Ornis Hungarica 1:29-36. 1991

Effect of environmental factors on tits wintering in a Hungarian marshland

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Báldi, A. and Csörgő, T. 1991. Effect of environmental factors on tits wintering in a Hungarian marshland. - Ornis Hung. 1: 29-36.

We studied Great Tits and Blue Tits during six winters in a marshland in Central Hungary. The number of wintering Tits increased during the study. Tits were found to be residents, immigrants and floaters. The number of immigrants decreased in mid-winter in both tit species, while the number of residents increased. The number of immature floaters changed parallel to that of immigrants, but the number of adult floaters was low and did not change considerably during winter. For both Great and Blue Tits the presence of nest-boxes and artificial feeding increased the overwintering numbers, and for the Blue Tit the effect of temperature was also significant.

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1. Introduction

Population fluctuations of tits and their regulating factors have puzzled ecologists for many years (e.g., Perrins 1965). There is a big 'surplus' of yearling Tits (*Parus* spp.) after fledgling, but only a small portion is able to survive until the next breeding season (Perrins 1965). The recruited portion mainly depends on winter survival (Perrins 1979, Ekman 1984, Tinbergen et al. 1985, Nilsson 1987, Orell 1989), therefore winter survival seems to be crucial in the regulation of Tit populations.

The available resources are probably sparse in winter. The mortality rate can increase because of food deficiency, low ambient temperature, snow cover, predation risk and competition (Balen 1980, Jansson et al. 1981, Ekman 1984, Desrochers et al. 1988). The influence of winter temperature and snow cover has indirect effects mediated by a weather-dependent food shortage (Svensson 1981, Källander & Karlsson 1981, Bejer & Rudemo 1985). Gibb (1960) found that the number of Tits and Goldcrest (*Regulus regulus*) changed in parallel with the abundance of insects and invertebrates. An abundant beechmast crop enhanced the survival of Tits in winter (Perrins 1965, Balen 1980, Drent 1984, Bejer & Rudemo 1985), just as did artificial food provided by man (Balen 1980, Brittingham & Temple 1988, Desrochers et al. 1988, Orell 1989). The greater the winter survival the greater the breeding density of Tits in the consecutive spring (Perrins 1979, Balen 1980, Jansson et al. 1981, Drent 1984, Ekman 1984), although the reproductive success was lower in food added areas (Jansson et al. 1981).

Although the overwinter movements and population fluctuations of tits has been thoroughly studied in Scandinavia (Orell 1989), England (Perrins 1965, 1966), Germany (Croon et al. 1985) and the Netherlands (Balen 1980, Balen & Hage 1989), much less is known about Central Europe. Particularly, our knowledge is weak concerning tits living in less preferable habitats such as marshes or plantations.

In this paper we were interested in Great Tits (*Parus major*) and Blue Tits (*P. caeruleus*) living in a marsh in Hungary.

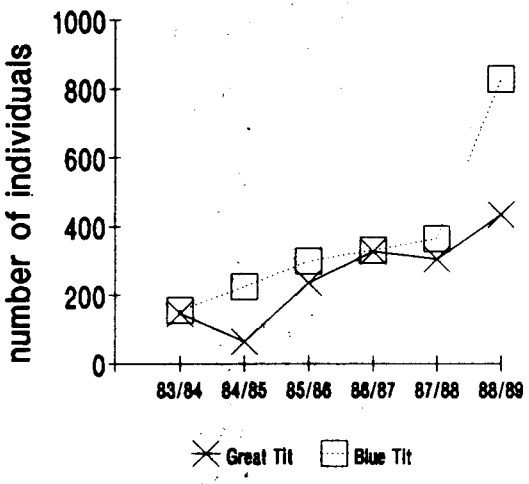

Fig. 1. Number of wintering Great and Blue Tits in the study area.

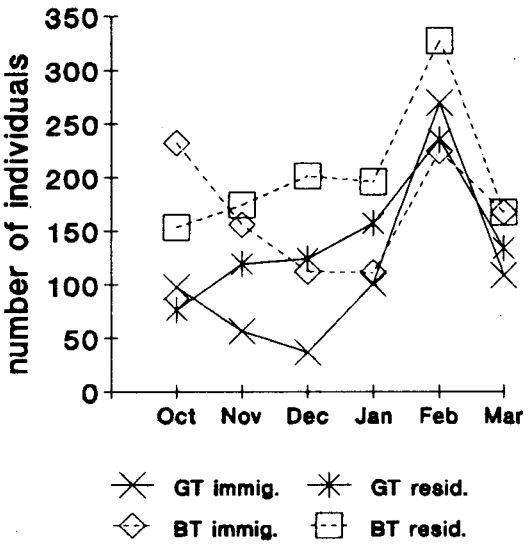

Fig. 2. Number of Tits in relation to time, based on pooled data of the survey.

