

## Do small hole nesting passerines detect cues left by a predator? A test on winter roosting sites

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Ekner A., Tryjanowski P. 2008. Do small hole nesting passerines detect cues left by a predator? A test on winter roosting sites. *Acta Ornithol.* 43: 107–111. DOI 10.3161/000164508X345392

**Abstract.** There are a lot of studies about relationships between prey and predators. However most have focused on the influence of lethal predators on their prey. We suggested that non-lethal effects may also be very important for a complete understanding of prey-predator interactions. Among many influencing factors predation is important because it affects survival probability, especially in winter, which is a critical period for many passerines living in temperate zones. Apart from killing prey, predators may also have an indirect influence on the choice of nocturnal resting sites. Therefore, small passerines should detect and avoid places where a predator has operated previously. We tested this prediction using data on wintering small passerines, mainly on Great Tits. The study was performed during the winter season of 2005/2006 in western Poland. In the experiment, we put fur and mangled feathers in half of 100 randomly selected nest boxes. Boxes were checked every ten days, from January–March. The birds showed a significantly stronger preference towards "clean" nest boxes (without predator traces). It seems that non-lethal predator influence modifies winter dispersion of birds and wintering passerines may detect, by visual signals left behind, nest boxes where predation has previously occurred.

**Key words:** Great Tit, *Parus major*, nest boxes, non-lethal predator-prey interaction, predator traces, predator detection, roosting site preferences, cavity nesters

Received — Oct. 2007, accepted — May 2008

Detection of a predator by prey may be crucial for survival. On the one hand, a predator can be detected during its operational activity, such as hunting or moving hunted prey to a safe place, as well as during the preparation of special hunting structures, such as spider webs (Sutherland 1996, Conover 2007). However, even earlier detection by other cues left by the predator may be favoured by natural selection, because it gives prey an opportunity to avoid places with high predator foraging or resting activity. Detection of these cues or predator traits is especially crucial in times of constrained energy budget, when time for foraging is strongly limited. That situation occurs for most resident passerines wintering in temperate zones (Houston & McNamara 1993, Paclik & Weidinger 2007). Moreover, after foraging during the day time, finding a safe night resting site is crucial for survival. One of the main factors responsible for the winter mortality of small

birds is predation (e.g. Ekman 1986, Carrascal & Moreno 1992, Suhonen 1993, Kullberg 1995). However, relative predation risk depends on prey density (Mitchell & Brown 1990, Sutherland 1996) and the hunting tactic of the predator (Ekman 1986). Thus birds select a roost site in which they can be well hidden from predators (Ligon et al. 1988, Mazgajski 2002, Lima et al. 2005). Obviously, other factors, such as food, heat and weather also play an important role (Hogstad 1981, Houston & McNamara 1993, Roos 2002, Carrascal & Alonso 2006, Pinowski et al. 2006a, Godard et al. 2007, Paclik & Weidinger 2007). Therefore, to avoid the influence of disadvantageous climatic factors like strong winds, freezing temperatures, snow and/or rain birds are looking for a safe nocturnal place (Jenni 1991, Lima et al. 2005). Classic examples are passerines spending winter nights in both natural holes and in nest boxes (eg. Báldi & Csörgő 1994, Pinowski et al. 2006a).

However, the choice of safe nocturnal places according to predation pressure is strongly limited. Most studies focus on lethal/direct impacts of predators on birds (Newton et al. 1997, Bradley & Marzluff 2003). Predators, besides killing, can also influence prey behaviour in other ways (Watts 1991, Jędrzejewski et al. 1993, Lima 1998, Carrascal & Alonso 2006, Trnka & Prokop 2006). For example in small mammals, predators influence prey cover choice by cues suggesting the presence of predators, such as the smell of the predator (Jędrzejewski et al. 1993, Fendt 2006) or the remains of the predator's meal, e.g. pellets (Sike & Rózsa 2006).

Birds also avoid places with strong predation pressure. It has been shown during the breeding season that predator presence influenced nesting site selection (eg. Suhonen et al. 1994, Tryjanowski et al. 2002). Moreover, predator presence also has an impact on changes in foraging areas (Carrascal & Alonso 2006), hormone secretion (Blanchard et al. 1998, Silverin 1998, Figueiredo et al. 2003), reproductive success (Hogstad 1995) and flocking behaviour (Carrascal & Moreno 1992).

However, to our knowledge, there is a lack of tests on predator presence as far as winter nocturnal site selection by birds is concerned. An important question is how, if at all, small passerines may detect predation pressure and avoid places with high predator activity. Because, as we argued above, winter can be a crucial period for survival, small passerines (as prey) should be especially sensitive to predators, and therefore easily recognize predator cues. Hence, we hypothesized that potential predator traces left in the nest boxes used for night resting sites by tits (and other passerines) during the winter may influence bird nocturnal site selection. Birds should prefer places without predator traces as that could be a good way to decrease predation risk. Finally, because the majority of Great Tits *Parus major* are sedentary in the study area (Authors' unpubl. data) we also check how winter selectivity of nocturnal sites may affect the usability of nest boxes during the forthcoming breeding season.

