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The importance of farmland for Ortolan Buntings nesting on raised peat bogs

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The majority of the Norwegian population of the endangered Ortolan Bunting, *Emberiza hortulana*, breeds on raised peat bogs. I studied whether their breeding site selection was affected by the availability of another habitat (farmland) close to bogs. At the landscape level, Ortolan Buntings always chose peat bogs that had farmland ≤ 50 m away. At the individual peat bog level, Ortolan Buntings had territories in those parts of the bog that were closest to farmland, and territories were usually ≤ 100 m from farmland. These results indicate that bog-breeding Ortolan Buntings require farmland in close proximity to their territories. This conclusion was further supported by observations at the behavioral level. Ortolan Buntings were frequently seen flying between territories on the peat bogs and adjacent farmland (oat fields), often returning with food in the bill. I also analysed the distribution of Ortolan Buntings in relation to peat bog size, availability of different bog microhabitats, and human use of peat bogs (peat extraction), but the effect of distance to farmland remained significant also in multiple analyses. Ortolan Buntings apparently do not have the classical all-purpose territory typical of most passerine birds, but have more or less separated nesting and feeding areas. I discuss possible reasons for this pattern and also the conservation implications of the habitat selection of the Ortolan Bunting.

1. Introduction

For successful breeding, birds require a suitable nesting site and foraging areas. It is often assumed that many birds, especially passerines, defend all-purpose territories where all breeding activities take place (Hinde 1956, Lack 1968, Schoener 1968, Perrins & Birkhead 1983). However, there are exceptions to this pattern, and birds may defend nesting territories in one area and feed in other areas that are some distance away. This obviously occurs in many seabirds and waterbirds, but also among some passerines such as colonial icterids and weavers (Lack 1968). Among solitary and territorial landbirds such a pattern is apparently rare, having been documented only in few cases, notably the Nightjar *Caprimulgus europaeus* (Alexander & Cresswell 1990, Cresswell 1996).

The Ortolan Bunting (*Emberiza hortulana*) is a migratory passerine bird which during the breeding season feeds on both seeds and insects (Cramp & Perrins 1994). Ortolan Buntings require breeding areas that are open, rather dry and with sparse vegetation (Durango 1948, Cramp & Perrins 1994). In many parts of the distribution range it breeds in mixed farmland, but in Norway it is now nearly extinct in this habitat (Dale & Hagen 1997).

The single largest population (about 50 males in 1997) in Norway breeds in a 23-year old forest-fire area where surrounding farmland seems to be important for foraging (Dale 1997, Dale & Olsen 1998). However, the majority of Ortolan Buntings in Norway (> 55 %) breeds on raised peat bogs (Dale & Hagen 1997), a habitat which is rarely used elsewhere in the species' range. It has been suggested that they require peat bogs that have farmland in close proximity (Dale 1997), and this hypothesis was tested in the present study. Understanding the habitat use of the Ortolan Bunting is of particular interest since the species is listed as vulnerable in Europe (Tucker & Heath 1994) and endangered in Norway (Størkersen 1996).

The importance of farmland for Ortolan Buntings nesting on peat bogs was studied at three different levels. First, at the landscape level, the occurrence of Ortolan Buntings on 109 bogs was analysed with respect to several factors including how far away the closest areas of farmland were situated. Second, at the level of each peat bog, the position of Ortolan Bunting territories was analysed with respect to distance to farmland and other factors. Third, at the behavioral level, I recorded whether individual Ortolan Buntings used farmland close to peat bogs for foraging. I use the results to address the question of whether Ortolan Buntings on peat bogs have a classical all-purpose territory, or nesting territories that are spatially separated from their main feeding areas.

