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SHORT REPORT

Nest-site selection and breeding ecology of Sky Larks *Alauda arvensis* in Hungarian farmland

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Capsule Nesting Sky Larks avoided arable fields and the vicinity of farm buildings, and preferred extensive and heterogeneous grassland, where nest success was 30%.

Sky Larks *Alauda arvensis* are one of the most characteristic farmland birds in the Palaearctic. Their original habitat is open steppe and grassland, which have been created by man over centuries of the expansion of farmland (Donald 2004). However, changes in farmland management practices and intensification of agriculture from the 1960s have converted extensive farmlands to intensively managed habitats with poor food resources (Wilson *et al.* 1999, Chamberlain *et al.* 2000) and low numbers of favourable nesting sites (Wilson *et al.* 1997, Donald *et al.* 2002). These changes have resulted in the decline of breeding success (Wilson *et al.* 1997, Chamberlain *et al.* 2000) and the collapse of Sky Lark populations, with a 54% loss observed between 1970 and 2001 in the UK (Gregory *et al.* 2004). Similar population crashes have been described for other farmland bird populations, and other countries (Donald *et al.* 2006), as well as for several insect taxa on which Sky Larks are dependent (Dennis *et al.* 2008).

In central Europe, most farmland bird species have large population densities and stable or increasing population trends (Donald *et al.* 2002, Gregory *et al.* 2005, Szép & Nagy 2006). This is probably due to the decrease of most intensification measures after changes in the 1990s (Báldi & Faragó 2007).

Sky Larks breed in a wide range of natural and artificial open habitats, including grasslands, coastal marshes, arable fields and set-aside fields (Donald 2004). Interestingly, studies from intensive UK farmland showed that arable fields are among the most important breeding habitats for Sky Larks (Donald 2004). This contradicts our observations in various Hungarian farmland regions, where two to four times higher densities of Sky Larks were observed in semi-natural grasslands than in arable fields (Báldi *et al.* 2005, Batáry *et al.* 2007, Kovács *et al.* 2007).

The changing agriculture in Hungary may threaten semi-natural grasslands, mainly because of the cessation of traditional grazing (European Environment Agency 2004). Grassland vegetation structure has been modified, which, in turn, could influence Sky Larks' reproductive success, for example, via different predation pressures (Fuller & Gough 1999, Henderson *et al.* 2004).

We aimed to estimate the relative importance of arable fields and large grassland areas for nesting Sky Larks in central European farmland. We described breeding parameters, and determined whether grazing and/or human disturbance affected Sky Lark nest-site selection. Further, breeding parameters, and their differences between predated and successful nests were compared. Finally, we aimed to determine which kind of vegetation structure is preferred by nesting Sky Larks.

The study was carried out on alkali dry grassland and arable fields at Bösztörpuszta in the Kiskunság National Park, central Hungary (46°57′24″ North, 19°09′43″ East). This was an area of over 1000 ha of typical

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Hungarian grassland ('puszta'), interrupted by arable fields, woodlots, marshlands and farms (Fig. 1). Characteristic bird species were Sky Lark, Whinchat *Saxicola rubetra*, Corn Bunting *Emberiza calandra*, Northern Lapwing *Vanellus vanellus*, Common Quail *Coturnix coturnix*, Stone-curlew *Burhinus oedicnemus* and Great Bustard *Otis tarda* (Báldi *et al.* 2005, Kovács *et al.* 2007). The most widespread agricultural activity is traditional grazing; a herd of 320 Hungarian grey cattle grazed the grassland from April to November. There were no fences; a shepherd took care of the herd. No fertilizer, pesticide or other chemicals were applied to the grassland. The crop on the arable fields was winter cereals. Mean nitrogen input (by artificial fertilizer) was 92 kg/ha/year, and the mean yield/output was 4.1 tonnes/ha.