The study was conducted in Poznań (17°N, 52.5°E), in the west of Poland, in the 2005/2006 winter season. The area covers the Morasko campus of Adam Mickiewicz University, about 1.2 km<sup>2</sup>, with three large buildings and a small forest mainly containing Scotch Pine *Pinus silvestris*. One hundred new nest boxes were hung out on the trees on campus in October 2005. The distance between nest boxes was 8–400 m.

Nest boxes were checked regularly at 10-day intervals from October 2005 to determine if they were being used. Thus we had information about nest box occupation before the experiment, which started in January 2006. We selected randomly (random procedure in Excel package) 50 experimental nest boxes while the other 50 were left as a control. In the experimental boxes, we twice put in some dog and cat hair, as well as cut tit feathers to simulate a predator visit to the nest box during the previous days. The hair and feathers were previously kept in a refrigerator to reduce potential parasites and pathogens. The number of hairs and feathers was marginal (up to five altogether) to avoid potential interpretation by the birds that it was nesting material. All of the boxes (the experimental and the control groups) were checked every 10 days for 3 months (January–March). The nest boxes were classified as occupied for nocturnal activity when tracks of birds in the form of excrement were seen. Additionally, once a month, at night, the birds were caught in the boxes according to standard procedure (Busse & Olech 1968, Krištín et al. 2001) and ringed in order to determine their species, age, sex and to find out how often birds were recaptured. It wasn't done more often to avoid the researchers influencing the birds' behaviour. Nest boxes were cleaned of excrement after each nocturnal and daily check.

During each nocturnal visit (during the experiment  $n = 2$ ; before the experiment  $n = 3$ ) 13–50 (mean  $30.7 \pm 11.8$ ) birds were caught and the majority of them (86%) were Great Tits. However, because determining occupancy (during the experiment  $n = 4$ ; before the experiment  $n = 6$ ) was also done by faecal presence, with no chance to distinguish between passerine species, we have assumed that it was mainly a result of Great Tits. Additionally, studies were continued during the forthcoming breeding season, and the nest boxes were checked weekly ( $n = 8$ ), without any experimental procedures.

Because the same birds used the nest boxes during the whole winter (or at least for several days; see Báldi & Csörgő 1994, Krištín et al. 2001) data from each visit are not statistically independent. Therefore we solved this problem by comparing the obtained results of occupancy pattern (% of occupied nest boxes during a visit) by a Wilcoxon matched test, where a pair was a number of boxes from the control and experimental groups during a single visit.

To reduce the anthropogenic effect on the birds, they were caught only once a month (see

above). Therefore, due to the small number of visits, data on the number of caught birds cannot be compared by a pair-wise test. However, because the mean number of birds in the occupied box was always one, results obtained in this way should not differ from those presented below. All results are presented as mean  $\pm$  SD.

Before the experiment began there were no significant differences between the control and experimental groups ( $49.6 \pm 7.7\%$  vs.  $50.4 \pm 7.7\%$  of occupied boxes,  $n = 9$  visits, Wilcoxon test,  $Z = -1.198$ ,  $p = 0.231$ ).

During the experiment the nest boxes with a predator's trace were occupied at  $26.68 \pm 12.76\%$ , and in the control group the occupation pattern was  $73.32 \pm 12.76\%$  ( $n = 6$  visits), and this difference was found to be statistically significant (Wilcoxon test,  $Z = -2.023$ ,  $p = 0.043$ ). Moreover, nest boxes occupied during winter were also more often used by birds as breeding places (Kendall's tau correlation,  $b = 0.734$ ,  $p < 0.0001$ ).

There was no observed influence of capturing birds on their behaviour. Birds did not stop roosting in a given box post-capture. They were using such nest boxes again, and some individuals were even re-caught in the same boxes as previously (data from ringing).

In our study, birds show an ability to detect cues left by a predator and clearly showed a preference towards "safe boxes", e.g. those without "predator traces". It is not due to breeding success from a previous breeding season (Danchin et al. 2004, Pinowski et al. 2006b), because we hung up new boxes in the autumn. Also, the effect of nest box traits connected with location and microclimate (Mazgajski 2002, Pinowski et al. 2006a) was marginal, because in this study, nest boxes were selected randomly to the experiment, as well as tested before the experiment. Therefore, there are a couple of likely reasons for such a behaviour pattern. First of all birds can identify and use the traces left in the boxes by predators to avoid them. Do birds really recognize left traits as predator cues? At this stage of our research of course we can not be sure, but we strongly believe that tits recognize left feathers and hair as signs of a predator. Our results are supported by similar studies, which may be interpreted from a predator-prey relationship perspective. Firstly, studies on small mammals showed that traces can be chemical cues and that animals respond to a variety of predator odours, both in the field (Müller-Schwarze 1972,