We analysed the data on the number of birds and composition of populations and also the effect of temperature, snow cover, artificial feeding and nestboxes on these populations.

2. Study area and methods

Field work was done in the Nature Reserve of Ócsa SE of Budapest in central Hungary (47°15' N; 19°15' E). There is a full successional sere of swamp vegetation in the area from open water to Alder (*Alnus glutinosa*) woods.

Area I. The main part of the study was carried out at the Bird Ringing Center of the Hungarian Ornithological Society, near Ócsa. The study area is situated between agricultural land and reedbeds (*Phragmites communis*). The vegetation in the ecotone is very variable, there are patches of reeds, Bullrush (*Typha angustifolia*), marshes, various willow bushes (*Salix alba, S. cinerea, S. caprea*), Elder (*Sambucus nigra*), and Poplar Trees (*Populus* spp.).

Data were collected in winters from 1983 to 1989. We used data from October to April for this paper. The birds were mist-netted at bird tables. In the winters of 1983/84 and 1984/85 we fed the birds with sunflower seeds only when mist-netting was carried out. This was not enough however to influence the settlement of birds. In the following years we continuously provided a large surplus of artificial food, therefore we influenced the settlement of birds throughout the winter. The bird tables were placed among bushes and the mist-nets were placed around them in the shape of a triangle or square. Mist-netting was carried out only under fine weather conditions, when there was no rain, snow or wind. The different number of mist-netting days in different months were linked to an equal number of mist-netting days throughout the six winters. Nestboxes were put in the area in the spring of 1987.

Occasionally mistnets were placed in a reed patch both in the winter and breeding seasons.

Area II. The second part of the study was conducted in the same region, about 10 km from the Bird Ringing Center. The area was a small plot of alder wood (7 ha) with bushy surroundings. 100 nestboxes were placed in the forest patch in the spring

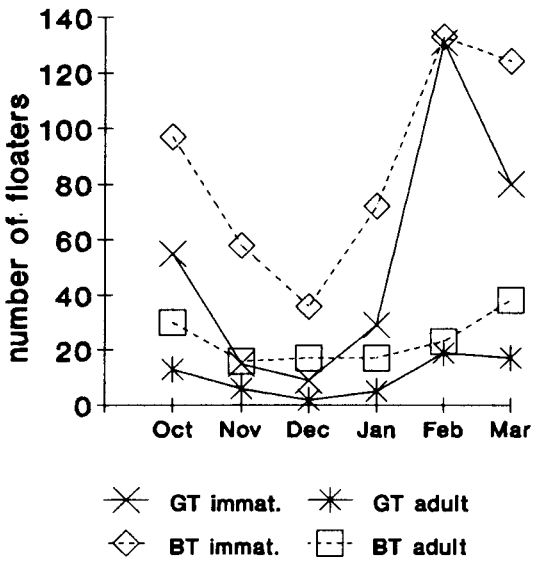

Fig. 3. Number of floater Tits in relations to time, based on pooled data of the survey.

of 1986. The nestboxes were visited at night every two weeks in the winters from 1986/87 to 89/90, to check the roosting tits. Beside the nestbox area bird feeders were put out and mist-netting was carried out.

Meteorological data (monthly mean temperature, snow cover and depth) were available from Monor, a village 20 km from Ócsa.

The recorded Tits were distinguished on the basis of their status, being floaters, immigrants or residents. Residents were those birds already captured in summer or in more winters, immigrants were the newly captured birds. Those birds captured only once were considered as floaters.

The data were analyzed with the SPSS/PC+ statistical program package (Norusis 1986). We applied multiple stepwise regression- correlation- and principal-component analyses. The multiple stepwise regression calculations were performed on the basis of summed monthly number of individuals, linked to an equal number of mist-netting days. The independent variables were monthly mean temperature, percentage of days covered by snow in a month, number of bird tables and number of nestboxes.

3. Results

The number of captured tits increased in the six consecutive winters in both species (Fig. 1). The number of Blue Tits increased monotonously, but the increase in Great Tits broke down in the harsh winters of 1984/85 and 1987/88. The decrease was greater in the winter of 84/85, because in this winter there was no continuous feeding (see above).