Fieldwork was carried out from April to July in 2004 and 2005. We located Sky Lark nests by systematically searching the ground vegetation of the grassland and arable fields. It was not possible to follow the flushing or returning adults, since in this open landscape, adults flush at a distance of *c.* 100 m. Roughly 170 days were devoted for nest searching in the whole study area. Nests were marked by 10 cm-tall sticks placed 5 m from the nests and the exact geographical position was noted with a global positioning system (GPS) (Garmin Geko 201). Nests were visited every 3–6 days to record breeding parameters: clutch size, egg size, tarsus-length and reproductive success. The nests were monitored until the chicks left the nests. After that, grass height and vegetation cover were estimated by eye within 25, 50, 100 and 200 cm radii around the nests. The effect of vegetation was tested using repeated measures ANOVA. Since the assumption of sphericity was violated, we applied the Greenhouse–Geisser test, which did not require sphericity. We compared the vegetation between predated and intact nests using the Mann–Whitney *U*-test. Only predated nests, but not all failed nests, were used in this analysis, since we expected that vegetation structure, via visibility, influenced predation. Egg volume

Figure 1. Map of the study area at Bösztörpuszta, Kiskunság, central Hungary. Dark grey, arable fields; grey (patterned), grassland; black squares and polygon at 'F', farm buildings; FO, forest; circles, failed Sky Lark nests; stars, successful Sky Lark nests.

was estimated with Carey's (1996) formula: egg volume = max. length × max. width^2 × 0.51. We considered the nests predated if one or more of the eggs disappeared or were found damaged.

A total of 50 nests were found in the grassland over the 2 years (29 nests in 2004 and 21 nests in 2005). No nests were found in the arable fields. Sky Larks nested far away from human disturbance and away from the most intensively used parts of the pastures; the nearest nests were found 550 m from the farm buildings (Fig. 1). However, it should be noted that we had only one farm in the study area; therefore the avoidance of farm buildings needed further investigation.

From the total of 50 nests, 15 were successful, 28 nests were predated, 6 nests were not hatched and in one case we found two dead chicks close to the nest. Mean clutch size was 4.13 (n = 15, sd = ± 0.8) and mean egg volume was 3228.4 mm^3 (n = 158, sd = ± 309.8), calculated from 43 clutches with eggs. There were no differences between egg dimensions of predated and intact nests (P > 0.1 for all comparisons applying t-tests).

The vegetation around the nests in the sampled circles (radii 25, 50, 100 and 200 cm) showed significant difference for both grass height and vegetation cover (repeated measures Greenhouse–Geisser tests: Grass height, sum of squares = 690.290, df = 1.761, mean square = 391.989, F = 7.871, P = 0.001; Cover, sum of squares = 1607.227, df = 1.867, mean square = 861.057, F = 4.071, P = 0.023). Both grass height and vegetation cover had higher values in the smallest, 25 cm radius, circles indicating a preference for a tussock close to a nest (22, 17, 18 and 19 cm mean height in the 25, 50, 100 and 200 cm circles, respectively, and 81, 74, 73 and 75% mean cover in the 25, 50, 100 and 200 cm circles, respectively).

Vegetation height and cover around the fledged nests were higher than at predated nests, although this was not statistically significant, probably due to high variation (Mann–Whitney tests: Height, 25 cm, U = 142.5; 50 cm, U = 134.5; 100 cm, U = 131.5; 200 cm, U = 145.5; Cover, 25 cm, U = 168.0; 50 cm, U = 164.0; 100 cm, U = 154.5; 200 cm, U = 170.0; for all cases n = 44 and P > 0.1). The difference between mean grass height of predated *versus* intact nests was largest at the 25 cm sample circle, suggesting that nest success mainly depends on this finest scale (Fig. 2).

We have shown that nest-site selection by Sky Larks in our study area seems to be different from that in

