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Present occurrence and habitat selection of the Wood Lark *Lullula arborea* in SW-Finland

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The Wood Lark population in SW-Finland crashed at least once during 1960–1993. This was probably due to the severe winters in South and Central Europe during 1984–1986. The population recovered from the crash in SW-Finland by the beginning of the 1990s. The population crash of the mid-1980s was reflected in the two Atlas-samples (1974–79 and 1986–89): the number of Atlas-squares with Wood Larks declined by 29% in Turku-Pori, and by 67% in the whole of Finland. We estimate the size of the Wood Lark population in SW-Finland to be about 400 pairs. We could not confirm the steady decline from the 1940s, which has been reported based on migration counts, probably because observer density and behaviour have changed concurrently. By an analysis of habitat characteristics we show that Wood Larks select their breeding sites carefully. Wood Lark territories were larger and more open than nearby control plots. The number and height of trees, and proportion of deciduous trees also differed between territories and control plots. Based on the same analysis, we estimate that 10–35% of the suitable sites of the rocky habitat type were vacant in the beginning of the 1990s.

1. Introduction

During the 1980s there occurred a significant increase in the awareness of problems that many species meet under changing environmental conditions. In many European countries, including Finland (Rassi 1985), "red books" on endangered species appeared. The data seemed to show that many species had decreased down to the verge of local extinction. More importantly, the data showed the lack of information, especially the lack of detailed studies on species occurrence and on factors causing variability in abundance. Although birds are the most eagerly monitored target group, the quality of amateur data usually does not allow for firm conclusions. The main problem is that biased sampling cannot be corrected *a posteriori*. We try to use some amateur data, together with a detailed study by an adequate sampling design, to address this problem. Our target species is the Wood Lark *Lullula arborea*, which was classified as a rare species by Rassi (1985) and reclassified as a vulnerable one by Rassi (1991). Therefore, knowledge of its population dynamics and habitat requirements are important.

The Wood Lark is sparsely distributed nearly all over Europe, but it is not very abundant in any part of the continent (Glutz von Blotzheim & Bauer 1985). In Finland, this species has always

been rare. However, no censuses were conducted before the 1970s.

Mela (1882) said that the species was not very rare, especially in southwest Finland. Merikallio's (1958) estimate for the size of the Finnish Wood Lark population was 500 pairs. According to von Haartman et al. (1963–72), the Wood Lark was a rare species in the 19th century, and started to increase in 1910s. Migration counts, both in Finland and in Scania, Sweden, showed that the northern Wood Lark populations started to decrease in the 1950s (Hildén 1974, 1979). In the late 1970s, the Finnish population size was estimated to be 2000–3000 pairs (Koskimies 1983). The present estimate for the whole country is 800 pairs (Koskimies 1991, 1993, Rassi 1991).

The main breeding areas of the Wood Lark are located in southern and southwestern Finland (Hyytiä et al. 1983). In these regions the Wood Larks breed in three habitats: eskers (e.g., Hämeenkangas, Salpausselkä), rocky areas, and gravel pits. The last one is a new manmade breeding habitat. Gravel pits are mostly alongside eskers, but more recently also in rocky areas. Wood Larks avoid areas with coarse and tall vegetation, mainly because they search for food by walking on the ground (e.g., Cramp 1988).

First, we describe the present and past occurrence of the Wood Lark in SW-Finland. We do it (1) by studying the archival materials of the Ornithologists' Societies of Turku and Pori, (2) by comparing the results of the Breeding Bird Atlas I (conducted 1974–1979) and II (1986–1989) in the province of Turku and Pori, and (3) by analysing the results of an intensive field study conducted in SW-Finland in 1990–1993. Second, we analyse the habitat selection of the population that breeds in the rocky areas. Exact knowledge of habitat requirements is essential when considering conservation of the species and its environment.

2. Material and methods

The study area was the province of Turku and Pori (coordinates of Turku 60°27′N, 22°15′E). The southern part of the area is mainly agricultural land, broken by forests and rocky areas. The proportion of rocky areas declines to the east and north, and they are replaced by the eskers Säkylänharju and Hämeenkangas-Pohjankangas (Fig. 2).