The pooled data of the six winters showed that there were parallel changes in the number of birds between the resident and between the immigrant Great and Blue Tits (Fig. 2). Within the two species the number of individuals did not change in parallel between residents and immigrants. In all cases there was a peak in the number of individuals in February (Fig. 2).

The ratio of Blue Tit:Great Tit was 7:10 in summer and 30:12 in winter in the reeds. The difference between summer and winter proportions proved to be significant (Student test for proportions; $t=8.52$, $n=42$, $p<0.001$), that is the number of Blue Tits increased significantly in

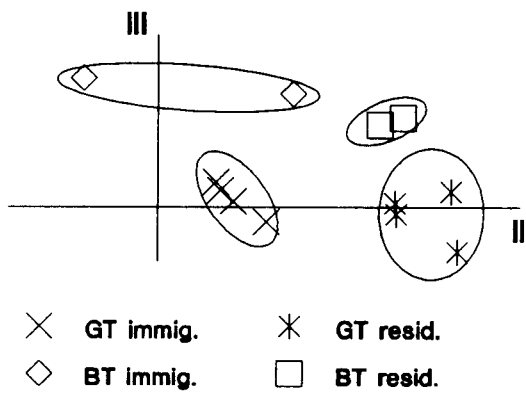

Fig. 4. Position of Tit groups on second (II) and third (III) Principal Component axes explaining 12.2% and 10.9% of the total variance, respectively. The second axis can be interpreted as status, the third as species.

Tab. 1. Pearson's correlation coefficients and its one-tailed significance (*: $p<0.01$; **: $p<0.001$) between the different groups.

	G.T. ad. male immig.	G.T. ad. fem. immig.	G.T. im. male immig.	G.T. im. fem. immig.	G.T. ad. male resid.	G.T. ad. fem. resid.	G.T. im. male resid.	G.T. im. fem. resid.	B.T. ad. immig.	B.T. im. immig.	B.T. ad. resid.	B.T. im. resid.
G.T. ad. male immig.	1	*	**	**	**	NS	**	**	NS	NS	*	NS
G.T. ad. fem. immig.		1	NS	**	NS	NS	NS	**	NS	*	NS	NS
G.T. im. male immig.			1	**	*	NS	**	**	NS	*	*	*
G.T. im. fem. immig.				1	*	NS	**	**	NS	*	NS	*
G.T. ad. male resid.					1	**	**	**	NS	*	**	**
G.T. ad. fem. resid.						1	**	**	NS	NS	NS	*
G.T. im. male resid.							1	**	NS	*	**	**
G.T. im. fem. resid.								1	NS	*	**	**
B.T. ad. immig.									1	**	NS	NS
B.T. im. immig.										1	**	**
B.T. ad. resid.											1	**
B.T. im. resid.												1

the reeds in winter.

The pattern of monthly fluctuations in abundance in both species was more vigorous in the change of the immature floaters (Fig. 3), while the number of adult floaters was low, and did not show considerable changes.

The principal-component analyses (PCA) separated four groups, namely resident Blue and Great Tits and immigrant Blue and Great Tits (Fig. 4).

Only the Great Tit data of Area II. were analysed here, because the sample size was too small for the Blue Tit. We divided the Great Tit population into two groups. In group F those birds were clustered, which were registered only at the bird feeders, by mist-netting. Group R consists of birds checked when roosting in the nestboxes, with no attention to whether they visited the feeders or not. The tendency to be resident (group R) or floater (group F) was significantly different between group F and R (chi-square test with Yates correction; $\chi^2=31.90$, $df=20$, $p<0.05$) (Fig. 5). These findings supported the results of PCA, that is the status is one of the most important factors affecting winter population fluctuations in tits.

The correlations between the species, age, sex and status groups were significant only in the case of a positive correlation, that is the number of individuals of the different groups changed in parallel (Tab. 1).

Four environmental factors were analysed in the study, the temperature, snow cover, presence or absence of artificial feeding and the number of nestboxes. These factors showed different relationships with the groups of tit species, age, sex and status (Tab. 2). The results of the multiple stepwise regression analyses showed that artificial feeding had by far the greatest effect on the population fluctuations of the Great Tit, but the number of nestboxes had a significant effect, too (Tab. 2). In the case of the population