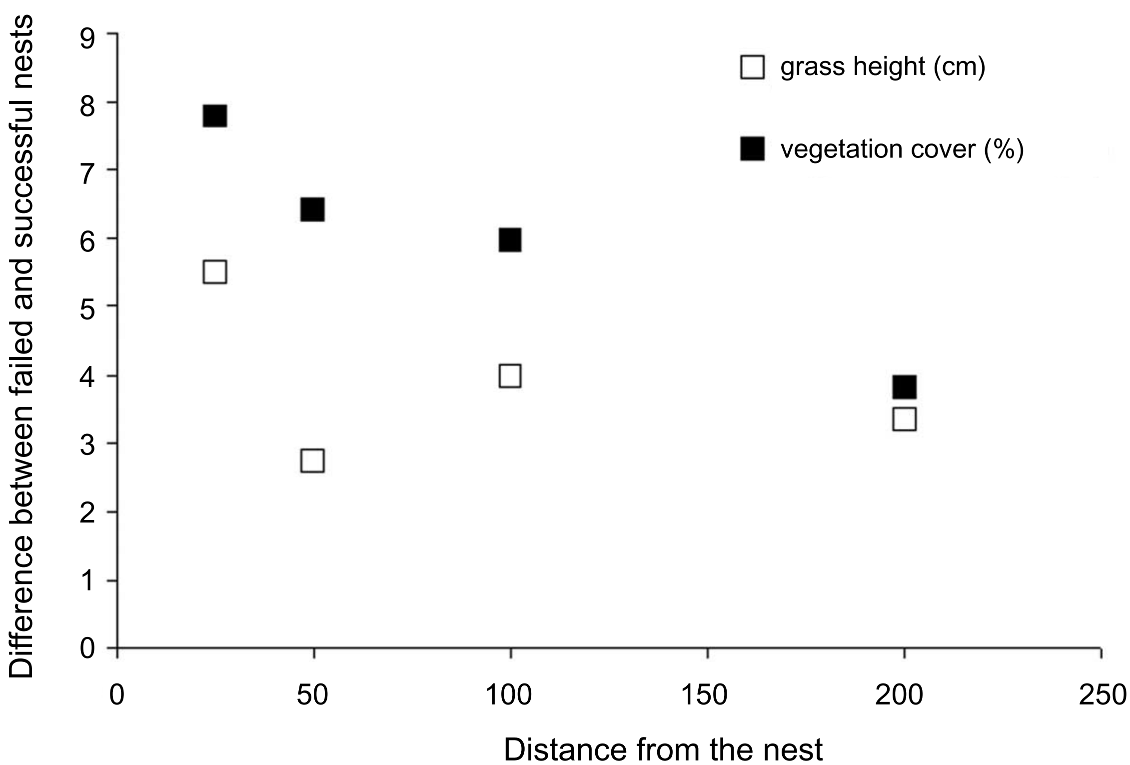

Figure 2. Differences in vegetation structure (i.e. grass height at successful nests subtracted from grass height at predated nests) within 25, 50, 100 and 200 cm radii around predated *versus* successful Sky Lark nests.

western Europe, especially with respect to the avoidance of arable fields and human presence in our study area. We suggest that grassland vegetation heterogeneity (presence of tussocks) is necessary for nesting, and this contributes to higher breeding success. In spite of these differences, breeding ecology measures (clutch and egg sizes, tarsus-length) seem to be comparable to UK populations (Donald 2004).

The selection of arable fields by British populations may be explained by the result of different farmland management practices. UK grasslands are intensively managed and heavily fertilized, resulting in dense and homogenous vegetation, not suitable for Sky Lark breeding (Donald 2004, Vickery *et al.* 2001), or allowing only low reproductive success (Wilson 2001). UK swards do not provide enough food for the chicks (Wilson *et al.* 1999). By comparison, only *c.* 5% of Hungarian grasslands are fertilized (Nagy 1998), they are rarely seeded and improved, and usually grazed or mowed. Therefore, there are sharp differences between UK and Hungarian grasslands, while in arable fields the management is more similar in the two regions.

The semi-natural grasslands in Hungary have a local-scale vegetation heterogeneity, which provides tussocks. We found that tussocks are the preferred nest-sites for Sky Larks, probably owing to the higher concealment, which usually increases breeding success (Flaspohler *et al.* 2000, Wilson 2001).

A major factor in nest-site selection of Sky Larks in our study area seemed to be the avoidance of farmland buildings and cattle shelters. There are at least three possible explanations. First, the vegetation structure at these sites, which the 320 cattle visited twice a day, is not suitable for Sky Larks due to lack of vegetation (Fuller & Gough 1999, Vickery *et al.* 2001, Pavel 2004). Secondly, the frequent livestock movement increased trampling and disturbance, which decreased the suitability for nesting (Shrubb 1990, Vickery *et al.* 2001, Pavel 2004). No large trampling effect is expected further in the pasture because the herd is dispersed over an area of several hundreds of hectares. Thirdly, humans, free-ranging dogs and cats may frighten away Sky Larks from the vicinity of the farm buildings (Woods *et al.* 2003).

Farmland management is different across Europe, and it may cause variations between habitat selections of farmland birds. Most farmland biodiversity studies originate from a few west European and North American countries (Kleijn & Báldi 2005). However, central and east European countries play an important role in farmland biodiversity conservation, therefore there is a need for intensive studies. We suggest that to promote the breeding populations of Sky Larks in Hungarian lowlands the maintenance of heterogeneous grasslands with a traditional, extensive grazing regime is necessary. The grassland management scheme of the agri-environment programme is a potential tool to support such management. However, studies from other regions in Hungary and of other species of farmland birds are also needed before advising policy makers.

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