The archives of the regional ornithological clubs include observations from the 1930s on in the Turku region and from the early 1960s on in the Pori region. Observations before the 1960s were so scattered that they were of limited help. Heterogeneity of data remains a problem also in the recent data, because changes in observers' efficiency and habits in the field could not be estimated.

Breeding bird atlas data were collected from 1974–1979 and 1986–1989 (for the methods, see Koskimies & Väisänen 1991). Species were given a breeding index for each 10 × 10 km square (index range: 0–9; the larger the number, the higher was the probability of breeding). Thus, we obtained data on how many squares were occupied by the Wood Lark and how certain breeding was, but not on the number of breeding pairs.

Our own field study was concentrated in an area close to Turku, where from our previous knowledge we knew the density to be sufficiently high (Fig. 2). The study was based on the following sampling plan. (1) We selected seven study areas (size 14 × 18 km = 252 km^2/area) randomly from the whole study area (dashed squares in Fig. 2). (2) We then randomly chose 20% of those 1 × 1 km squares that contained rocky areas (seen from detailed landscape maps, scale 1:20 000) and carefully checked them with the help of a song decoy. Checking was carried out mostly in April, between 4 and 10 a.m. The number of checked squares was 20–42/area, totalling 207 in the whole study area. The total number of squares with rocky areas was 2750 in the whole study area. The eskers and gravel pits were checked systematically (see also Virtanen 1991).

Data on habitat characteristics were collected mainly in 1991 and 1992. About 180 rocky areas without a Wood Lark territory were checked. We selected 24 of these plots randomly for comparison with occupied territories. The most important criterion for inclusion of a plot into the control sample was that it was, in human eyes, similar to

the nearby occupied Wood Lark territory. However, the control plots were neither occupied by Wood Larks during 1990–1992 nor earlier (according to the archival material). These areas were about 1 km away from the nearest territory, but not a part of any territory. By the analysis of territory quality we want to find such habitat characteristics, which are not appreciated enough by the human eye that need to be known for conservation purposes. The habitat analysis also allows an estimate of the degree of occupancy of suitable habitat patches.

The following distance variables describe, how close to unsuitable plots and possible disturbance sources each plot is: DH, distance to nearest inhabited houses; DR, distance to the nearest road (small forest roads constructed for forestry neglected); DO, distance to other kinds of open habitats (fields, lawns etc., not rocky areas); DU, distance to closest unsuitable habitat plot (lake, dense forest etc.). Distances were measured from the centre of the plot, which, in territories, was usually the highest point on the plot and the favoured location of the larks.

We described the habitat quality by the following characteristics: AR, the total rock area (limits of the rock area were usually easily defined by the borders to an unsuitable habitat); BR, proportion of the bare rock surface; OA, the area of open part of the territory (includes the bare rock areas, and areas with field layer vegetation); OP, proportion of the open area from the whole territory area; HT, average height of the trees; NT, number of trees (height >1 m) in the centre of the territory (25 m radius around the favoured site in the territories, centre of the "non-territory"); DT, percentage of deciduous trees and bushes of all trees/bushes.

Distance measurements and total rock area were log-transformed because of skewness. We compared territories and non-territories to each other both by ANOVAs on single characteristics, and by principal components analysis and discriminant analysis on the important principal components. We used Jackson's (1993) recommendations to decide the importance of principal components. The statistical analyses were made by SAS procedures UNIVARIATE, GLM, PRINCOMP, and DISCRIM (SAS Institute Inc. 1990).

3. Results

3.1. Population changes

Archival data. Archival material of the Ornithologists' Unions is described in Table 1. The low number of observations in the first period (15) results apparently from low numbers of observers and not from low numbers of Wood Larks. Since 1965, the numbers seem to remain even until the middle of the 1980s, when they crash sharply. The two last years are perhaps not strictly comparable to the others, because of our intensive study and attempts to direct the amateur ornithologists' attention to the species. However, we got a strong impression that the species had recovered from the population crash of the mid-1980s. We cannot confirm by data from the breeding areas the reported population decline of the 1950s and 1960s based on migration counts (Hildén 1974). The number of observers then was too low, and the style of field trips was simply not productive for the probability of observing Wood Larks. The only thing suggesting decline is that many territories, which were occupied during 1940-1960 are now empty. At least some of the territory desertions has been due to overgrowth of the habitat, and close to Turku, from construction of new suburbs. Figure 1 summarises the distribution of Wood Lark territories in the southern part of the province of Turku and Pori in the beginning of the 1990s.

