Adaptedness of the Willow Tit *Parus montanus* to the migratory habit

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Migrating Willow Tits were studied on the Hanko peninsula in autumn 1976. When the invasion was at its height, the mean weight of the tits was 10 % lower than that of resident birds in some inland localities at the same time of the year. This reduction in weight at the time of leaving the normal forest habitats of the species shows that the Willow Tit is poorly adapted to the migratory habit although emigration often takes place in the autumn.

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Introduction

The energy reserves deposited by migratory birds in preparation for their demanding performances may be 30—50 % of the live weight in a long-distance migrant and 13—25 % in a short-distance one (review by Berthold 1975). In contrast, the lipid contents of a small nonmigrant may be 3—5 % of its live weight (Berthold 1975). As most irruptive birds are normally stationary, the question arises whether they show the same preparation for migration during their invasions as true migrants (Newton 1970, Ehrenroth & Marcström 1979).

In Fennoscandia, the Willow Tit *Parus montanus* is a typically stationary bird, which, however, undertakes occasional emigrations (e.g. Linkola 1961, Ehrenroth 1973, 1976). In autumn 1976, Willow Tits migrated fairly strongly (Hildén 1977). During the invasion, about 120 tits were caught on the tip of the Hanko peninsula, the southernmost point of the Finnish mainland. In this report, it will be shown that their weights were reduced in comparison to those of conspecific residents.

Material and methods

The material used here was gathered in three different localities: the Hanko peninsula on the southern coast of Finland (Tulliniemi 59°48′N, 22°54′E, Tvärminne 59°50′N, 23°15′E), Lammi in the southern part of central Finland (61°03′N, 25°03′E), and Savonlinna in eastern Finland (61°54′N, 28°55′E) (Table 1). Juvenile and adult Willow Tits were recognized by the form and degree of wear of the rectrices, which usually show a characteristic pattern (Laaksonen & Lehikoinen 1976). Some individuals (denoted by fl.) could not be aged. Most birds were weighed with a 30-g Pesola string balance and the wing was measured to the nearest millimetre by the maximum method (Svensson 1970). All measurements were made by the author. Student's *t*-test was used to test the statistical significance of differences between the means. The means ± standard deviations *(SD)* are given in the text.

During the first period of observation on the Hanko peninsula, Willow Tits were migrating intensively. At Tulliniemi, the tip of the peninsula, the birds met the Baltic Sea, and did not venture to continue. The flocks, numbering about 100—150 individuals, came hurrying restlessly along the tree tops to the tip of Tulliniemi (observations on 17 Sept.),

TABLE 1. Numbers of Willow Tits, grouped according to age, captured in various localities. Figures in brackets show numbers of uncertain age determinations. Fl. = not aged.

Localities and study periods	Juv.	Ad.	Fl.	Total
Savonlinna 9—10.9.1972	—	—	15	15
Lammi 17.9.—19.10.1975	13 (+1)	10 (+3)	5	32
Hanko peninsula 13—17.9.1976	78 (+4)	6 (+5)	5	98
Hanko peninsula 23—27.9.1976	18 (+2)	0 (+1)	0	21

and after some hesitation flew southwest towards the sea, rising higher all the time. After having flown a few hundred metres, the birds always turned back, and, still flying high, made for the thick pine forest about 500 m from the tip of Tulliniemi. After some time they again came flying along the trees to the tip, hesitated, flew seawards and again turned back (cf. Ulfstrand 1962, Salminen & Sisula 1974). During the second period, Tulliniemi was visited twice (on 24 and 27 Sept.). By now, the Willow Tits were no longer so numerous as on 17 Sept., but were still migrating, as was clearly shown by a bird ringed on 27 Sept. and recaptured at Tauvo Bird Station, 560 km N of Tulliniemi, on 21 Oct.

Tvärminne is not as favourably situated as Tulliniemi with respect to Willow Tit migration. Restless tits were observed and some (N=25) were captured, but no invasion similar to that at Tulliniemi occurred there.

In Savonlinna, where the catching place was not on a guide line, the Willow Tit flocks seemed to be stationary, circling around in a pine forest and high birch and willow bushes.

At Lammi, all the tits captured in September were in the willows at the W end of the N shore of Lake Pääjärvi. It is possible that most of these tits were migrating south- or westward and were gathered by the guide-line effect of the lake. In October the tits were captured in forest. Four of the adults had been ringed earlier as breeders in the area. Some of them were also retrapped later.

Results

On average, the juveniles had slightly shorter wings than the adults, but the difference was not significant. The smaller means on the Hanko peninsula (Table 2) may, however, be explained by the general difference between age groups, which was found to be c. 1 mm by Laaksonen & Lehikoinen (1976; later the difference was found to be even slightly greater, E. Lehikoinen pers. comm.). The mean for the 6 adults included in the Hanko data was only 63.17±1.17 mm, a significantly lower figure ($P<0.05$) than at Lammi (65.50±2.01 mm, N= 10). This may be attributed to the sexual size difference which, on average, is almost 2 mm in the Willow Tit (Haftorn 1971, Ehrenroth & Marcström 1979, E. Lehikoinen, pers. comm.). The differences between the mean wing lengths in Table 2 were significant only between Lammi and the first period in Hanko peninsula ($P<0.02$). No difference was found between the samples of September and October from Lammi.

TABLE 2. Mean wing lengths (mm) and weights (g) of Willow Tits captured in various localities in Finland in September - October. Hanko I and II refer to the two study periods on the Hanko peninsula.