Stoddard 1980, Dickman & Doncaster 1984, Jędrzejewski & Jędrzejewska 1990, Weldon 1990, Pusenius & Ostfeld 2000) and laboratory environment (Jędrzejewski et al. 1993, Dell'Omo et al. 1994, Fendt 2006). Dominant resources of that factor are predator skin and fur, urine, faeces and anal gland secretions (Apfelbach et al. 2005), as well as digested remains of food, such as owl pellets (Sike & Rózsa 2006). However this is not true for birds that prefer visual cues (Godard et al. 2007). Our study shows that detecting predator presence may be done on a strongly limited number of signals, mainly because predator avoidance was under strong pressure from natural selection (Ekman 1986, Lima 1998). Secondly, data from the breeding season suggest that birds avoid sites where predators occur, eg. dens of the Red Fox *Vulpes vulpes* (Tryjanowski et al. 2002), and Kestrel *Falco tinnunculus* nests (Norrdahl & Korpimäki 1998), which are visual signals of predator occurrence to prey. Except for those examples in which predators were somewhere in the vicinity, in the case of using and comparing nest boxes there might exist a slightly different mechanism of predator avoidance. Birds might avoid places where predators left traces, because of the likelihood of them coming back to exactly the same place afterwards, which occurred in several different studies (Sonerud 1985, Nilsson et al. 1991, Sorace et al. 2004, but see Korpimäki 1987).

On the other hand, potential predator traces, including hair, feathers of killed birds, and even faeces may not only be a cue of predator presence, but also a cue of parasites and pathogens in the place. For example, similar studies showed that some birds choose clean boxes for breeding, or those with microwaved old nests (e.g. Rendell & Verbeek 1996, review in Mazgajski 2007). A similar result was obtained by Oppliger et al. (1994), comparing nest boxes infested with the hematophagous Hen Flea *Ceratophyllus gallinae* and those without, where birds preferred those without ectoparasites. In the presented study parasites and pathogens couldn't influence the bird's decision because the materials used were sterilized beforehand.

Another explanation might be that the birds perceive the left traces as evidence that a given box may be occupied by another bird. However, in the presented experiment potential clues related to parasites, pathogens, a different individual's presence or even some sort of dirt in the nest have a predator origin. We do not know if birds recognize a connection between traces and predators,

but we know that all probable reasons of their decisions mentioned above are caused by such a potential predator, because only a predator could leave such traces. Therefore, predators should be underlined as a main factor influencing nest box nocturnal occupancy by small passerines in winter conditions. The ability to detect predator presence early may be key for survival in this period, and this affects nest box occupancy patterns in the forthcoming breeding season.

**ACKNOWLEDGEMENTS** We would like to thank M. Prange, M. Adamczak, T. Czyżak, S. Dziemian, A. Garczarek, T. Grzyb, R. Hybsz, K. Kaczmarek, T. Kniola, J. Kosicki, M. Przystański, M. Pyrc, P. Rosik, W. Szydło, M. Tobółka for help in the field. L. Carroll, V. Takacs and J. Pinowski critically read the previous versions of the manuscript.

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## STRESZCZENIE

### [Czy małe dziuplaki rozpoznają ślady obecności drapieżnika? Eksperyment z ptakami nocującymi zimą w skrzynkach lęgowych]

Większość badań dotyczących relacji drapieżnik — ofiara skupia się na bezpośrednim (letalnym) wpływie drapieżników na swoje ofiary. Nieletalny (pośredni) wpływ, mimo iż często trudny do zarejestrowania, jest także istotny i nie powinien być pomijany. W prezentowanym eksperymencie analizowano właśnie taki wpływ potencjalnych drapieżników na wybór miejsc noclegowych przez ptaki nocujące w skrzynkach lęgowych. Badania prowadzone były w sezonie zimowym (2005/2006), krytycznym dla przetrwania ptaków żyjących w umiarkowanej strefie klimatycznej.

Do losowo wybranych, nowo powieszonych skrzynek wrzucono poszarpane pióra ptaków oraz sierść drapieżnika, symulując w ten sposób jego obecność. Skrzynki sprawdzane były co dziesięć dni. Jako miejsce noclegowe dziuplaki znacznie bardziej preferowały skrzynki czyste, bez pozostawionych śladów sugerujących działanie drapieżnika. Ptaki najprawdopodobniej identyfikowały sierść i pióra z drapieżnikiem i w ten sposób unikały jego obecności. Dziuplaki odstraszać mogły również takie czynniki, jak obecność pasożytów, czy też innych ptaków w budkach. Jednakże wszystkie powody, dla których dziuplaki wybierały skrzynki bez sierści i poszarpanych piór były konsekwencją obecności potencjalnego drapieżnika, gdyż to właśnie on zostawia takie ślady. Z tego powodu, drapieżniki powinny być uwzględniane jako jeden z głównych czynników wpływających na zajmowanie skrzynek lęgowych nocą przez drobne ptaki wróblowe w okresie zimowym.