2. Methods

2.1. Peat bog survey

In 1997, a total of 109 bogs [mostly raised peat bogs (ombrotrophic bogs) and poor fens (minerotrophic mires); Økland 1989, Fremstad 1997] in Hedmark and Akershus counties in south-eastern Norway were searched for Ortolan Buntings. This included almost all peat bogs below 200–250 m altitude along the river Glomma south of Elverum in Hedmark county and many bogs below 200 m altitude in Akershus county. In addition, a number of peat bogs at higher altitudes was also visited. Nearly all bogs close to farmland areas were visited whereas a number of peat bogs in forested areas with no farmland in the vicinity was also searched. The names and exact locations of all bogs visited are given in Dale and Hagen (1997). The areas investigated included the main distribution range of Ortolan Buntings in Norway (about 95% of the Norwegian population; Dale & Hagen 1997).

The peat bogs were searched systematically by walking slowly across the bogs so that no point would be more than approximately 100 m from the observer's transect. On small bogs the observer walked in a circular route on the bog (approximately as far from the edge as from the centre), on larger bogs cross transects were also made. The presence of Ortolan Buntings was determined by sight observations, song or alarm calling. The position of all birds observed were recorded on maps of each bog, and different pairs/territories were distinguished on the basis of distance between birds observed and simultaneous recordings of different individuals. Furthermore, notes on the behaviour of birds were made, especially use of nearby farmland. Bogs in Hedmark county and Aurskog-Høland municipality in Akershus county were visited once during the nestling period (14–23 June), whereas bogs in other municipalities in Akershus county were visited once during the nest-building or incubation period (end of May or beginning of June). Bog searching during the nestling period ensured that a high proportion of the birds present would be detected on single visits (0.5–4 h per bog). In the nestling period, breeding pairs will alarm call at a high rate which is not much affected by time of day or weather conditions (personal observations; however, searches were not done during heavy rain). A previous test (Dale & Hagen 1997) indicated that during short visits in the nestling period > 80% of breeding pairs were detected, and also 30% of unmated males even this late in the season. Thus, in this study the presence of Ortolan Buntings on most peat bogs was probably detected though a small proportion may have been missed.

Some peat bogs were also visited in 1996 and one Ortolan Bunting territory was found on a bog (Rønnåsmyra) where no Ortolan Buntings were present in 1997. This observation was included in the present study. In addition, observations on Ortolan Bunting behaviour on peat bogs also included data from both 1996 and 1998 when 22 and 76 bogs, respectively, were searched.

2.2. Peat bog characteristics

Peat bog size was determined from Norwegian topographical maps (1993–1995 editions of series M711, scale 1:50.000) to the nearest hectare (ha) for bogs < 15 ha and to the nearest 5 ha for bogs > 15 ha. The distance between peat bog margins and closest farmland was also measured from the topographical maps, and values in steps of 50 m were used (0, 50, 100 etc.). The closest farmland consisted in all cases of grain fields, mostly oats (*Avena sativa*). In addition, as a measure of farmland area close to peat bogs, the total farmland area < 500 m from bog margins was determined from the same topographical maps. Four farmland area classes were used: no farmland, < 10 ha farmland, 10–100 ha, and > 100 ha. Distance to closest farmland was not related to peat bog size ($r_s = -0.07$, N = 109, P = 0.47), but farmland area < 500 m away increased with peat bog size ($r_s = 0.31$, N = 109, P = 0.0013).

The availability of microhabitats on bogs was measured on two scales. (1) Vegetation density was classified as open (no or few trees and bushes), partly closed (trees of small or medium size which covered at most 50% of the ground, mostly *Pinus sylvestris*), or dense (trees of medium or large size which covered most of the ground; more or less like forest). (2) Bog moisture was classified as dry (no apparent soil moisture, vegetation dominated by *Calluna vulgaris*), partly wet (water in soil apparent in footprints, vegetation dominated by mosses, especially *Sphagnum* spp.), or wet (surface water, vegetation often dominated by *Eriophorum vaginatum* and *Carex* spp.). Most bogs had several microhabitats available (91 of 109; mean number = 2.7; Table 1), and the number of microhabitats increased with bog size ($r_s = 0.35$, N = 109, P = 0.0003), but was not related to distance from farmland ($r_s = -0.15$, N = 109, P = 0.11).

