

Relationship of the Common Treecreeper *Certhia familiaris* to edge effect and forest fragmentation

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The paper deals with two questions: 1) Do the breeding success of the Treecreeper and its occupancy of nest-boxes vary in relation to the proximity of the forest edge (data from S Finland)? 2) What is the area of the smallest forest fragments and real islands accepted by a breeding Treecreeper pair (seven data sets from northern and western Europe)? According to the breeding records the egg-laying date, clutch size and size of breeding adults did not differ in relation to the proximity of the forest edge. A greater proportion of nests (37%) was destroyed in forest margins (<20 m) than in the interior parts (26%). The occupancy of nest-boxes in large forest stands (>50 ha, 65%) exceeded that in smaller ones (<20 ha, 56%).

The minimum area of forest fragments supporting a breeding pair of Treecreepers increases from about 1 ha in Britain to about 20 ha in N Finland. Correspondingly the minimum area of a real island increases from about 3 ha in Britain to 11 ha in SW Finland. The minimum area for islands is slightly larger than for terrestrial forest fragments, but no data are available on the quality of the habitats or possible variation in the degree of isolation.

Factors affecting the minimum area are discussed: in the north a larger area is needed for overwintering and/or successful breeding; on the other hand, the higher the regional density of a species, the greater is the probability that small habitat patches will also be colonized. The effects of forestry on the species are more dramatic in the north, where it needs large areas of old forest.

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Introduction

The effects of forest fragmentation on temperate bird communities have received much attention during the past decade, but detailed population studies are lacking. Among Finnish bird populations, one of the most dramatic declines observed in recent years is that of the sedentary foliage-gleaning species of coniferous forests, reported by Järvinen et al. (1977). The group of species that they studied ("Tit guild") comprises *Parus montanus*, *P. cristatus*, *P. ater*, *P. cinctus*, *Perisoreus infaustus* and *Certhia familiaris*, and the northern species and populations have been most severely affected. It has been suggested that it is not only the reduction in the area of old forest, but also the fragmentation that has played an important role in the decline of these species (Järvinen et al. 1977, Helle & Järvinen 1986). Detailed data on *Parus cinctus*

support this explanation (Virkkala 1985) and it seems that winter conditions play a central role here.

The data on these species have usually been so scarce that they are discussed as a group. The Common Treecreeper *Certhia familiaris* is often included in the group, but the species is partially migratory and not all the population is exposed to the northern winter. According to the Finnish winter bird censuses, the Treecreeper has shown fairly stable population development during the past two decades (Hildén 1986).

In this paper, we address two questions. 1) Using data on the density of breeding Treecreepers in forest fragments and real islands of different size, we try to find out whether the species prefers small or large forest patches. 2) Using data collected in S Finland with special Treecreeper nest-boxes, we examine whether the nesting success and occupancy of nest-

boxes by the species differ between forest margins and the forest interior. There is evidence that nest predation in forest edges is heavier than that in the forest interior (e.g. Andrén & Angelstam 1988, Yahner & Scott 1988); this idea can also be examined from the present data.

Material and methods

Breeding data

The field work was carried out in southern Finland (Hauho, 61°10'N, 24°40'E) in 1974–1983. The study area (5870 ha) is situated in the south boreal phytogeographical zone and it comprises mainly (65%) forested land. The forests are chiefly coniferous and consist of Norwegian spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*); deciduous tree species (birches *Betula pendula* and *B. pubescens* and European aspen *Populus tremula*) are rare (for a detailed description of the study area see Kuitunen 1987).

The data were collected from a population of about 30–80 pairs breeding yearly in 156 special nest-boxes (for details see Kuitunen 1985). About 36 per cent of the pairs laid a second clutch. Altogether 534 breeding attempts were used in the analyses. The distance of every nest-box from the nearest clearing or other open habitat (lake, shore, field, bog) was determined by consulting the local forest management officials and forestry maps. The distances from the nearest open habitat edge were classified as follows (the number of breeding attempts in parentheses, data from different years pooled): <20 m (71), 21–50 m (70), 51–90 m (120), 91–140 m (116), 141–200 (56) and >200 m (56). The areas of the stands with a nest-box were measured and the patches were divided into three categories (<20 ha, 20–50 ha and >50 ha). The values of the above variables at the nest-box sites may have differed between the years and in 45 instances of breeding we were not able to determine these variables. Further, we were not able to measure the areas belonging to the different edge categories, due to lack of information, and we cannot calculate Treecreeper densities for these edge classes.

