Ornis Hungarica 12-13: 229-236. 2003

On the importance of nestbox age in monitoring populations of small hole-nesting birds

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Vilka, I. 2003. On the importance of nestbox age in monitoring populations of small hole-nesting birds. – Ornis Hung. 12-13: 229-236.

In Latvia, monitoring of small hole-nesting birds that use nestboxes has been carried out during a 20-year period (1981-2000). For data analysis, 20 nestbox plots from different parts of Latvia were used. The total number of nestboxes was 2140. The main species breeding in the nestboxes were Pied Flycatcher *Ficedula hypoleuca* and Great Tit *Parus major*. Breeding populations of both species declined during the study period. These negative trends may reflect the actual state of the populations or may have been caused by other factors, such as nestbox aging. That birds tend to avoid old nest boxes has been mentioned in the literature, but many nestbox surveys have not taken this factor into account. To test the importance of nestbox age, the current study investigated nestbox occupancy against nestbox age. It found a significant correlation between declining occupancy rate and nestbox age. When in one study plot 7-year old nestboxes were replaced by new boxes, in the subsequent year the number of the Pied Flycatcher broods substantially increased. However, Pied Flycatcher clutch size increased in older nestboxes.

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1. Introduction

The tendency for birds to avoid selecting as nest sites nestboxes several years old (in comparison with new nestboxes) but still in good condition has been observed in several nestbox surveys in Europe (Shcherbakov 1956, Blagosklonov 1970, Lundberg & Alatalo 1992) and in a survey in Latvia (Mihelsons 1958a). Some possible explanations for nestbox aging affecting their selection by hole-nesting birds have also been proposed (*e.g.* microclimatic conditions, visibility, the presence of old nesting material, parasite load and internal illumination). To monitor hole-nesting bird populations properly, it is therefore important to determine if nestbox aging actually has an effect on nestbox selection and how significant the effect is, so that monitoring methods can be optimised. In Latvia, the practice of using nestboxes in ornithological studies has a long history. The first nest box surveys had already started by the late 1940s, and reached a peak of activity in the 1950s (Mihelsons 1958a, 1958b; Spuris *et al.* 1958, Mihelsons 1964). After an interruption of several decades, the studies were renewed in the 1980s in the form of a monitoring programme carried out in various parts of Latvia (Cauns 1990). By the late 1980s, there were *c*20 nestbox plots. Monitoring project data are used in the

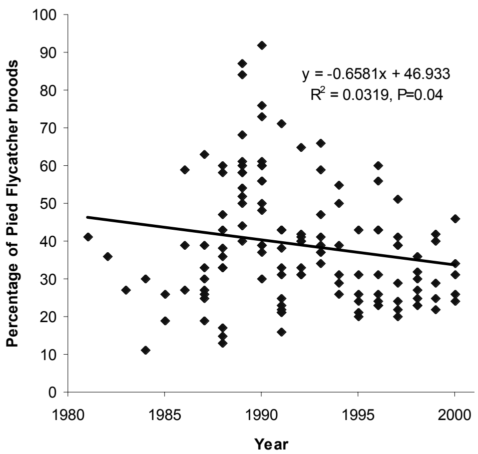

Fig. 1. Percent of nest-boxes occupied by Pied Flycatcher during the study period (1981-2000). Line indicates linear regression.

current study to analyse the impact of nestbox aging on the breeding of hole-nesting birds.

2. Study area and methods

The study plots were chosen in different parts of Latvia in pine forest stands on poor soils. There were 100 nestboxes in each study plot (except for 2 plots with 160 and 180 respectively). The nestboxes used were a special type designed by Maris Cauns to protect nesting birds from pine marten (*Martes martes*) (Vilka 1999). Nestboxes were placed generally at intervals of 35 m (some plots had 25 m or 50 m intervals). Amateurs as well as professional ornithologists collected data. The quality of data differs between study plots and years. Of all the nestbox plots (41) established during the monitoring project, only 20 have been used in the current data analyses (because the plots had regular intervals between nestboxes, the nestboxes were a standard type, and the plots had produced a sufficient level of data). Study plots were checked at least twice during the breeding season to obtain information on productivity (clutch size and fledgling numbers in each brood) and the number of broods of each species. During the survey period, the number of study plots monitored annually fluctuated between 5 and 14, and the number of nestboxes between 530 and 1400. In total, the data from *c*12 700 'nestbox seasons' (nestboxes × seasons) are used in the analyses.