Breeding bird atlas records. The number of 10×10 km Atlas-squares inhabited by the Wood Lark are shown in Fig. 1. In the province of

Table 1. Numbers of known occupied Wood Lark territories in the province of Turku and Pori in 1960–1991. In each period, an occupied territory is counted only once.

Years	No. of territories
1960–64	15
1965–69	51
1970–74	63
1975–79	70
1980–84	96
1985–89	31
1990–91	80

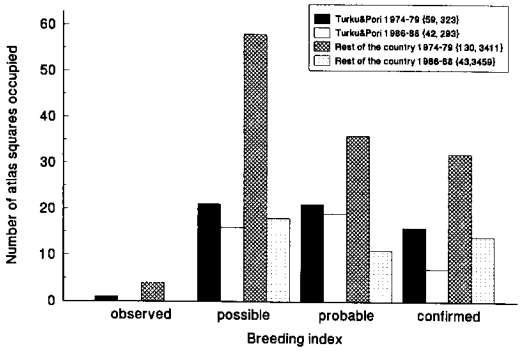

Fig. 1. Occurrence of the Wood Lark according to Breeding Bird Atlas studies in the province of Turku and Pori and in other areas of Finland for 1974–1979 and 1986–1988. Breeding Index (BI) was translated to probability of breeding as follows: BI 1 = species was observed, but did not breed in the square, BI 2–3 = breeding was possible, BI 4–6 = breeding was probable, and BI 7–9 = breeding was confirmed. Numbers in in the legend show the number of squares with Wood Larks and the total number of squares checked.

Turku and Pori, the number of inhabited squares declined from 59 to 42 (–29%) between the two studies. The proportion of verified breeding occasions also declined appreciably. In other parts of Finland numbers of occupied territories declined more strongly, from 130 to 43 (–67%). However, the proportion of verified breeding occasions did not decline. In the 1970s, breeding was confirmed in 31% of the squares inhabited by the Wood Lark located in SW Finland, but in the late 1980s this proportion was as high as 49%.

Field study. We checked 207 rocky squares out of a total of 1043, in seven sampling areas from 1990–1991 (Table 2, Fig. 2). We found 22 occupied territories, which gives a mean density of 0.11 pairs/km^2 (95% confidence interval 0.04–0.17) for rocky areas. Based on the total number of squares with apparently suitable open rocky areas (2750) we estimate that the Wood Lark population living in the rocky areas in the province of Turku and Pori was in the beginning of the 1990s, 290 (120–470) pairs. This may be an optimistic estimate, since some plots viewed by us as suitable may actually not completely fulfil the requirements of the Wood Lark (see habitat selection below). Besides the rocky areas, about a hundred pairs of Wood Larks, in our study area, breed in gravel pits and on eskers. Our total estimate for the size of the Wood Lark population, in the province of Turku and Pori, is 400 pairs. Virtanen (1991) and E. Topp (1992) estimated the whole Finnish population at 2000 pairs, which based on this study and notes from SE-Finland (Koskimies, pers. comm.) may be an overestimation by a factor of two. On the other hand, Karhumäki (pers. comm.) observed several inhabited territories in Perniö in 1993, where most of the territories known to us from the archival material (Fig. 2) were not in use during 1985–1991. Indications of continuing recovery were also reported from Rymättylä in 1993 and 1994 (Saari, pers.comm.).

3.2. Habitat selection

The inhabited Wood Lark territories were larger and more open than the nearby control plots. In non-territories, unsuitable habitats, such as mature forests, were closer to the plot center than in territories, which suggests avoidance of too closed landscape (Table 3). The species appeared to avoid roads ($P < 0.044$).