Of the 109 bogs, 54 (50%) did not have any signs of human use. The remainder had been drained by ditches, used for peat extraction previously, or were presently used for peat extraction. Eighteen bogs did not have any areas of natural bog left, whereas the remaining 37 bogs had areas both unused and used by humans. Bogs that had been used for peat extraction previously (earlier this century; Engström et al. 1976, Vasander 1996) now had a more or less continuous cover of two vegetation types: wet troughs with *Sphagnum* spp., *Eriophorum* spp. and/or *Carex* spp. where peat had been dug out, alternating with dry ridges with *Calluna vulgaris* and varying density of trees (*Betula pubescens* and/or *Pinus sylvestris*) which reflected the original bog surface. Bogs used for peat extraction at present usually had large areas completely stripped of vegetation and large machines removed the top layer of peat at frequent intervals, thereby effectively preventing regeneration of vegetation (Engström et al. 1976, Vasander 1996). However, even many of the most intensively used bogs had narrow strips of more or less disturbed bog vegetation along the bog margins. Bogs with previous or present peat extraction (N = 34) were larger than other bogs (N = 75; U-test: U = 902, P = 0.015), and were also closer to farmland (U = 871, P = 0.005).

2.3. Territory characteristics

The locations of territories were plotted on field maps of bogs. Even though bogs were visited only once, the reliability of single plots were considered high based on detailed behavioral studies of a colour-ringed population on a forest-fire site (S. Dale, unpublished data). The estimated centre of a territory was used when determining distance from farmland, microhabitat and kind of human use. For the latter two variables, territory characteristics followed the classification used for bog characteristics (see above).

2.4. Statistical analyses

Because of the correlations between variables describing peat bog characteristics (see above), logistic regression (SAS Institute 1989) was used to determine their independent effects on presence/absence of Ortolan Buntings. Peat bog size (log(x) transformed) and distance to closest farmland (log(x+1) transformed) were continuous variables, area of farmland within 500 m from peat bogs was measured as < 10 ha or > 10 ha, microhabitat was classified as open and dry areas present or not, and human use was classified as no use at all, or some or all parts of the bog affected by peat extraction. All statistical tests are two-tailed.