Not every nestbox plot was established in the first year; the first being in 1981 and the last two in 1991. To estimate the effect of nestbox aging, the bird data were arranged by age after establishment of the corresponding study plots (1st, 2nd year *et seq*). New nestboxes (100) replaced all old boxes in one study plot (Livberze) in 1996 (7 years after the plot had been established).

In the analysis of Pied Flycatcher productivity, broods with extreme numbers of eggs and nestlings (fewer than 5 or more than 8) were excluded from the study to avoid incomplete or repeat broods and to discount clutches made by more than one female. To estimate the population trends and the impact of nestbox age, simple regression analysis was used. To test each comparison (bird data versus years and bird data versus nestbox age) the significance level α/k (where k is number of comparisons; the Bonferroni method) was used.

3. Results

The breeding numbers both of Pied Flycatcher and Great Tit declined significantly in nestbox plots during the survey

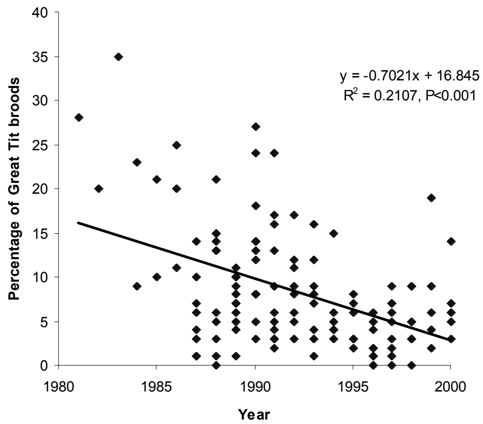

Fig. 2. Percent of nest-boxes occupied by Great Tit during the study period (1981-2000). Line indicates linear regression.

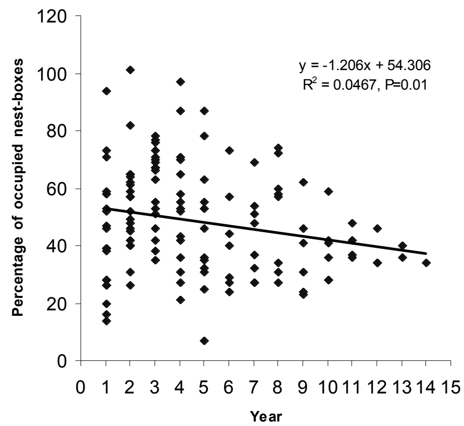

Fig. 3. Percent of occupied nest-boxes versus the age after the establishment of study plot. Line indicates linear regression.

period (Fig. 1 & 2). When the bird data were arranged by the corresponding age of nestbox plots, the percentage of nest boxes used by birds decreased significantly with nestbox age (Fig. 3). An increase in occupation of nestboxes was observed in the 2nd and 3rd year after the nestbox plots had been established, but a decrease then followed (Fig. 3). When the number of broods versus nestbox age were analysed separately for each species, there was still a negative trend for Great Tit (Fig. 5). The numbers of Pied Flycatcher also seemed to decrease with nestbox age (Fig. 4), but the decline was not significant.

If the factor of nestbox aging was taken into account in the estimation of population trends (using the Bonferroni method to test the comparisons), the negative trend in breeding numbers was still significant ($P<0.05/2$, Fig. 2) for Great Tit, but not for Pied Flycatcher ($P>0.05/2$, Fig. 1). The number of Pied Flycatcher broods increased after new nestboxes had replaced the old in the sole selected study plot in 1996 (1995, 26 broods; 1996, 43 broods). Over the same period, the number of Great Tit broods seemed to decrease (7 and 4 respectively). However, in 1996 the number of Pied Flycatcher broods also increased in other study plots: in 1995 the mean percentage of nestboxes occupied by Pied Flycatcher was 27.5 (6 study plots used) and in 1996 36.6% (9 study plots used).

