et al.* 2008).

The Lesser Spotted Eagle *Aquila pomarina* (Brehm 1831) is a rare and vulnerable predatory bird species (listed in Annex I of the Birds Directive), whose distribution ranges from Northern Germany to Russia, Turkey, the Caucasus and Northern Iran (Cramp and Simmons 1980). Most of the European population is found in Belarus, Poland, Lithuania and Latvia. As a consequence of large-

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scale changes in land use and habitat loss processes, a serious decline of this species has been noted during recent years in Lithuania (Treinys *et al.* 2007), Germany (Meyburg *et al.* 2004a) and former Yugoslavia (Meyburg *et al.* 2001). Probable causes of the decline were indicated to be overgrowth of vegetation on meadows, agriculture intensification, loss of nest sites caused by forestry practices and increase in aggressive interactions with the growing population of the White-tailed Eagle, *Haliaeetus albicilla* (L.). Moreover, the Lesser Spotted Eagle is a strongly philopatric bird (Meyburg *et al.* 2005). This means that there are low chances that recolonization of the old territories occurs, once the optimal habitat is damaged. Therefore, to predict the consequences of changes in forest management and land use transformations for the stability of the Lesser Spotted Eagle population, its habitat preferences should be examined on a local level, since they can vary significantly across Europe (Meyburg *et al.* 2004b, Väli *et al.* 2004).

The aim of this study was to determine the foraging and nesting habitat preferences of the Lesser Spotted Eagle. This knowledge could subsequently be used in the conservation and monitoring of this species.

The study was conducted in the northern part of the Knyszyńska Forest (NE Poland). It is a large (839 km^2) forest complex protected as a Landscape Park Puszcza Knyszyńska (with 21 nature reserves in it) and also as a part of NATURA 2000 network. It is composed mostly with coniferous forests (*Peucedano Pinetum, Molinio Pinetum*), mixed forests (*Querco roboris-Pinetum, Serratulo-Pinetum*), swampy forests (*Ribeso nigri-Alnetum*), less frequently deciduous forests (*Tilio-carpinetum*) and also meadows and arable lands of anthropogenic origin. The whole forest complex has mosaic character of forested and open areas. It is intersected by river valleys and streams, moreover marshes and meadows in forest glades occur inside the complex, enriching the landscape diversity. Puszcza Knyszyńska is an important refuge for large mammals like: wolf *Canis lupus* (L.), lynx *Lynx lynx* (L.) and European bison *Bison bonasus* (L.), rare birds species like: Tree-toed Woodpecker *Picoides tridactylus* (L.), White-backed Woodpecker *Dendrocopos leucotos* (Bechst.) and also boreal plant relicts like: Leatherleaf *Chamaedaphne calyculata* (L.), Dwarf Marsh Violet *Viola epipsila* (Ledeb.) and Swamp Willow *Salix myrtilloides* (L.).

The study was conducted in 2006–2007, on a 440 km^2 study plot (53°2'N; 23°2'E). The plot consisted of mostly coniferous (rarely deciduous) forests with adjacent farmland mosaic: arable crops, meadows, pastures, wastelands, streams and marshes.

Occupied territories of Lesser Spotted Eagles were mapped by examining the study plot from observation points. The territorial behavior classification by Król (1985) was used to assess breeding probability on the basis of the field observations. In each occupied territory nests were located and their coordinates were saved with a GPS receiver.

The species of nest trees were recorded and their frequencies were compared with tree species frequencies in the whole forest complex. Also, the age of the occupied forest stands, taken from forest maps, was compared with the mean age of the stands in the whole Knyszyńska Forest. Both characteristics were compared with T-test.

For each eagle nest and territory several landscape and habitat characteristics were measured. The shortest distance to open spaces (such as grasslands, arable lands and wastelands), watercourses (like: rivers and streams) and human settlements was measured on maps at 1:10 000 scale. The same measurements were conducted for 2 sets of random points in the forest part of the study area. The first set was used to investigate the relationship between distance to potential hunting grounds and nest location. As this study confirmed that the birds preferred to locate nests near forest edges, the second set of random points was used to check whether proximity to watercourses and settlements affects nest location. In this case, a 0.5 km forest edge zone, which corresponded to the maximum nest area used by the eagles in this study, was chosen. The mean distances computed for the nests and for the random points were compared with the T-test. Furthermore, for each nest 2 km-radius zones (approximately 12.5 km^2) were delimited in GIS environment, using Corine Land Cover 2000 maps (European Commission 1994, European Environment Agency and European

Topic Center 2002). The radius value used here (following Treinys 2004) corresponds to the area in which most of the Lesser Spotted Eagle hunting activity took place in Latvia (Meyburg *et al.* 2004a, b). In the 2-km areas, excluding forested parts, the proportion of land use types: built-up areas, meadows and pastures, arable lands, habitat mosaic (small plots of cultivated land) and wasteland was calculated, to determine their amount in each foraging territory. The same calculations concerning land use types were performed for the whole study plot, in order to asses the availability of each habitat. The proportions were compared with the t-test.