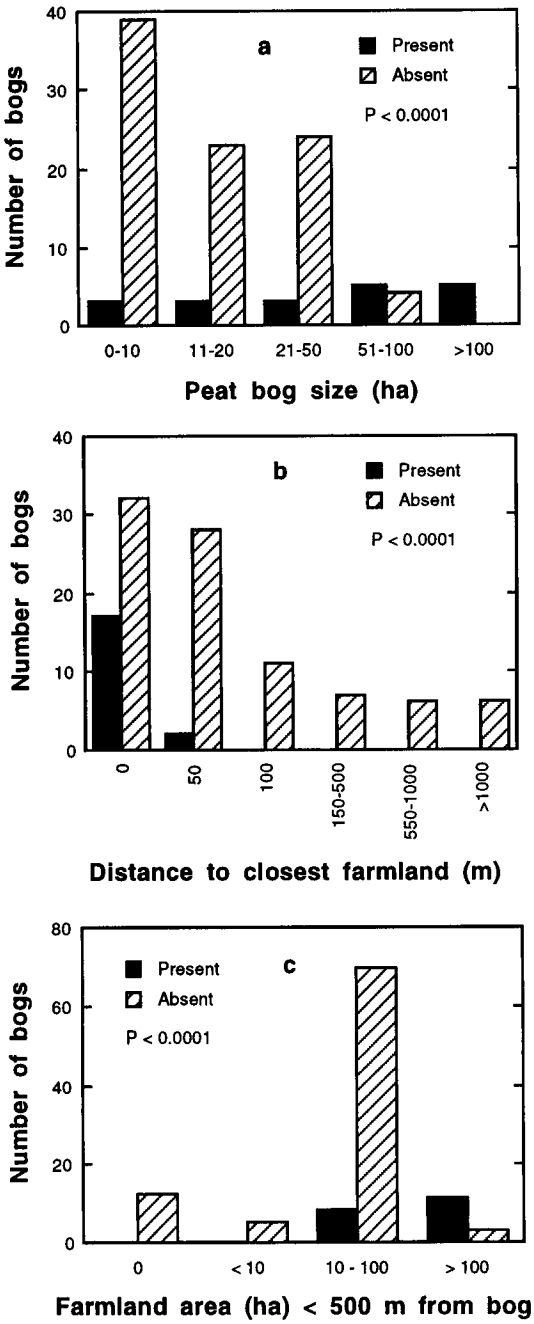

Fig. 1. Comparisons of peat bogs used (present, N = 19) and not used (absent, N = 90) by Ortolan Buntings. (a) Frequency distributions of sizes of bogs. (b) Frequency distributions of distances between bogs and closest farmland. (c) Frequency distributions of area of farmland < 500 m away from bogs. See text for details of statistical test.

3. Results

3.1. Selection of peat bogs

Ortolan Buntings were recorded on 19 of the 109 peat bogs that were searched, and there were 1–9 territories on each bog (median 2, total number was 60). Bogs that were used by buntings had a median size of 60 ha (range 6–200, N = 19) whereas bogs not used had a median size of 12 ha (range 3–90, N = 90; U = 365.5, P < 0.0001; Fig. 1a). The distance between the peat bog and the closest farmland was shorter for bogs that were used by buntings (median 0 m, range 0–50) than for bogs not used (median 50 m, range 0–3000; U = 364, P < 0.0001; Fig. 1b). The total area of farmland less than 500 m away from bogs was larger for bogs used by buntings (median farmland area class was > 100 ha) than for bogs not used (median farmland area class was 10–100 ha; no farmland and < 10 ha farmland were combined in the test due to small sample sizes: $\chi^2 = 35.3$, df = 2, P < 0.0001; Fig. 1c).

Bogs that were used by Ortolan Buntings always had areas that were dry and open or partly closed (Table 1; 18 of 19 bogs used had open and dry areas, the exception offered dry and partly closed vegetation instead). Buntings occurred both on bogs without signs of human use and on bogs that had been affected by various human activities (Table 2). Seven of the 19 bogs used by buntings had no signs of human use at all, whereas 5 of the bogs used had no areas of natural bog vegetation left. The remaining seven bogs had areas both used and unused by humans.

A logistic regression of how peat bog characteristics were related to presence or absence of Ortolan Buntings, showed that bog size and distance to closest farmland had significant effects; large bogs and bogs close to farmland had buntings more often (Table 3). Bogs with dry and open microhabitat available tended to have buntings more often, although not significantly so (Table 3). However, among bogs ≤ 50 m away from farmland and > 20 ha in size (N = 33), buntings were present on 13 of 25 bogs with dry and open areas available, whereas none of eight bogs without such microhabitat had buntings present (Fisher exact test: P = 0.012). A similar analysis of large bogs

close to farmland showed that buntings were present on 8 of 16 bogs with peat extraction, and on 5 of 17 bogs without peat extraction (Fisher exact test: $P = 0.30$), paralleling the overall absence of an effect of human use (Table 3).

3.2. Territories

Territories of Ortolan Buntings were in general positioned close to farmland (Fig. 2). Out of the 60 territories, 75% were ≤ 100 m from farmland. On all 19 bogs with Ortolan Buntings they occurred closer to farmland than if territories had been randomly distributed over the bogs (sign test: $P < 0.001$; test done by comparing average distance from farmland for the whole bog with that of bunting territories).