No significant trends in the productivity of Pied Flycatcher were found during the survey period, but the clutch size was positively correlated with nestbox age (simple regression, P=0.01, R-squared=0.19, n=3134). The number of fledglings seemed to show a similar trend (P=0.05, R-squared=0.18, n=2060). No significant correlation was found between the productivity of Great Tit and nestbox age (simple regression, p=0.4 for eggs and p=0.5 for fledglings).

4. Discussion

Throughout most of Europe, breeding populations of Pied Flycatcher and Great Tit are considered to be stable, with small

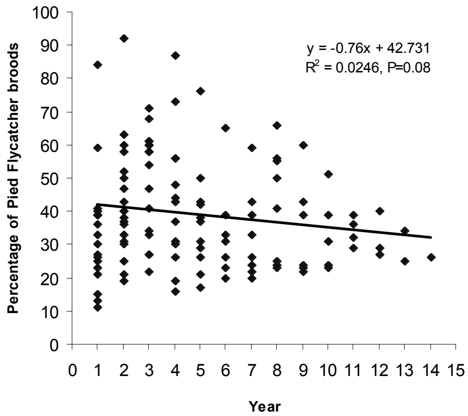

Fig. 4. Percent of nest-boxes occupied by Pied Flycatcher (% of all available nest boxes in the study plot in corresponding year) against the nest-box age (years after the establishment of study polt). Line indicates linear regression.

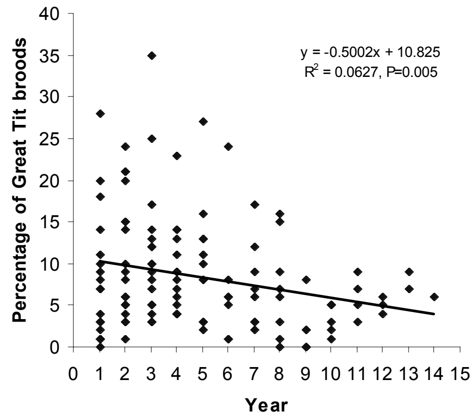

Fig. 5. Percent of nest-boxes occupied by Great Tit (% of all available nest boxes in the study plot in corresponding year) against the nest-box age (years after the establishment of study polt). Line indicates linear regression.

changes in numbers (Gosler & Wilson 1997, Lundberg 1997, Snow & Perrins 1998). Several authors have noted an increase in numbers of hole-nesting birds in the 1980s due to nestbox provision (Snow & Perrins 1998, Edula 1998). A decrease since the early 1980s in breeding numbers of both species has been observed in Latvia (Fig. 1 & 2). For the Pied Flycatcher, a similar trend has also been observed in breeding populations in Norway during 1986-1997 (Thingstad & Fjeldheim 1999) and in the numbers of birds migrating on the southern Baltic coast during 1961-1990 (Busse 1994). For the Great Tit a slight decrease has been registered in Estonia, but the population is still considered stable (Kuresoo & Ader 2000).

The probable decreases in numbers of Pied Flycatcher and Great Tit, as observed in the current study, could have been caused by a number of other factors. One such reason might be forest management activities in the study plot stands, for considerable area of 8 stands were thinned. However, both species are believed to exhibit a cyclic pattern of abundance (Busse 1994, Baumanis & Celmins 1993), and so a subsequent increase in numbers could follow. The number decrease may also have been influenced by peripheral side factors that are functions of the monitoring methods used (*e.g.* nestbox aging). Our study on the impact of nestbox age on the breeding of small hole-nesting birds suggests that nestbox age can affect brood numbers (Fig. 4 & 5).