Because several habitat characteristics were correlated with each other (13 of the 66 correlations were significant at $P \leq 0.05$), principal components analysis is a more meaningful approach. The first principal component (PC1) is an openness factor, since the four highest loadings

Table 2. Sampling areas of the field study conducted in 1990–1991 and density variation of the Wood Lark in them. See Fig. 2 for the location of sampled areas.

Area	Rocky squares	Checked squares	Occupied territories	Density (/km^2)
I	200	40	1	0.025
II	211	42	7	0.167
III	137	27	2	0.074
IV	110	22	5	0.227
V	104	20	2	0.100
VI	130	26	2	0.077
VII	151	30	3	0.100
Total	1043	207	22	0.106±0.067

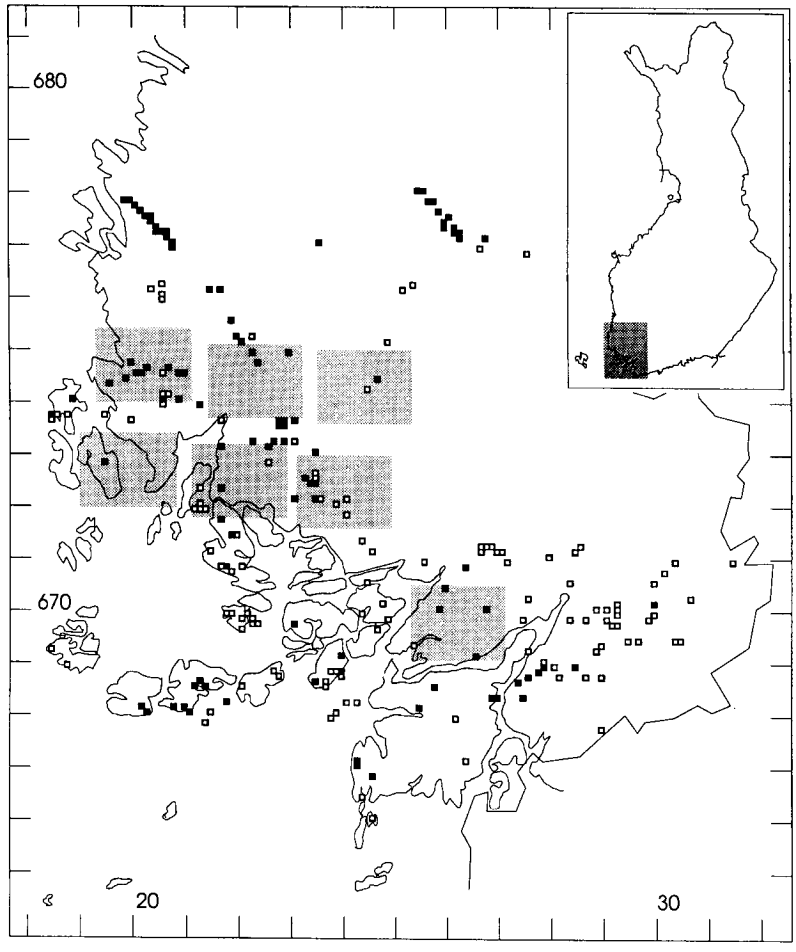

Fig. 2. The occurrence of the Wood Lark in SW-Finland. Open squares = territories known to be inhabited before 1985. Filled squares = territories inhabited during 1985–991. Filled large squares = the seven sampled study plots of the intensive study (see Table 2). The coordinates are according to the Finnish uniform grid

(78.9% of Σa^2_{ij}) are due to the original variables describing openness of the plot in different ways. PC1 collected 31.9% of the total variation. In PC2, a further 15.0% of variation was accumulated. The second component is a bit heterogeneous, but we regard it mainly as a size factor. The three highest loadings comprised 77.1% of it, and they were: size of the plot, proportion of deciduous trees and bushes, and distance to the nearest house (Table 4). PC3 is even harder to interpret, and we therefore leave it without notice, although it is at the border of the "stopping" zone (see Jackson 1993).