The microhabitat of the bunting territories was in 44 cases dry and open and in 16 cases dry and partly closed. No territories occurred on parts of the bogs where the vegetation was partly wet, wet or dense. An analysis of territory selection on bogs where both open and partly closed areas existed close to bog margins showed that the majority of territories were in open areas (24, compared to 13 in partly closed areas). Since bog margins were usually the driest parts of bogs a preference for dry areas could not be tested further.

In 23 cases Ortolan Bunting territories were situated in areas where the peat bog vegetation was undisturbed, whereas the remaining 37 territories were in areas that had been used for peat extraction earlier this century. No territories occurred in areas that were presently used for peat extraction. An analysis of territory selection on bogs where both types of bog habitat were available close to farmland showed that the majority of territories was on previously used bog (18, compared to six on unused bog).

3.3. Behaviour

In total, 21 flights between peat bogs and farmland were observed. In five cases, the flights involved pairs, but pair members were not treated as independent observations here. Flights were observed on 14 of the 19 peat bogs. Twelve flights were from bog to farmland and 11 flights were from farmland to bog (there were two cases in which a bird was observed flying from bog to farmland and back again). Observed flight distances were < 100 m (N = 9), 100 m (N = 1), 150 m (N = 1), 250 m (N = 1), > 100 m (N = 5), > 300 m (N = 3), and > 400 m (N = 1). In 12 cases the birds were seen on the ground in grain fields (before or after flights). Birds on the ground in fields were ≤ 50 m from the bog in 10 cases, in the remaining two cases they were 100 m and 150 m from the bog. Birds were seen foraging in fields singly or in pairs, not in flocks, even at those bogs where there were several pairs breeding.

In five cases birds returning from farmland were seen to have food (insects) in the bill, even though it was not always possible to see if returning birds carried food. On the other hand, I made no observations of flights within bogs which would suggest that foraging on the bog itself had occurred, and I made no direct observations of foraging on bogs.

Table 1. Number of peat bogs used by Ortolan Buntings in relation to bog microhabitats (total number of bogs with each microhabitat available in brackets). Note that many bogs had several microhabitats available. Total number of bogs used by Ortolan Buntings was 19, total number of bogs was 109.

Microhabitat	Dry	Partly wet	Wet
Open	18 (71)	9 (61)	8 (29)
Partly closed	17 (72)	1 (17)	1 (1)
Dense	7 (35)	1 (3)	– (–)

Table 2. Number of peat bogs with Ortolan Buntings present in relation to kind(s) of human use (total number of bogs with each combination of use(s) in brackets). Some bogs had 2–4 kinds of use available. Total number of bogs used by Ortolan Buntings was 19, total number of bogs was 109.

Human use	Only one kind of use	Other use(s) also
Not used	7 (54)	13 (79)
Drained	0 (9)	3 (26)
Old peat extraction	2 (11)	10 (32)
Present peat extraction	0 (1)	7 (13)

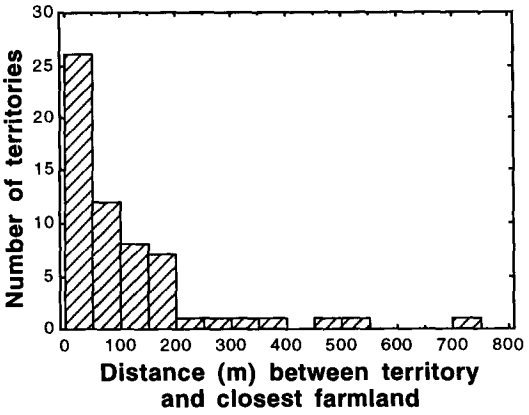

Fig. 2. Frequency distribution of distances between territories (N = 60) of Ortolan Buntings and the closest area of farmland.