Forest fragments and islands

Four studies have dealt with the occurrence of the Common Treecreeper in forest 'islands'. Helle (1984) studied 12 mature forest plots of varying size in

Kuusamo, N Finland; the fragments were surrounded by clearings, seedling stands or open bogs. Similarly, Haila et al. (1987) inspected 35 forest fragments in S Finland; the stands were coniferous and surrounded by clearings or other open habitats. In Central Sweden (P. Angelstam, unpubl.), 58 "islands" were censused, most of them coniferous. The southernmost data originate from England (Ford 1987), where 20 forested "islands" were censused; the stands were mainly deciduous and bordered by agricultural land.

We have used data from three archipelagoes in approximately the same geographical region. Haila et al. (1983) studied the distribution of birds on 44 islands in the Åland archipelago, SW Finland. These were mainly forested and included a variety of habitats. Ahlén & Nilsson (1982) presented records from 91 islands censused in Lake Mälaren, Central Sweden, which carried mixed forest. Reed's (1983 and unpubl.) material includes observations from 120 islands around the British coast, most of them carrying deciduous or mixed tree stands. A number of these islands lay at some distance from the mainland, especially the larger ones.

We did not include records from archipelagoes in the Gulf of Bothnia, Gulf of Finland or large Finnish lakes, since the Treecreeper was sparsely represented in these data, and we concluded that the habitats (mainly pine forests) were not suitable for the species. We did not perform a detailed quantitative analysis of the density distribution of the Treecreeper on islands and forest fragments, since large variation naturally occurs in the data: the size distributions of patches (or islands) are not the same, the degree of isolation varies, the habitats are not fully comparable, etc.

Results

Breeding performance and habitat choice in forest fragments

In the Hauho study area, the preferred breeding habitat of the Treecreeper was old spruce forest. The average distance of the occupied nest boxes from open habitats was 115 m (SD = 98, n = 489), which did not differ from that expected by chance (mean distance of nest-boxes 109 m, SD = 94, n = 782). The average occupancy in the first clutches was 41.2% and there was no difference between the occupied and non occupied boxes in distance from the forest edge (Table 1; Mann-Whitney U-test, $z = 0.24$, $P > 0.1$). The mean laying date and size of the first clutches did

Table 1. Percentage of occupancy in the total records (A) and first clutches (B), laying date, clutch size and number of eggs (including incomplete clutches) in the first clutches in different edge categories in the Hauho data.

Edge category	Occupied (A) %	Occupied (B) %	Mean laying date	Clutch size	Eggs
<20m	63.1 (65)	45.6 (47)	26.4. (25)	5.35 (23)	4.62 (42)
20–50m	58.3 (67)	41.7 (48)	28.4. (34)	5.44 (32)	4.76 (45)
51–90m	61.1 (118)	36.8 (71)	25.4. (46)	5.28 (46)	4.75 (67)
91–140m	59.1 (110)	41.4 (77)	27.4 (52)	5.19 (43)	4.97 (69)
141–200m	51.9 (56)	33.3 (36)	27.4. (30)	5.41 (29)	5.33 (33)
>200m	70.1 (54)	55.8 (43)	26.4. (33)	5.33 (24)	5.05 (39)
Mean	60.1 (470)	41.2 (322)	26.4. (220)	5.32 (197)	4.89 (295)
SD			5.6	0.6	1.45
F			1.1	0.86	1.3
P			0.34	0.51	0.28

not show a difference between edge and interior sites (Table 1). In each year, the mean laying date in the most southern part of the study area was about 2–3 days later than in other two sub-areas (see Kuitunen 1987). This area was also the most fragmented. The mean distance from the forest edge averaged 70 m ($N = 121$, $SD = 51$), differing significantly from that in the rest of the study area ($t = 7.3$, $P < 0.001$), but no correlation was found between the distance from the forest edge and the laying date of the first clutch ($r = 0.06$, $N = 220$, $P > 0.20$).

When completely destroyed clutches were excluded, the number of fledglings per breeding attempt varied significantly between the six edge distance classes (mean 4.78, $SD = 1.15$, 1-way ANOVA $F = 3.1$, $df_1 = 5$, $df_2 = 243$, $P < 0.01$). Spearman's rank correlation was not significant, however ($r_s = -0.12$, $P = 0.06$). If adjusted for the completely destroyed clutches the number of fledglings seemed to be lower very near the edge (Table 2). Of the breeding attempts, 28.4% ($N = 137$) were unsuccessful for various reasons (Kuitunen & Aleknonis unpubl.). The proportion was highest near the edge (36.8%), but there was no difference between the destroyed and undestroyed nests in distance from the forest edge (Mann-Whitney U-test, $z = 0.93$, $P > 0.1$). The same tendency is observed in the number of eggs per breeding attempt, including destroyed clutches. The Treecreepers fairly frequently abandoned their nests during the laying or incubation period without any observable reason. The difference was not significant between marginal and interior parts of the forest, but the correlation was ($r_s = 0.10$, $P < 0.05$; Table 2).