The distributions of territories and control plots separate well in the habitat space defined by PC1 and PC2 (Fig. 3). Only two points, in both directions, are on the "wrong side" of the demarcation line. This line is the average of the discriminant functions calculated from the two first principal components. The message of the principal components analysis thus is that the Wood Larks are far better in judging the habitat quality for their purposes than are humans, and select carefully their territory sites from all superficially suitable sites.

4. Discussion

4.1. Population trends

According to the archival material, the number of Wood Lark territories varied considerably. However, the results were difficult to interpret,

because we did not exactly know how effectively bird watchers had checked habitats suitable for the Wood Lark, in different periods. It is certain that up to the 1960s there were so few ornithologists in the field that the low numbers were due to the ineffectiveness of field work. In addition, the mobility of amateurs was restricted with most activity concentrated near the cities. During the last twenty years, the efficiency has increased, because there are more bird-watchers and they have improved possibilities for their hobby. In light of this, the crash in the middle of the 1980s, was unquestionably real. A. Topp (1988) also reported this decline based on migration count data. According to Bijlsma et al. (1988), the crash, which was detected even in Central Europe, could have resulted from severe and snowy winters of 1984/85 and 1985/86 in South and Central Europe.

Our results suggest that Wood Larks have recovered from this low phase. This could be due to favourable wintering conditions and good breeding seasons. In good breeding seasons, the Wood Lark can recover from a population crash

Table 3. Univariate description of habitat characteristics of occupied territories and nearby control plots of the same general type. Arithmetic mean with standard deviation and sample size in brackets is given. Comparison between groups with one-way ANOVA. See Table 4 for the description of variables.

Variables	Territories	Control plots	F	P
DH (m)	523. (311, 26)	499. (415, 24)	0.05	0.8211
DO (m)	263. (143, 30)	257. (252, 24)	0.02	0.9029
DU (m)	146. (116, 29)	83. (47, 24)	6.16	0.0164
DR (m)	276. (232, 29)	166. (129, 24)	4.26	0.0440
AB (%)	39. (24.1, 22)	8.9 (11.8, 24)	30.29	0.0001
AO (m^2)	9727.0 (8964, 26)	1377.0 (3096, 24)	18.74	0.0001
AR (ha)	4.9 (14.64, 26)	3.1 (1.73, 24)	0.36	0.5496
PO (%)	49.6 (26.2, 28)	5.9 (13.9, 24)	53.54	0.0001
HT (m)	4.9 (2.0, 28)	6.0 (2.1, 24)	3.36	0.0727
NT (n)	69.1 (32.0, 22)	91.0 (32.7, 24)	5.28	0.0264
DT (%)	11.0 (9.5, 22)	26.2 (19.0, 24)	11.47	0.0015

Table 4. Eigenvectors of original variables in the principal component analysis.

	PC1	PC2	PC3
Distance to			
nearest house (DH)	0.122	0.376	0.263
other open habitat (DO)	0.111	-.225	0.208
unsuitable area (DU)	0.242	0.236	0.268
road (DR)	0.122	0.004	0.737
Area of			
bare rock (AB)	0.446	-.035	-.092
open habitat (AO)	0.472	0.091	-.045
the total plot (AR)	-.074	0.628	0.140
Proportion of open area (PO)	0.468	-.233	-.033
Height of trees (HT)	-.293	-.163	0.399
Number of trees (25m radius, NT)	-.384	-.181	0.108
Proportion of deciduous trees (DT)	-.138	0.484	-.265

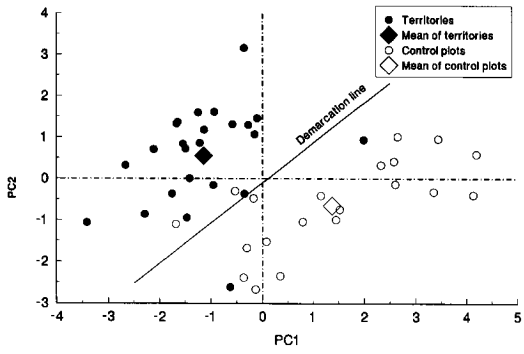

Fig. 3. The distribution of Wood Lark territories and control plots in the habitat space of the two first principal components axis. PC1 is an openness factor and PC2 a size factor. See Table 4 for more details of the composition of axes. Demarcation line separates territories and control plots in a discrimant function analysis based on these two habitat axes.

quickly, since it can produce 3–5 young/pair/brood (E. Topp 1988, Virtanen 1991). It also can raise two (even three) broods in a year.