4. Discussion

4.1. Importance of farmland

At the landscape level, all raised peat bogs used by Ortolan Buntings had farmland very close by (≤ 50 m away). This pattern was significant even when controlling for correlated variables such as peat bog size and amount of farmland around bogs. At the level of each bog, most territories of Ortolan Buntings were close to farmland which may suggest that they depend on food resources in grain fields for successful breeding. This was confirmed by direct observations of buntings foraging in farmland and returning to peat bogs with food. Foraging in adjacent farmland was not only done by those Ortolan Buntings that had territories at the edge between bogs and farmland, but also by birds with territories further inside the bogs. Thus, several observations of buntings flying over other bunting territories on their way to farmland were made, and flights over strips of forest between bog and farmland were also seen.

A similar pattern has been observed in the large Ortolan Bunting population breeding on a forest-fire area in Hedmark county in Norway. There, few males can hold territories immediately adjacent to farmland, but direct observations and a radio-telemetry study have shown that farmland is frequently used, even areas as far away as 1–2 km from territories (Dale 1997, Dale & Olsen 1998). Despite the ability to fly some distance to feed, territories on the forest-fire area are also located closer to farmland than expected by random (S. Dale unpublished data). Thus, Ortolan Buntings breeding on both peat bogs and forest fire areas in Norway appear to have separated nesting and feeding areas. On the other hand, territories are placed so that distances between nesting and feeding areas are often as short as possible, possibly to reduce travel costs.

I made no observations of Ortolan Buntings feeding on the peat bogs themselves. This does not mean that no food is collected on peat bogs at all, because buntings would probably start alarm calling if they were feeding inside their territories when I made my short visits in the nestling period. However, raised peat bogs have a low productivity (Fremstad 1997) and the density and the number of species of breeding birds is low (Järvinen & Sammalisto 1976). Food may be more abundant on farmland where seeds (grain) are available early in the breeding season and insects later. It is likely that several of the other bird species present on raised peat bogs also forage in surrounding farmland. I have made observations of Curlews (*Numenius arquata*), Yellow Wagtails (*Motacilla flava*) and Yellowhammers (*Emberiza citrinella*) flying from bogs to farmland. Thus, part of the avian community on raised peat bogs may breed there because of suitable nest sites while an unknown proportion of the food must be collected elsewhere.

Table 3. Logistic regression of the influence of peat bog characteristics on presence or absence of Ortolan Buntings on bogs. Total N was 109. R^2 for the whole model was 0.44.

Variable	df	χ^2	P
Peat bog size	1	8.72	0.0031
Distance to closest farmland	1	8.25	0.0041
Area of farmland < 500 m from bog	1	0.01	0.94
Microhabitat	1	2.05	0.15
Human use	1	0.81	0.37

4.2. Bog size and microhabitats

In addition to the effect of adjacent farmland, peat bog size also influenced the probability of Ortolan

Buntings being present on a bog. Large bogs had a wider range of microhabitats available, and the size itself would make it more probable that the preferred bog microhabitat was available close to farmland. Ortolan Buntings in general require open and dry areas for nesting (Durango 1948, Cramp & Perrins 1994), and it seemed that this was the case also for peat bog nesting Ortolan Buntings, even though this factor was not significant in multiple analyses. Most Ortolan Buntings had territories in open areas, but about one quarter of the territories were in areas that were partly closed. In a few cases this resulted from an absence of open areas on individual bogs, but in other cases it may have resulted from territorial behaviour. Some birds may then have had the choice between a territory close to farmland but in partly closed area, or a territory in open area but further away from farmland. Some birds may then choose a denser than preferred habitat to reduce travel costs.