Table 2. Number of fledglings per breeding attempt in different forest edge categories in the Hauho data.

Edge category	Excluding (n) completely destroyed clutches	Including (n) completely destroyed clutches	Percentage of completely destroyed clutches
<20m	4.73 (43)	2.99 (68)	36.8
20–50m	5.19 (52)	3.91 (69)	24.6
51–90m	4.79 (87)	3.50 (119)	26.9
91–140m	4.50 (80)	3.13 (115)	30.4
141–200m	5.17 (42)	3.88 (56)	25.0
>200m	4.38 (42)	3.29 (56)	25.0

We also checked whether the weight or wing length of breeding adults (see Kuitunen 1987 for details) differ with the distance of the nest-site from the forest edge: no significant differences were observed except in the female weight (ANOVA, $F = 2.4$, $df_1 = 215$, $df_2 = 5$, $P < 0.05$). However, female weight in the edge categories did not show any clear trend.

The percentage of nest-boxes occupied varied significantly between forest stands of different size, as shown in the tabulation below (Mann-Whitney U-test, $z = 2.01$, $P < 0.025$):

Category	Occupied (N)
<20 ha	56% (55)
20–50 ha	57 (215)
>50 ha	65 (195)

The breeding data may be unreliable, since they have been gathered from special nest-boxes. The

Table 3. The area of the smallest forest fragment or forested island occupied by a pair of *Certhia familiaris* and other relevant data (see text for further explanation).

Locality	Minimum		Fragments/islands studied	
	area (ha)	N	Range (ha)	Source
<i>Forest fragments</i>				
N Finland 66°N	24	12	18–70	P. Helle, unpubl.
S Finland 61°N	2	35	0.4–101	Haila et al. 1987
Central Sweden 59°N	1.5	58	0.1–138	P. Angelstam, unpubl.
England 52°N	0.7	20	0.1–18	Ford 1987
<i>Islands</i>				
SW Finland 60°N	11	44	0.5–582	Haila et al. 1983
Central Sweden 59°N	3.2	91	0.6–613	Ahlén & Nilsson 1982
Great Britain 53–57°N	3.2	120	0.2–361	T. Reed, unpubl.

nest-boxes were not distributed at random, but located in sites which seemed to be good Treecreeper habitats, so that the variation in the quality of the nest-sites is smaller than that in the available habitats. Moreover nest predation is much lower in artificial nest-boxes than in natural sites: in nest-boxes it amounts to about 7%, whereas in natural holes it can reach 37% (Kuitunen & Aleknonis unpubl.).

Minimum areas: forest fragments vs. islands

The minimum areas of forest 'islands' supporting a breeding Treecreeper pair in the material used in this study are presented in Table 3. The figures show a clear geographical trend from less than 1 ha in Britain to over 20 ha in N Finland. It may be noted that the minimum area observed is not the smallest size available in any data set. It is impossible, however, to quantify the isolation of the fragments in the different data sets.

The minimum size of a true island occupied by Treecreepers shows a similar geographic trend: it amounts to 3 ha in Great Britain and Sweden and 11 hectares in SW Finland (Table 3). Again, we do not know how isolated the islands are or how suitable the habitats for the species. Interestingly, however, the forest fragments and islands show a very similar geographical pattern, though the minimum area of islands appears to be somewhat larger than that of forest patches. This was to be expected, since terrestrial forest 'islands' are probably more easily colonized than true islands, and the surroundings of forest fragments, e.g. sapling stands, can be used for foraging, unlike the water surrounding a true island.

