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Does the sex and age of birds and the size of human settlements affect recapturing of the Great Tit (*Parus major*) at bird feeders?

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ABSTRACT

Urban and rural habitats provide different conditions to wintering birds mainly due to different access to bird feeders. Returning to the food sources, even under the stress related to trapping, could play an important role in the energetic budget of wintering birds. We studied the duration of period between the first and the second capture of the Great Tits (*Parus major*) caught and ringed at bird feeders. We expected that recapturing of birds, which could be connected with their experience, would depend on their sex, age and on the size of human settlements (urban vs. rural areas), which could modify the behavior of wintering birds. We found that the length of the period was the shortest for immature females and the longest for adult males (the difference being 3.8 days in average). In contrast to more experienced adults, more frequent visits in case of immature tits, which increased probability of being trapped, could be affected by their weaker condition and smaller size, which resulted in feeding whenever it was possible. At the same time we did not find any differences between urban (duration of 29.5 days in average) and rural (28.5 days) areas. Differentiation in bird densities, access to feeders and various environmental factors seems to be the reason why this issue awaits further, more detailed studies including influence of weather on the behavior of birds.

1. Introduction

For birds, winter is a crucial period of the year round life cycle (Newton, 1998). During this period the snow cover makes many food sources unavailable and short days leave very little time for the birds to search for food. Moreover, energy consumption grows when the weather conditions deteriorate and birds must increase their feeding intensity to survive this period (Siriwardena et al., 2008; Golawski and Kasprzykowski, 2010). Human settlements may be especially favourable for the birds during winter, when the weather conditions are harsh and the food sources are limited. It is particularly important that in the cities the waste food of restaurants, schools, supermarkets, and especially bird-feeders are widely available for birds (Tryjanowski et al., 2015a, 2016).

In relation to the number of bird feeders in the urban areas, trapping birds for scientific reasons is relatively easier here in winter (Dingemanse and De Goede, 2004; Golawski et al., 2015). Capturing birds for ringing and further subsequent manipulations related to measurements is a source of stress for the birds (Le Maho et al., 1992; Cabezas et al., 2012), who in turn may change their behaviour in response to capturing. Studies on avian migrants showed that they may depart from a winter staging site as a reaction to capturing (Nisbet and Medway, 1972). Moreover, birds may avoid capturing for some time after they have been captured. This reaction might be permanent, or it

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may last only for a short time (Pradel, 1993; Roche et al., 2013). On the other hand, Salewski et al. (2007) argued that birds do not modify their behaviour so strongly due to catching activity, so capturing them does not have a significant impact on recapture probability. Moreover, several avian studies have shown that all individuals in a population are not equally catchable (Pollock et al., 1990; Senar et al., 1999). Possible changes in the behaviour of birds as a reaction to capturing are therefore not thoroughly investigated and it is not really known how common they are and which factors they mostly depend on (Salewski et al., 2007; Camacho et al., 2017).

Based on studies done on the Great Tit (*Parus major*), the dominant species visiting feeders in winter in Poland and many other European countries (Tryjanowski et al., 2015c), we tested the factors affecting the length of the period (number of days) between the first and the second capture of individual birds. We expected this period to be longer for the birds living in cities because generally birds show greater curiosity in searching for food sources and have much wider access here to the feeders in comparison to village birds (Liker and Bókony, 2009; Sol et al., 2011; Tryjanowski et al., 2016). We also expected to detect differences between sex and age groups. Immature tits with inferior social status seem to forage more intensively and thus they are expected to be recaptured in the nets earlier (Gosler, 2002). Furthermore, sex can also play an important role here as it has already been proved that males first discover some new food sources and they do it faster in the cities than in the villages (Tryjanowski et al., 2015b). Besides, adult birds should be more experienced and better avoid dangers (Erritzoe et al., 2003; Orłowski, 2005) and we predicted that they might avoid the mist-nets more efficiently (Senar et al., 1999).

2. Material and methods

2.1. Study area

Study plots were located in six human settlements across Poland (Fig. 1). Three rural sites were situated in villages with the population not exceeding 2 000 people: Przebendowo (N Poland) was located in an overgrown park near an old manor house. Wapnica in NW Poland was situated in a garden separated from the village by a forest. The last rural study plot was Mirków (SW Poland), located in an old orchard. The other three study sites were located in the cities, where the population exceeded 300 000 inhabitants: Białystok (NE Poland) – in a district of detached houses, while Bydgoszcz (central Poland) and Kraków (S Poland) – in botanical gardens which were located in the centers of these cities.