Several European researchers had observed that hole-nesting birds exhibit a preference for new nestboxes over old (Shcherbakov 1956, Mihelsons 1958a, Blagosklonov 1970, Lundberg & Alatalo 1992). In a study of hole-nesting birds in central Russia, Blagosklonov (1970) observed maximum nestbox occupation in the 2nd year after establishment, followed by a gradual decrease. These results correspond with our current study (Fig. 3). In Latvia, the nestbox aging effect had already been observed in the 1950s by Mihelsons (1958a). Occupation of nestboxes made from fresh pine deal and sited in the Riga Forestry District in 1948, had already decreased by 1952. During spring 1954, in two forest areas where half of the nestboxes had been replaced by new ones, occupancy increased in the new boxes: in one district new occupancy rate was 65.5% and old 37.3%, in the other 73.3% and 48.3% respectively. When old and new nestboxes were sited in a new area, occupancy rate was 17.3% in the new and only 4.3% in the old (Mihelsons 1958a). Subsequently, one more study was carried out in another forestry district with similar results (Mihelsons 1958a). Mihelsons concluded that nest boxes made of fresh 25 mm-thick deal became less attractive for hole-nesting birds in the fourth or fifth year after establishment (Mihelsons 1958a).

Several reasons have been proposed to explain why hole-nesting birds prefer new nestboxes to those that are older but still usable (Mihelsons 1958a, Blagosklonov 1970, Lundberg & Alatalo 1992): presence of parasites, presence of old nesting material, microclimatic conditions, visibility (external brightness) and internal light conditions in the nestbox.

To investigate the role *parasites* play in prospecting birds avoiding old nestboxes, Blagosklonov (1970) removed more than 50 nestboxes, stored them dry for 2-3 years to kill off parasites, and then placed them again in the forest. Occupancy did not increase, suggesting that parasites were not the reason prospecting birds tended to avoid older nestboxes. Studies have also shown that the impact of *old nesting material* has no effect on birds' choice of nestbox. In several studies in Sweden, Pied Flycatcher show no preference for nestboxes lacking old nesting material (Alerstam 1985; as cited by Lundberg & Alatalo 1992), but did show a preference for new nestboxes containing old nest material to those without any nest material (Olsson *pers comm* as cited by Lundberg & Alatalo 1992). Changes of *microclimate* inside the nestboxes due, for example to development of cracks with age and accumulation of moisture, had also been suggested as a possible reason for avoidance of old nestboxes (Mihelsons 1958a, Lundberg & Alatalo 1992). However, in many cases, nestboxes that appear to be intact and quite suitable for breeding were not occupied by birds, while neighbouring nestboxes that had many cracks were (Mihelsons 1958a).

New nestboxes, being brighter, contrast with the background against which they are mounted and therefore birds may detect them more easily (Lundberg & Alatalo 1992). However, several researchers by their observations have denied the role of *external brightness* of nestboxes in nest-site choice. For example, in an experiment to catch Pied Flycatchers in spring when they are prospecting for nest sites, Mihelsons, using special nestboxes designed to capture birds (externally they resembled ordinary boxes), recorded similar numbers of birds in new and old boxes (Mihelsons 1958a). These results suggest that flycatchers can find old nest boxes as easily as new ones, and that *external brightness* could not be the main reason for them avoiding old nestboxes as nesting sites. To check the role of *internal light conditions* in nestboxes, Blagosklonov (1970) blackened the inside of nestboxes, without changing the external colour. Pied

Flycatchers showed an obvious preference for boxes with a bright interior (Blagosklonov 1970). Importance of *internal light conditions* in nestboxes in association with the depth of the nestbox had been observed earlier by Shcherbakov (1956) in the Mordovian Nature Reserve. According to his observations, Pied Flycatchers prefer shallower nestboxes than Great Tits. When Pied Flycatchers found nestboxes to be too deep, they filled them with nest material to the level they preferred (Shcherbakov 1956). Based on Shcherbakov's (1956) findings and on his own measurements and calculations, Mihelsons suggested that the internal reflectance of the nestbox is of great importance to the Pied Flycatcher in selecting a nestbox in which to nest. Pied Flycatcher avoided selecting those nestboxes in which daylight could illuminate the nest directly and those whose internal reflectance was too low (nestboxes made from dark materials). However, to the Great Tit, a nestbox that had low interior reflectance did not affect greatly its selection as a nest site (Mihelsons 1958a).