Discussion

Forest edge vs. forest interior

A relationship exists between forest size and the ratio of the areas of the marginal and interior forest; the smaller the patch, the greater is the proportion of marginal forest. In view of this relationship, if the Treecreeper tends to prefer larger forest stands, one might expect higher Treecreeper densities in the interior than in the margin of the forest. The records available (Helle 1983 and unpubl., N Finland; Vickholm 1983, S Finland; Hansson 1983 and unpubl., Sweden) do not show a consistent pattern ('margin' in these records is 0–50 m (100) from the forest edge and 'interior' more than 200 m from the edge). In both Finnish studies the species shows a nearly significant preference of interior forest to margins, whereas the Swedish records do not show any significant preference. Comparison between margin and interior records is difficult, because the vegetation in stands bordering open habitats often differs from that in the forest interior (see e.g. Helle 1984). Consequently, observations of various "margin avoidance/preference" patterns may be due to differences in habitat. Vickholm (1983) reported almost significant edge avoidance by the Treecreeper in Lammi, S Finland; of the 31 most numerous passerine species, only *Parus ater* had its territory at a greater average distance from the forest edge than the Treecreeper. After the effect of habitat difference was removed, however, this pattern disappeared, which means that the habitats preferred by the Treecreeper were not present in forest edges, but were frequent in interior parts of the forest (Vickholm 1983). The same may

apply to Helle's (1984) records from N Finland, since the hole-nesting species as a group were relatively more abundant in the forest interior than near the forest edge (10.2 vs. 5.2% of the whole community).

Geographical trends in minimum area

The fact that the minimum area in the material from Great Britain and Sweden is about one tenth of that in N Finland may be due to several factors. Firstly, the territory size increases with increasing latitude, which is presumably connected with habitat productivity and the predictability of the climate. Further, it is probable that the Treecreeper populations are limited by winter survival: the lower the productivity of a habitat (or the harsher the climate) the larger is the area required for overwintering.

Nilsson & Alerstam (1976) observed that the total density of the Tit guild wintering in coniferous forests was seven times as high in S Sweden as in N Finland. They also calculated that the tree biomass per unit area is about five times as high in the south, which fits well with the observed difference in bird density. Our conclusion that the minimum area of a Treecreeper pair is tenfold in the north accords relatively well with these results. The breeding density of the Common Treecreeper increases from about 0.5 pairs/km, or less, in N Finland to about 5 pairs/km in S Sweden and Britain (e.g. Flegg 1973).

Secondly, the geographical pattern observed in island colonization depends on the regional density of the species. It is clear that our qualitative minimum area method is rough and the result should be considered with caution. A quantitative method of measuring forest island occupancy would have been preferable, because the average density in the region influences the likelihood of occupation of a fragment or an island. Using a quantitative method, Haila et al. (1987) did not observe that the area of forest fragments had any effect on *Certhia familiaris* in southern Finland. In another study, a quantitative analysis (prevalence function; Haila et al. 1983) indicated that *Certhia familiaris* preferred islands in the Åland archipelago to the mainland in SW Finland (not the smallest unforested islands, however). The result could not be explained by the authors; the species has a wide habitat amplitude on the mainland of Åland and the pattern does not seem to be due to habitat differences.

The geographical trend found in the minimum area requirement in *Certhia familiaris* probably also

occurs in forest tits. If so, this supports the hypothesis put forward by Järvinen et al. (1977) that large-scale forest fragmentation has been responsible for the population crash of forest tits in Finland during recent decades.

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Selostus: Reunavaikutuksen ja metsien pirstoutumisen vaikutus puukiipijän esiintymiseen ja pesintämenestykseen

Kirjoituksessa tarkastellaan kahta kysymystä: 1) Riippuuko puukiipijän pesintämenestys tai pesäpönttöjen käyttö pöntön etäisyydestä metsän reunaan? Kysymykseen etsitään vastausta Etelä-Suomesta kerätyllä aineistolla. 2) Mikä on pienin saareke, jonka puukiipijäpari hyväksyy pesimäpaikakseen rikkonaisessa metsämaastossa tai todellisissa saariolosuhteissa? Tätä tutkitaan seitsemästä joko kirjallisuudessa esitetystä tai julkaisemattomasta aineistosta, jotka on kerätty eri puolilta Pohjois- ja Länsi-Eurooppaa.

Pesimäbiologisessa aineistossa ei havaittu eroja puukiipijän muninta-ajankohdassa, pesyekoossa tai emojen koossa verrattaessa keskenään eri etäisyyksillä metsän reunasta sijainneita pesiä. Sen sijaan lähellä metsän reunaa (< 20 m) sijainneista pesistä tuhoutui suurempi osa (37%) kuin metsän sisäosissa sijainneista pesistä (26%). Pönttöjä puukiipijä hyväksyi pesäpaikakseen suurissa saarekkeissa (> 50 ha) enemmän (65%) kuin pienissä (< 20 ha, 56%) saarekkeissa.