Locality	Wing length Mean ± *SD* *N*	Weigth Mean ± *SD* *N*
Savonlinna	65.15±2.22 13	11.90±0.64 14
Lammi	65.31±2.04 29	11.49±0.77 32
Hanko I	64.35±1.74 93	10.95±0.57 92
Hanko II	64.76±1.48 21	11.78±0.51 21

At Lammi, the juveniles (11.38±

TABLE 3. Multiple regression analyses of the weight of the Willow Tit. The independent variables are the time of day in hours (X_1) and the wing length in mm (X_2). The regressions give the daily weight increase from 07.00 hr on. The weights predicted for birds with a wing length of 65 mm at 10.00 hr are also given. *F*, the asterisks and *df* relate to the analysis of variance made to test the significance of the regressions. Hanko I and II as in Table 2.

Localities	Regressions	Analyses of variance		Correlation matrices			Predicted weights
					X_2	Y	
Savonlinna	$Y=-3.864+0.077X_1+0.233X_2$	$F=9.105^{**}$	$df=11$	X_1	−0.126	0.235	11.51
				X_2		0.748	
Lammi	$Y=-0.952+0.066X_1+0.181X_2$	$F=6.018^{**}$	$df=31$	X_1	−0.039	0.270	11.01
				X_2		0.459	
Hanko I	$Y=-2.465+0.050X_1+0.204X_2$	$F=37.064^{***}$	$df=91$	X_1	0.158	0.292	10.95
				X_2		0.646	
Hanko II	$Y=-4.121+0.025X_1+0.243X_2$	$F=7.867^{**}$	$df=20$	X_1	−0.234	−0.056	11.75
				X_2		0.675	

0.81 g, $N=14$) were not significantly lighter than the adults (11.74 ± 0.77 g, $N=13$). The difference of 0.09 g between the means of September and October was not significant, either. The birds captured on the Hanko peninsula during the first period were lighter than all the others (Table 2), differing highly significantly ($P<0.001$) from the birds caught at Savonlinna and in the second period on the Hanko peninsula, and significantly ($P<0.02$) from the birds caught at Lammi. There were no other significant differences between the localities.

The daily changes in weight, ignored in the above comparisons, were examined by multiple regression analysis (Table 3). Of the independent variables, the size of a Willow Tit, indicated by the wing length, explained the variation in weight better than the time of day (see multiple correlation matrices). When the regressions are used to predict the weights of birds with a wing length of 65 mm at 10.00 hr, the difference shown in Table 2 is not so great, but the trend is the same.

Discussion

Weight increase due to fat deposition is well established for migratory birds (Berthold 1975). The ability to accumulate energy reserves is an adaptation of high value for birds which are going to cover long distances. The fat stores are deposited during the phase of migratory preparation and the migration. When the reserves are depleted, the migrating birds stop to rest for some days while the stores build up again (e.g., Dol'nik 1976, Bibby et al. 1976).

The results of this study revealed that the Willow Tit has not evolved the ability to store reserve energy for migration in fat deposits. On the contrary, the tits seem to lose as much as 10 % of their weight during their most active periods, and when their fat stores were depleted, they did not stop to rest. It is not likely that the Willow Tits examined in this study were from populations of different-sized birds. The shorter wings on the Hanko peninsula can be explained sufficiently by the difference between

juveniles and adults, and the age composition of the tits, although age-depended differences were not found in this study. The small sizes of the adults on the Hanko peninsula may have resulted from sexual size differences, the captured individuals probably being females.

In a study on fat deposits in tits, Ehrenroth & Marcström (1979) found that the mean lipid level in migrating Willow Tits at Hammarö Bird Observatory in central Sweden was 4.6 % of the total weight. The lipid level of the Hanko I tits (Table 3), calculated from Ehrenroth & Marcström's (1979) regressions, was still lower — c. 4 %.

Group territorialism regulates the autumn population size of the Willow Tit (Ekman 1979). Forced emigration of immature tits seems to be the reason for invasions (Ekman 1979). The species is not, however, well adapted to migration — or preadapted, considering its character as a stationary bird — since it is not able to accumulate energy reserves for strenuous migratory movements. Ehrenroth & Marcström (1979) found notably higher lipid levels (and thus better adaptedness to the migratory habit) in the Coal Tit *Parus ater*, the Blue Tit *P. caeruleus*, and the Goldcrest *Regulus regulus* (mean lipid levels 7.2—8.3 %), which are partial migrants. Hildén (1974) found lower weights in migrating Great Tits *Parus major* — also partial migrants — than in conspecific residents at the same time of the year. However, these birds were captured at Lågskär and Signilskär bird stations in the outer archipelago of Åland, whereas the migrating Willow Tits on the Hanko peninsula were just leaving forested areas and venturing forth over the sea.

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Selostus: Hömötiaisen sopeutuneisuus muuttokäyttäytymiseen

Sopeutumana muuttosuorituksia varten muuttolinnut keräävät huomattavia rasvavaroja eri puolille ruumistaan ihon alle sekä valmistautuessaan muuttoon että sen aikana. Näiden energiavarastojen ehtyessä linnut keskeyttävät muuttonsa ja pyrkivät täydentämään varastot ennen muuton jatkamista.

Tutkittaessa syksyllä 1976 Hankoniemellä vaeltaneiden hömötiaisten painoja havaittiin niiden olevan alhaisempia kuin paikoillaan elävillä tiaisilla. Hömötiainen ei paikkalintuna ole ainoastaan kykenemätön keräämään energiavarastoja muuttoa varten, vaan rasittavimmat muuttosuoritukset näyttävät kuluttavan niiden normaalejakin varastoja. Hankoniemellä vaeltavat hömötiaiset saapuivat niemen kärkeen suoraan metsästä, niiden normaalista ravinnonetsintäympäristöstä.

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