The trend suggested by atlas data for the whole of Finland is worrying, if it is real and steady. The two atlas study periods coincided, however, with very different weather phases. Field work of the first atlas was made after the mild, early 1970s, and the second atlas followed the two severe winters in mid 1980s. This difference between the field periods of the two atlas samples should be remembered when considering apparent population changes in sedentary and short-distance, intra-European migrants (see also Väisänen & Routasuo 1992).

4.2. Habitat requirements

Wood Larks favoured large, open rocky areas. In the largest of these, several pairs bred close together. Most Wood Larks in the province of Turku and Pori occur in a zone extending about 30–70 km inland from the coast (Fig. 2).

Rocky breeding habitats of the Wood Lark are typical of the northern Fennoscandian bedrock area. In the surroundings of the southern Baltic area, the species usually breeds in sparse coniferous forests on sandy soil (Viksne 1989). Clearcuts in coniferous woods benefit the species (Bowden 1990, Glutz von Blotzheim & Bauer 1985). In this sense, the species is dependent on habitat manipulation by man. The part of the Finnish population, which uses manmade habitats, e.g. gravel pits, road construction areas, and industrial sand fields, is growing all the time (see Virtanen 1991). Some of these habitat patches are, however, quickly overgrown and become unsuitable for the species.

The rocky, open areas studied by us are the natural breeding habitats of the Wood Lark in Finland. Until the 1950s many suitable high rocky places were continuously created by forest fires. Due to efficient fire monitoring and the avoidance by forestry to use such places, because they are difficult for mechanised harvesting and less productive, many potential Wood Lark plots have become overgrown. This may be a contributing factor behind the long term decreasing trend in the breeding grounds. We believe, however, that more important factors causing the decrease, since the 1940s, are changes in the availability of wintering habitats in northern Central Europe (see Glutz von Blotzheim & Bauer 1985). Superimposed on the long-term trends are the population crashes caused by hard winters and recovery of the population afterwards. The role of environmental pollution suggested by Rassi (1985) and E. Topp (1992), along with weather changes, as the main reason behind the decline has not been confirmed.

Wood Larks require a high proportion of bare ground and low field layer vegetation that can be interspersed with other taller vegetation types (Bowden 1990). In such places they can forage by walking and running for invertebrate food. In our habitat analysis a crude measure of these characteristics was included in the first principal component (Table 4). We showed that the Wood Lark selects its territory site by using a combination of criteria that is not easily seen by the human eye (Fig. 3). This means that without a detailed habitat analysis we cannot estimate precisely the saturation level of the Wood Lark population. Also, evaluation of the factors behind the long term population trend requires good understanding of habitat selection and habitat change characteristics.

Based on our habitat analysis we can estimate, if there is any empty space for more Wood Larks to settle. Because two or three of the control plots are within or very close to the group of dots representing the territories (Fig. 3), the minimum proportion of vacant plots of "high" territory quality is 12%. If, however, the two territory plots furthest down and to the right in the figure are also within the normal variation of acceptable territory sites, then there have been 30–35% "acceptable" sites available in the beginning of the 1990s.

Although the declining trend of the Finnish Wood Lark population is only partially due to habitat changes in the breeding area, and the declining trend (in SW Finland at least) appears to have stopped, monitoring of the Wood Lark population should be continued. The problems of the species in southeastern Finland (Koskimies 1991) should especially be studied. More important, the ongoing studies on the breeding biology of the species (Hannu Virtanen, see, Virtanen 1991 and Erkki Topp, see, Topp, E. 1992) should be encouraged and their results published. The breeding success and recruitment rates, and their dependence on habitat quality and weather conditions should be carefully analysed.

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