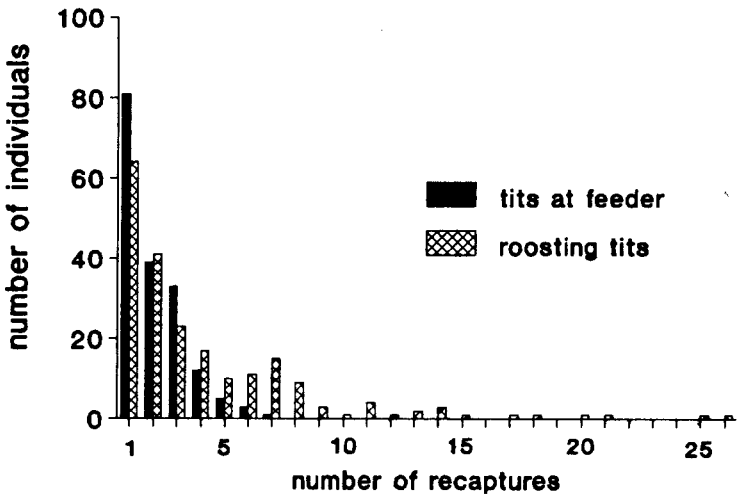

Fig. 5. Number of recaptures of Great Tits in area II, based on data of the consequtive winters.

fluctuations of Blue Tit, there were three significant factors, namely the number of nestboxes, temperature and feeding (Tab. 2).

4. Discussion

The number of recorded Tits increased during the study in Ócsa, like in several parts of Europe (Hildén 1987, Balen & Hage 1989, Winkel 1989). The number of wintering Great Tits dropped in the study area in hard winters. In Hungary Great Tits move to villages in winter, where human activity and farming may enhance the chance of survival (Sasvári 1978). Seasonal shifts in habitat use of the titmice seems to be common (Bilcke 1984, Møller 1984). This is contradictory to the findin gs of Perrins (1979), who showed that the Blue Tit moved to town, and the Great Tit stayed in forests in England.

The number of Blue Tits declined to a much lesser degree in cold winters. Hilden (1987) pointed out that the long-term increase in the abundance of Blue Tits in Finland is the consequence of the extending of the reed stands where the species forages in winter. The use of reed-beds was supported by this study, since the ratio of Blue Tit:Great Tit increased significantly in winter in the reeds.

According to Balen & Hage (1989) the increasing number of individuals during the study period may be the consequence of the decrease in the proportion of long-distance movements of the Great Tit, which might be caused by improved conditions in winter. In the Netherlands these improved conditions were due mostly to the enhanced proportion of artificial feeding (Balen 1980, Balen & Hage 1989).

Status is of crucial importance in determining the winter movements of individuals and thus the changes in winter populations of titmice. Clobert et al. (1988) reached similar conclusions, though they defined status in a slightly different way. It is not worth being floater (Smith & Arcese 1989).

The majority of the resident Tits were adult individuals, whereas floaters were mostly immatures. Adult floaters were scarce and might be residents in another part of the area, but they occasionally visited the feeders. The low number of resident immature individuals may be the consequence of the subdominant position of the immature Tits (e.g., Perrins 1979).

Artificial feeding provides very rich foraging patches, so it attracts birds from long distances, but the overcrowding, increased predation pressure, searching for emptied territories and better survival conditions led to the dispersion of transient

Tab. 2. Results of multiple regression calculations after stepwise elimination of insignificant variables. For significant relations R and significance of F are given (R (significance of F)).

	Temperature	Snow cover	Feeding	Nestboxes
G.T. male ad. immig.	NS	NS	0.379 (0.023)	NS
G.T. female ad. immig.	NS	NS	NS	0.463 (0.004)
G.T. male im. immig.	NS	NS	NS	NS
G.T. female im. immig.	NS	NS	0.488 (0.003)	NS
G.T. male ad. resid.	NS	NS	0.588 (0.000)	0.649 (0.000)
G.T. female ad. resid.	NS	NS	0.420 (0.012)	NS
G.T. male im. resid.	NS	NS	0.594 (0.000)	NS
G.T. female im. resid.	NS	NS	0.645 (0.000)	NS
B.T. ad. immig.	0.379 (0.023)	NS	NS	NS
B.T. im. immig.	0.672 (0.000)	NS	NS	0.604 (0.000)
B.T. ad. resid.	NS	NS	0.614 (0.000)	0.525 (0.001)
B.T. im. resid.	NS	NS	NS	0.644 (0.000)

tits (e.g., Kluyver & Tinbergen 1953, Ekman 1984, Orell 1989, Sullivan 1989). Thus the winter population fluctuations of titmice is mostly due to floaters. The number of resident tits fluctuated less, because it was determined by the characteristics of the area, that is the food availability and presence of nesting cavities. Their fluctuation is probably the consequence of the changes in the frequency of feeder visiting. There was a great peak in abundance in February in all of cases, because this is the period of the spring territory occupations of the floaters (Balen & Hage 1989).