4.3. Territory system

The present study indicated that Ortolan Buntings do not always possess the classical all-purpose territory. Feeding and nesting areas seemed to be more or less separated, and many birds would have to fly some distance to reach feeding areas, often crossing other territories and habitats (forest). Such a territory system has been documented in very few species of landbirds so far. In the Nightjar birds may fly up to 7 km from their nesting areas in heaths and conifer woodland clearings to feed in mixed and deciduous woodland and wetlands (Alexander & Cresswell 1990, Cresswell 1996). Otherwise separated nesting and feeding areas occur in colonial species which depend on food that is unpredictable in time and space, e.g. seeds, and in seabirds and waterbirds where breeding close to food is physically impossible (Lack 1968, Perrins & Birkhead 1983).

Separation of feeding and nesting areas may be related to particular requirements in nest site selection. It has become increasingly clear that a bird's niche is determined by specializations for avoiding nest predation as well as for avoiding competition for food (Martin 1993, 1996). Thus, one possibility is that the Ortolan Bunting chooses to nest in habitats with lower nest predation rates than in their feeding habitats. They may therefore accept travel costs between nesting and feeding areas in order to reduce predation costs. An alternative hypothesis may be that some species require specific microclimatic conditions for successful breeding.

4.4. Human use of bogs and conservation

The effect of human use of peat bogs (previous peat extraction versus natural bogs) on presence of Ortolan Buntings was not entirely clear-cut. Ortolan Buntings occurred on bogs with both kinds of areas, and territories were also located in both habitats. There might have been a preference for areas with previous human use because of a larger number of territories in such areas and because buntings avoided untouched areas on a few bogs, but I cannot exclude the possibility that these differences may ultimately be related to other factors important in breeding site selection of Ortolan Buntings.

However, on bogs which are used for peat extraction at present most of the bog vegetation has been destroyed. Effective harvesting of peat results in large, barren areas which have no cover for nest placement. Such bogs sometimes have parts that are not used for peat extraction, or they have narrow margins with more or less disturbed bog vegetation. Thus, some of these bogs had Ortolan Buntings present, but where peat extraction is intense the available areas for breeding may be small and regrowth of shrubs and trees may eventually make the habitat unsuitable for Ortolan Buntings. The negative effects of too intense peat extraction are important in relation to the survival of the Ortolan Bunting in Norway. The species has become increasingly rare with a current population size of only about 100 breeding pairs (Dale & Hagen 1997), and the species is classified as endangered by extinction (Størkersen 1996). The present study indicates that preservation of open and dry bog vegetation along bog margins facing towards farmland will be of great value for the continued survival of the Ortolan Bunting, and such management practices should not be too costly for peat extraction companies.

In Europe, the Ortolan Bunting is listed as vul-

nerable (SPEC category 2; Tucker & Heath 1994). Thorough understanding of threatened species' habitat requirements is important for their conservation. The finding of the present study that a combination of different habitats may be required for breeding should be considered when assessing the consequences of changes in land use for a number of different species. The value of a multiple-use agricultural landscape should be apparent (Tucker & Evans 1997).

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Selostus: **Maanviljelysalueiden läheisyyden merkitys soilla pesiville peltosirkuille**

Peltosirkku on vähentynyt monissa Euroopan maissa viime vuosina. Valtaosa Norjan peltosirkuista pesii poikkeuksellisesti soilla. Kirjoittaja tutki monimittakaavaisen tarkastelun avulla peltojen läheisyyden merkitystä soilla pesivien peltosirkkujen elinympäristönvalintaan Norjassa. Maisematasolla peltosirkku valitsi pesimäympäristöksi sellaisia soita, joiden läheisyydessä (≤ 50 m) oli peltoja. Yksittäisen suon tasolla peltosirkkujen reviirit sijaitsivat soiden niissä osissa, jotka olivat mahdollisimman lähellä peltoja. Yleensä reviirit sijaitsivat ≤ 100 m päässä pellosta. Tulokset viittaavat siihen, että peltojen läheisyydellä olisi merkitystä soilla pesiville peltosirkuille. Kirjoittajan mukaan Norjassa suot toimisivat peltosirkkujen pesimäalueina, mutta ruokailu ja ravinnonhankinta tapahtuisi pelloilla. Myös lintujen käyttäytymisessä havaitut piirteet viittasivat tähän. Peltojen läheisyyden lisäksi myös suon pinta-ala vaikutti positiivisesti peltosirkun elinympäristövalintaan, sen sijaan suon mikrohabitaateilla ei ollut merkitystä peltosirkun esiintymiseen. Norjalaisilla soilla pesivillä peltosirkuilla näyttää olevan pesimäaikana spatiaalisesti erilliset pesimä- ja ravinnonhankinta-alueet. Yleensä varpuslinnuilla sekä pesintä että ravinnonhankinta tapahtuu territoriolla, joka täyttää molemmat edellä mainitut tarpeet.