2.2. Field protocols

The data were collected throughout 11 winter seasons: 2005/2006 - 2006/2007 and 2008/2009–2015/2016, but in each locality it was 2–7 years. Bird ringing sessions were conducted 6–7 times during one study season, from the beginning of December till the end of February, with about 14-day breaks (mean = 14.1, SD = 0.2, n = 6 study plots, Table 1). Birds were caught in mist-nets and ringing was conducted during 5 consecutive hours, starting from sunrise (6 or 7 a.m.). The nets were located in the vicinity of bird feeders, with constant supply of sunflower seeds and/or animal fat. In each study site the position of the nets was the same during each study season. We used the following lengths of the nets: Przebendowo - 40 m; Wapnica - 10 m; Mirków – 27 m; Białystok - 30 m; Bydgoszcz - 16 m; Kraków - 12 m (mean 22.5 m). Birds were aged and sexed according to the standard methods proposed by Svensson (1992) and divided into the first calendar year (hereafter immature) and older (adult) males and females.

2.3. Statistic procedure

We studied the influence of two factors on the number of days between ringing and the next trapping of an individual in the same winter season. We used only the data on tits caught and ringed for the first time within a season, i.e. the birds that had not contact with researchers and nets before. The factors studied were: 1) urbanization – rural and urban study plots and 2) sex and age in four classes: first year females, adult females, first year males, adult males (according to Gosler, 1996). Similar as Camacho et al. (2017), we used generalized linear mixed model (GLMM) with zero-truncated Poisson error distribution and log link function using glmmTMB library for R (R Development Core Team, 2019). The response variable was the number of days between the capture of a bird and its first recapture. The two explanatory variables (fixed effects) were: 1) habitat (rural vs. urban), 2) sex and age divided into four categories described above. The year (11 winters) and study plot location (6 areas) were included as random effects. To test the difference between four categories of sex and age, we used Tukey post-hoc test for our GLMM model (multcomp library for R). By using the G-test, we analyzed the differences in the share of birds, taking into account their age and sex, between all caught birds and those who were recaptured. Values reported are mean ± 1 SE. This part of analyses was performed in SPSS v.21.0 (IBM Corp, 2012). P values < 0.05 were

Fig. 1. Study area.

Table 1
Day-intervals between consecutive bird ringing sessions for the 6 localities and numbers of capture/recapture birds for each locality/year. The first three places are cities, the next three are villages.

Localities	Day-intervals	Number of captured birds		Number of recaptured birds	
	Mean ± SD	Mean ± SD	Range, n	Mean ± SD	Range, n
Białystok	14.4 ± 3.1	199.3 ± 39.6	176-245, 598	47.0 ± 12.8	36-61, 141
Bydgoszcz	14.2 ± 1.4	249. 3 ± 26.6	233-280, 748	85.5 ± 10.6	78-93, 171
Kraków	13.9 ± 1.0	286.7 ± 109.4	170-387, 860	71.3 ± 49.8	31-127, 214
Mirków	14.0 ± 1.1	116.8 ± 48.0	46-181, 584	43.4 ± 21.5	23-86, 304
Przebendowo	14.2 ± 2.1	151.3 ± 86.6	94-251, 454	39.0 ± 20.5	19-60, 117
Wapnica	14.1 ± 1.2	143.0 ± 76.5	67-220, 429	7.7 ± 6.4	4-15, 23

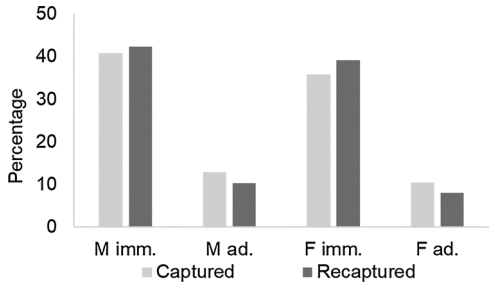

Fig. 2. Percentage of all captured (n = 3710) and re-captured within the season (n = 970) Great Tits (*Parus major*) split into sex and age groups (M – males, F – females, imm. – immatures, ad. - adults).

considered statistically significant.