72 hours of observations of 10 different pairs on their foraging territories were conducted between May and September 2006. 20 hours and 11 minutes comprised observations of hunting birds. Time spent on activities such as perch-hunting, patrol-flight and seeking for prey on foot was recorded separately for each type of the analyzed habitat: grasslands, arable lands, mosaic and others (settlements, ecotone, swamps). These data were compared with the time expected to be spent by birds in each of the habitats. The expected values were based on the percentage of the land use types in the whole study plot and in the eagles' foraging territories (2 km-radius nest zones).

During the study 13 occupied Lesser Spotted Eagle territories with 15 nests were found. The breeding density was 2.9 pair 100 km^{-2} in the total study area and 5.2 pairs 100 km^{-2} in the forested part. The forest stands occupied by the Lesser Spotted Eagles were more than 50-year old and their mean age was 85.6 (±30.3 SD) years, while the mean age of randomly selected trees in this forest complex was 47 years (Gątkiewicz and Tołwiński 1995). Due to small number of nests, there were no statistically significant differences between the class age of the random forest stands and the age of the forest at the occupied nest sites.

The most frequently used nesting tree was spruce (67%), next pine (20%), oak (7%)

Table 1. Comparison of distances (m) between some landscape features and Lesser Spotted Eagle nests locations (n = 15) on the study plot in the Knyszyńska Forest (NE Poland) versus random points.

Distance to the nearest	Nests			Random points				
	mean	range	SD	mean	range	SD	t	*P*
Open area	174	30–600	144	1001	60–2250	733	–4.288	<0.001
Settlement	1269	595–3995	858	447	170–807	229	3.59	0.002
Watercourses*	425	85–1190	341	884	255–2040	638	–2.457	0.03

* like rivers and streams

Table 2. Comparison of share in land-use types between Lesser Spotted Eagle hunting territories (n = 13) in 2 km-radius zone from nests and the whole study plot in the Knyszyńska forest (NE Poland).

Land-use type	Hunting territories		Study plot		
	Share %	SD	Share %	t	*P*
Built-up area	2	5	2	–	ns
Arable land	32	19	48	–3.257	0.006
Meadows and pastures	50	20	29	4.091	0.001
Mosaic	1	2	4	–5.882	<0.001
Wastelands	9	13	15	–	ns
Others	5	11	1	–	ns

and birch (7%). In the Knyszyńska Forest the dominating species is pine (68%), then spruce (13%), birch (7%), oak (5%) and oters (7%) (Gątkiewicz and Tołwiński 1995). The relative proportions of the occupied tree species differed significantly from the proportions of these species in the whole forest ($\chi^2 = 150.9$; df = 4; $P < 0.001$). It should be emphasized that 40% of the occupied nests were located on marshy wood stands.

The mean distance from the nests to open areas was over 5 times shorter than the distance of the random locations, and the difference was highly significant (Table 1). Similar preferences were recorded in the case of proximity to water bodies. The eagles significantly avoided built-up areas, as the mean distance to buildings was almost three times longer than in the case of the random points. The hunting territories of the eagles were characterized by significantly lower proportion of arable lands and higher proportion of meadows and pastures (Table 2). Also, the percentage of mosaic habitats differed between the territories and the whole study plot, being higher in the latter.

The observations of hunting birds provided some detailed information about the habitats most often used for hunting. As much as 96% of hunting behavior was recorded on grasslands. Only 1.3% of hunting time was spent in a mosaic of small farm fields, 1.2% in arable fields and 0.6% in strips of ecotone between forest and open spaces. The observed and the expected hunting time expenditure (Fig. 1) differed significantly for grasslands both on the whole study plot ($\chi^2 = 1210$; df = 1; $P < 0.001$) and the hunting territories ($\chi^2 = 682$; df = 1; $P < 0.001$).

The Lesser Spotted Eagles showed a clear preference for spruce as the nesting tree. Spruce is common in all types of forests in NE Poland and cannot be a factor that limits nesting of this eagle species. The high preference for spruce may result from its dense branches, which are well hidden out of sight of humans and predators and so they seem suitable for constructing a nest.