Blagosklonov (1970) showed that Great Tit preferred deep nestboxes if they were new, but shallower boxes as these became older. He concluded that the level of *internal light conditions* was the most important factor for hole-nesting birds in their selection of nestboxes as nest sites. Blagosklonov (1970) also noted the part that entrance hole and depth played in determining the light levels inside the nestbox.

He noted that internal light levels diminish as the nestboxes aged, the amount of light that the internal walls reflected reducing as the brightness reduce, thus placing the nest in increasing darkness from season to season. Blagosklonov (1970) confirmed this idea by making measurements of light intensity. He tested this further by dividing into pairs those nestboxes that had been in place in the forest for 7-8 years and painting white the rear inside wall of one of each pair. He put up a third set of nestboxes newly made from fresh wood. The old nestboxes having a white inside rear wall all became occupied, but occupancy of the unchanged old boxes was only 37% and of the new boxes, 71%. In another experiment, he blackened the internal walls of 20 new nestboxes, the other 20 new boxes serving as controls. Pied Flycatcher avoided selecting blackened boxes for nesting (only 5% were occupied), preferring the control boxes (80% occupancy) (Blagosklonov 1970).

According to the above literature it would seem that reduced *internal lighting conditions* could be the main reason for the nestbox aging effect. The current study suggests that the aging of nestboxes affects Great Tit more than the Pied Flycatcher. In the study by Mihelsons (1958a), Great Tit also seemed to prefer new nestboxes to old ones. Possibly, the *internal lighting conditions* are not the sole factor causing the aging effect of nestboxes on nest site selection. It should be noted that the significant negative trend of Great Tit breeding numbers in the nestbox plots during the study period presented difficulties in estimating the impact of nestbox aging on nest site selection.

In the current study, after nestbox replacement in one of the study plots, the number of Pied Flycatcher broods increased, but the number of Great Tit broods did not, circumstances that support suggestions that Great Tit prefers deeper nestboxes that characteristically have poorer *internal lighting conditions*, unlike the Pied Flycatcher (Shcherbakov 1956). Although the number of Pied Flycatcher broods in 1996 also increased in other study plots compared to 1995 levels, the increase in the study plot where the nestboxes had been changed was even greater.

It may seem surprising that Pied Flycatcher productivity increases with nestbox age. One explanation could be the occupancy of new nestbox plots by young (2nd summer) first-time breeders, which had, after fledging the previous year, dispersed widely and have no strong connection to their natal area (Mihelsons, 1958b). Inexperienced breeders have a lower productivity than older birds (Haartman 1951, Berndt & Winkel 1967). Another explanation could be the density dependence of productivity (Stenning *et al.* 1988, and Virolainen 1984, both as cited by Newton 1998). Occupancy of nestboxes in new study plots was higher (Fig 3) than in older plots, leading to higher breeding density and hence reduced productivity (Stenning *et al.* 1988,and Virolainen 1984, both as cited by Newton 1998).

Results of the analyses of our hole-nesting bird monitoring data and the literature data show that nestbox aging seems to be an important factor influencing nest site selection and, by definition, monitoring results. Our present knowledge allows us to recommend that nestboxes should be replaced by new ones every 3 to 4 years. However, the best replacement schedule should be established to minimise the impact of nestbox aging on the results of any monitoring scheme. Such a schedule should be derived from the results from study plots containing nestboxes. More research into the importance of *internal light conditions* that a bird species requires in a nestbox to select it as a nest site is needed. Such research would require techniques developed to minimize the reduction of *internal light conditions* that arises as the nestbox ages.

Acknowledgements. I am very grateful to all volunteers participated in the field work, especially to Juris Kazubiernis, Oskars Keiss, Valdis Adamsons, and Dr. biol. Varis Liepa. Special thanks go to my doctoral supervisor Dr. biol. Janis Priednieks, to Dr. biol. Agnis Smits for the help with statistical analyses and to Guntis Brumelis, who improved my English.

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