Pienin puukiipijäparin asuttama metsäsaareke kasvoi Brittein saarten noin yhden hehtaarin kokoisesta noin 20 hehtaarin kokoiseksi Pohjois-Suomessa. Vastaavan aidon saaren koko kasvoi Brittein saarten noin kolmesta hehtaarista 11 hehtaariin Lounais-Suomessa. Aidoissa saariaineistoissa pesimäsaaren minimikoko oli hiukan suurempi kuin metsäsaarekkeita tarkasteltaessa. Aineistoista ei sen sijaan voitu selvittää mahdollisia elinympäristöjen laadun tai saarten ja saarekkeiden eristyneisyyden eroja.

Artikkelissa tarkastellaan pesimäpaikaksi hyväksytyn saarekkeen minimikokoon vaikuttavia tekijöitä. Pohjoisessa puukiipijäpari näyttää tarvitsevan suuremman liikkumalan selviytyäkseen ankarammasta talvesta ja onnistuakseen lisääntymään. Toisaalta mitä korkeampi on puukiipijän alueellinen tiheys sitä todennäköisemmin laji asuttaa myös pienet saarekkeet. Metsätalouden vaikutukset ovat puukiipijän kannalta pohjoisessa tuhoisia, koska näissä olosuhteissa selviytyäkseen laji tarvitsee suuria ja yhtenäisiä vanhan metsän alueita.

References

- Ahlén, I. & Nilsson, S. G. 1982: Samband mellan fågelfauna och biotopareal på öar med naturskog i Mälaren och Hjälmaren. — *Vår Fågelvärld* 41:161–184.
- Andrén, H. & Angelstam, P. 1988: Elevated predation rates as an edge effect in habitat islands: experimental evidence. — *Ecology* 69:544–547.
- Flegg, J. M. 1973: A study of Treecreepers. — *Bird Study* 20:287–302.
- Ford, H. A. 1987: Bird communities on habitat islands in England. — *Bird Study* 34:205–218.
- Haila, Y., Järvinen, O. & Kuusela, S. 1983: Colonization of islands by land birds: prevalence functions in a Finnish archipelago. — *J. Biogeogr.* 10:499–531.
- Haila, Y., Hanski, I. K. & Raivio, S. 1987: Breeding bird distribution in fragmented coniferous taiga in southern Finland. — *Ornis Fennica* 64:90–106.
- Hansson, L. 1983: Bird numbers across edges between mature conifer forest and clearcuts in Central Sweden. — *Ornis Scand.* 14:97–103.
- Helle, P. 1983: Bird communities in open ground-climax forest edges in Northeastern Finland. — *Oulanka Reports* 3:39–46.
- Helle, P. 1984: Effects of habitat area on breeding bird communities in Northeastern Finland. — *Ann. Zool. Fennici* 21:421–425.
- Helle, P. & Järvinen, O. 1986: Population trends of North Finnish land birds in relation to their habitat selection and changes in forest structure. — *Oikos* 46:107–115.
- Hildén, O. 1985: Muuttuva Suomen talvilinnusto (Summary: Long-term trends in the Finnish winter birds). — *Lintumies* 20:262–268.
- Järvinen, O., Kuusela, K. & Väisänen, R. A. 1977: Effects of modern forestry on the numbers of breeding birds in Finland in 1945–1975 (in Finnish with English summary). — *Silva Fennica* 11:284–294.
- Kuitunen, M. 1985: Is the Common Treecreeper *Certhia familiaris* more widespread in Hungary than has been previously believed? — *Aquila* 92:255–261.
- Kuitunen, M. 1987: Seasonal and geographical variation in the clutch size of the Common Treecreeper *Certhia familiaris*. — *Ornis Fennica* 64:125–136.
- Nilsson, S. G. & Alerstam, T. 1976: Resource division among birds in North Finnish coniferous forest in autumn. — *Ornis Fennica* 53:15–27.
- Reed, T. M. 1983: The role of species-area relationships in reserve choice: a British example. — *Biol. Conserv.* 25: 263–271.
- Vickholm, M. 1983: Avointen reunojen vaikutus metsälinnustoon. — Unpubl. M. Sc. thesis, Dept. Zoology, Univ. Helsinki.
- Virkkala, R. 1985: Lapintiaisen (*Parus cinctus*) ekologiasta hakatulla ja luonnontilaisella metsäalueella Metsä-Lapissa. — Unpubl. M. Sc. thesis, Dept. Zoology, Univ. Helsinki.
- Yahner, R. H. & Scott, D. P. 1988: Effects of forest fragmentation on depredation of artificial nests. — *J. Wildl. Manage.* 52:158–161.

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