I also found that the nest sites were located closer to potential foraging habitats than the random points. Similar results were obtained in other parts of the Lesser Spot-

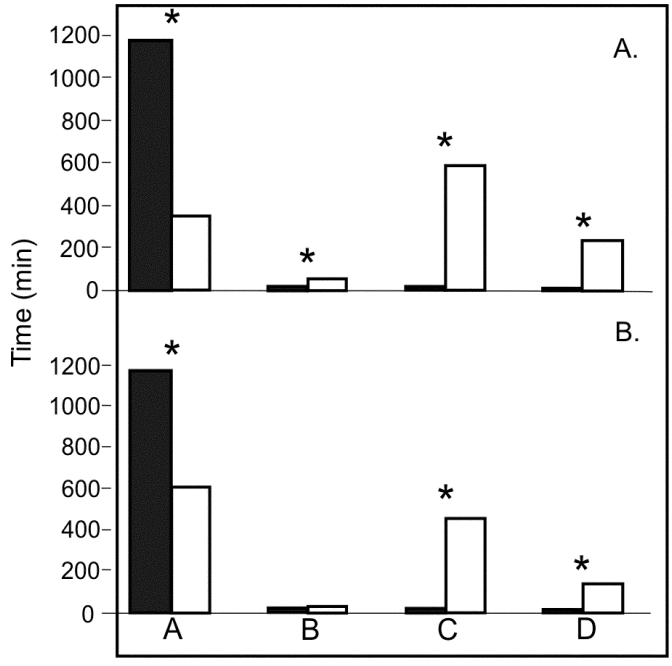

Fig. 1. Comparison of the time (n = 1211 min) Lesser Spotted Eagles spent hunting on different habitats, between observed values (grey bars) and expected values (white bars). Upper figure (A.) present comparison within the whole study plot, lower figure (B.) within the 2 km-radius zones from birds' nests. Highly significant differences (P <0.001) are marked with *. A – grassland, B – mosaic, C – arable land, D – others (explanations are given in text).

ted Eagle distribution range – in Lithuania (Drobelis 1996), Estonia (Lõhmus 2006) and also elsewhere in Poland (Pugacewicz 1994). The nests were located inside the forest complex only if there were large clear-cut meadows in their vicinity. This observation confirms the importance of the proximity of the nest to hunting territories.

The results have shown that the eagles selected forest areas away from human settlements. The nests were located significantly further away from built-up areas than the random points, and in the optimal distance to potential foraging habitats. Surprisingly, in a study conducted in Estonia, among the surveyed raptor species the Lesser Spotted Eagle bred nearest to human settlements. This pattern was most probably accounted for by the eagle's strong preferences for low vegetation habitats of anthropogenic origin and low human population density in Estonia. In Germany and Lithuania, whose human population density resembles that of Poland, the Lesser Spotted Eagle also avoided proximity to human settlements (Langgemach *et al.* 2001, Treinys 2004). Different preferences were recorded in Spain in the case of a widespread raptor species – the Common Buzzard *Buteo buteo* (Linnaeus 1758) and the Golden Eagle *Aquila chrysaetos* (Linnaeus 1758). The Common Buzzard was found to prefer hunting sites in the vicinity of human settlements, while the Golden Eagle avoided human settlements (Tapia *et al.* 2008). In my study, the Lesser Spotted Eagles showed trends similar to the latter species and both the Golden Eagle and the Lesser Spotted Eagle are relatively rare in managed landscapes.

Another factor affecting nest site location by the eagles was distance to watercourses. The birds preferred sites near rivers and streams. This may be explained by the fact that the majority of grasslands are cultivated in river valleys, unlike arable lands, which are situated in dry habitats. Additionally, watercourses limit disturbance of nest sites by humans, because they make the forest less accessible and occasionally may flood it. Similar trends were observed in Estonia, where the Lesser Spotted Eagle nested near water bodies (Lõhmus and Väli 2005).

The analysis of the foraging habitat components indicates that meadows and pastures were highly preferred by the Lesser Spotted Eagles. This is supported by the results obtained through observations of hunting birds. Grasslands are often richer in prey than are arable lands (Butet and Leroux 2001, Rodriguez and Bustamante 2008), which were avoided by the birds in this study. Also, prey accessibility, dependent on vegetation structure, is a key factor in selection of foraging habitats (Aschwanden *et al.* 2005, Bechard 1982, Preston 1990, Romanowski and Żmihorski 2008). The proximity of a foraging habitat that is rich in prey seems to be the most important factor affecting the occurrence of the Lesser Spotted Eagle, since it hunts for relatively small prey (Zawadzka 1999, Jędrzejewska and Jędrzejewski 1998), although with high frequency.

Land use types similar to these found in this study were preferred by the Lesser Spotted Eagle in Latvia (Meyburg *et a*l. 2004b). Also in Germany Lesser Spotted Eagles spent more time hunting on grasslands than it would be expected from their proportion in hunting territories, although the percentage of grasslands in the territories was smaller than the percentage of arable lands (Meyburg *et al.* 2004b). What is more, the hunting territories were much larger in Germany than in Latvia. It seems that the Lesser Spotted Eagle actually prefers meadows but when it lacks optimal foraging habitats it also searches for food on arable lands.

It can be concluded that open areas, especially grasslands, located in the vicinity of old stands with high proportion of spruce are the habitat types which are preferred by the Lesser Spotted Eagle. Therefore, to maintain its population stable, habitat management in areas with large populations of this bird of prey, e.g. SPAs (Special Protection Areas – according to Council Directive of 2 April 1979 on the conservation of wild birds) should take into consideration the habitat preferences reported in this study.

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