References

Alexander, I. & Cresswell, B. 1990: Foraging by Nightjars Caprimulgus europaeus away from their nesting areas. — Ibis 132: 568–574.

Cramp, S. & Perrins, C. M. 1994: The birds of the western Palearctic. Vol. IX: buntings and new world warblers. — Oxford Univ. Press, Oxford.

Cresswell, B. 1996: Nightjars — some aspects of their behaviour and conservation. — Brit. Wildl. 7: 297–304.

Dale, S. 1997: The Ortolan Bunting — an endangered species in Norway. — Vår Fuglefauna 20: 33–38. (In Norwegian with English summary).

Dale, S. & Hagen, Ø. 1997: Population size, distribution and habitat choice of the Ortolan Bunting Emberiza hortulana in Norway. — Fauna norv. Ser. C, Cinclus 20: 93–103.

Dale, S. & Olsen, B. F. 1998: Different breeding and feeding habitats of Ortolan Buntings Emberiza hortulana in Norway. — Ostrich 69: 281.

Durango, S. 1948: Notes sur la reproduction du Bruant Ortolan en Suède. — Alauda 16: 1–20.

Engström, R., Leander, S. & von Malmborg, B. 1976: Myrmarker. — Riksförbundet för hembygdsvård, Sweden. (In Swedish).

Fremstad, E. 1997: Vegetasjonstyper i Norge. — NINA Temahefte 12: 1–279. (In Norwegian).

Hinde, R. A. 1956: The biological significance of the territories of birds. — Ibis 98: 340–369.

Järvinen, O. & Sammalisto, L. 1976: Regional trends in the avifauna of Finnish peatland bogs. — Ann. Zool. Fennici 13: 31–43.

Lack, D. 1968: Ecological adaptations for breeding in birds. — Methuen, London.

Martin, T. E. 1993: Nest predation and nest sites. — Bioscience 43: 523–532.

Martin, T. E. 1996: Fitness costs of resource overlap among coexisting bird species. — Nature 380: 338–340.

Økland, R. 1989: Hydromorphology and phytogeography of mires in inner Østfold and adjacent parts of Akershus, SE Norway, in relation to SE Fennoscandian mires. — Opera bot. 97: 1–122.

Perrins, C. M. & Birkhead, T. R. 1983: Avian ecology. — Blackie, Glasgow.

SAS Institute. 1989: JMP user's guide. — SAS Institute Inc., Cary, NC, USA.

Schoener, T. W. 1968: Sizes of feeding territories among birds. — Ecology 49: 123–141.

Størkersen, Ø. R. 1996: Nye rødlister for truede arter i Norge. — In Brox, K. H. (ed), Natur 96/97: 71–78. Tapir, Trondheim, Norway. (In Norwegian).

Tucker, G. M. & Evans, M. I. 1997: Habitats for birds in Europe: a conservation strategy for the wider environment. — BirdLife International, Cambridge.

Tucker, G. M. & Heath, M. F. 1994: Birds in Europe: their

conservation status. — BirdLife International, Cambridge.

Vasander, H. (ed). 1996: Peatlands in Finland. — Finnish Peatland Society, Helsinki.