Ekman (1984) pointed out that the number of Willow Tit (*Parus montanus*) declined in winter and it had minimum value in February. The Willow Tit probably has a different wintering strategy than Blue and Great Tits. The former species winters in closed social units, whereas the two latter species winter in loosely organized systems (Ekman 1989, but see Saitou 1978). Furthermore, the Willow Tit is a hoarding species (Perrins 1979), therefore the pressure on this species to float or migrate in winter may not be as strong as is the case with Blue Tits and Great Tits.

Resident Great Tits had roosting sites in the area and nesting holes and they can claim territories in spring. The resident individuals move from their territories to a much greater extent in winter than in spring. In winter we recorded resident tits at the feeders in area II, which have regularly bred and continuously roosted for four years in the nestbox area, about 700-800 m from the feeders. The territorial Great Tits leave their territories to a considerably lesser extent in the breeding season (Ydenberg 1984).

Competition is an important factor affecting the populations of Tits in the breeding season (Minot & Perrins 1986, Török 1987) and in winter (Dhondt & Eyckerman 1980, Alatalo et al. 1986). The existence of competition assumes that when conditions deteriorate, the number of individuals in one species decreases, while the other increases. Similar patterns can be expected within species, too. This could be detected as negative correlations in the number of birds between species or within species, but we were unable to find such correlations, only positive ones. This led us to the conclusion that there was no significant competition between Tits.

Environmental factors had different effects on the Tits. Great Tits usually forage on the ground in winter (Perrins 1979, Székely 1985), therefore one might expect that the effects of snow, ice and frost are

significant for them through the availability of food (Svensson 1981, Bejer & Rudemo 1985). In spite of these expectations, there were no significant relationships between the population changes of Great Tit wintering in the study area and the weather. We supposed that the artificial feeding caused this lack of correlation, which is found in other studies (Grubb 1987). The roosting sites also had a significant effect on the population fluctuations of Great Tits besides the effects of artificial feeding, because cavities can be crucial for winter survival as protected roosting sites (Drent 1987).

Blue Tits are good competitors by exploitation (Minot & Perrins 1986, Török 1987) and they are able to adapt to survive in the reeds (Hildén 1987). Therefore, this species has a lesser demand for artificial food in winter. However, the weather has a great effect on the population fluctuations of Blue Tit through the availability of natural food (Gibb 1960). The number of available nestboxes was the most important factor that influenced their winter population fluctuations.

The different effects of the weather on the two Tit species in Ocsa is contradictory to the findings of others (Bejer & Rudemo 1985). We supposed that this result may be the consequence of the atypical habitat, where the Blue Tit forages and disperses in the marsh in winter, whereas the Great Tit depends on artificial feeding and moves into the village when the weather becomes harsh.

Acknowledgements. We wish to express our gratitude to the members of the Hungarian Ornithological Society who helped with field work. T. Székely, J. Török and Z. Waliczky made helpful comments on the manuscript.

Összefoglalás

Környezeti tényezők hatása télen egy magyarországi láp cinegéire

1983-89 közötti hat télen vizsgáltuk a széncinegék és kék cinegék téli populációit az ócsai lápvidéken. A tanulmány ideje alatt a két faj egyedszáma növekedett, valószínűleg a rendszeres etetés hatására. A hat tél októbertől márciusig terjedő időszakának összevont adatai alapján a bevándorlók száma mindkét fajnál lecsökkent tél közepére, az állandó cinegék száma viszont folyamatosan nőtt. A populációk téli ingadozását elsősorban a fiatal kóborló egyedek számának változásai okozták. Az öreg kóborlók száma igen kicsi volt. Az állandó és az újonnan bevándorolt cinegék egyedszám változása között (mindkét fajon belül) legalább olyan jelentős volt az eltérés, mint a két faj azonos helyzetű csoportjai között.

Négy abiotikus tényezőt vizsgáltunk: etetés, hőmérséklet, hótakaró és oduk száma. Az októbertől márciusig terjedő időszakban a legjelentősebb hatása az etetésnek és az oduknak volt mindkét cinege faj esetében. A növekvő etető illetve odu szám hatására az egyedszám szignifikánsan megnőtt. A kék cinegék populációméretére még a hőmérsékletnek is jelentős volt a hatása.

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Received 24 November 1990, revised 10 January 1991, accepted 2 February 1991