3. Results

Altogether we ringed 3 710 Great Tits, of which 970 were re-captured (26.1% of all, Table 1). Immatures were the most numerous, accounting for about 75–80% of all captured and recaptured tits (Fig. 2). The proportions of sex and age groups among the recaptured birds were very similar to those in all the captured birds and the differences were not statistically significant (G-test, G = 0.76, df = 3, p = 0.859). Moreover, there were no significant differences in proportions of birds according to sex and age groups captured and recaptured in urban and rural areas separately (G-test, $p > 0.713$ in both cases).

The number of days between the first and second capture was affected only by the sex and age of birds (GLMM, Z = 9.31, $p < 0.001$). The number of these days was the lowest for immature females (mean = 27.4, SE = 0.8, n = 379) and it was significantly different for all the others group of birds (Tukey post-hoc in all cases $p < 0.05$, Fig. 3). The highest number of days between the first and second capture was found for adult males (mean = 31.2, SE = 0.2, n = 101, Fig. 3) with statistical differences in comparison to immature and adult females (Tukey post-hoc in both cases $p < 0.05$, Fig. 3). Moreover, there were no differences in capture days between adult females (mean = 29.3, SE = 1.7, n = 79, Fig. 3) and immature males (mean = 29.8, SE = 0.9, n = 441) (Tukey post-hoc in both cases $p > 0.05$, Fig. 3). There were no differences in duration of period between both captures in urban habitats (mean = 29.5, SE = 0.8 days, n = 526,) and rural areas (mean = 28.5, SE = 0.8, n = 444 days,) (GLMM, Z = 0.11, p = 0.73, Table 2).

4. Discussion

We found that the only two factors affecting the length of the period between the capture and the first recapture were age and sex of tits. Immature females were recaptured earlier than other groups of tits, especially than adults males which were recaptured almost four days later. Our results are similar to those shown by Senar et al. (1999), where immature individuals of both sexes had the highest recapture

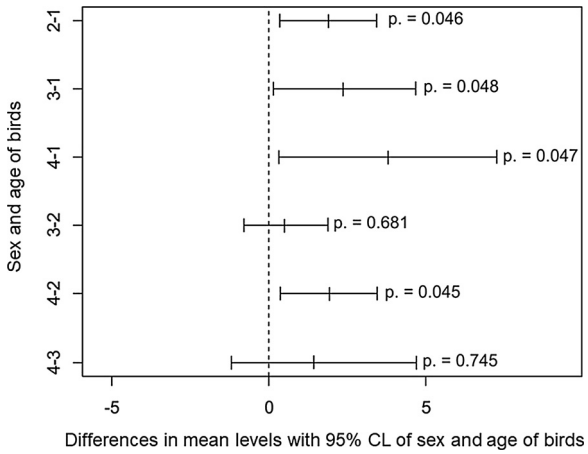

Fig. 3. Post-hoc Tukey test for the first and the second capture within the season in relation to sex and age in Great Tits (*Parus major*) (1 – immature females, n = 379; 2 – adult females, n = 79; 3 – immature males, n = 411; 4 – adult males, n = 101).

Table 2
Results of the general linear mixed model with zero-truncated Poisson distribution showing factors affecting the number of days between the capture of a bird and its recapture. Year and study plot were used as random factors.

Variable	Estimate	SE	Lower 95% CL	Upper 95% CL	P value
Female imm.	−0.081	0.021	−0.168	−0.087	< 0.001
Female ad.	−0.059	0.028	−0.113	−0.004	0.034
Male imm.	−0.074	0.020	−0.114	−0.034	< 0.001
Male ad.	0.000				
Habitat of study plot: city	0.118	0.120	−0.216	0.253	0.877
Habitat of study plot: village	0.000				

probabilities, followed by adult males, while adult females had the lowest recapture probabilities. Immature Great Tits were found to use the feeders more intensively in comparison to adults, and adult females were the least dependent on food supplementation (Senar et al., 1999). It is in accordance with studies of Krams (2002), who found that in adult males average daily weight increased largely in compare to the juvenile females. Generally, immature tits tend to accumulate larger fat reserves than adult birds, which may be connected with their inferior social status. Birds in winter form parties with a distinct hierarchy, where the dominant individuals forage as the first (Gosler, 1996). Dominant adult males do not have to accumulate extra loads of fat, more than necessary to survive to the next day, as they have priority in access to food sources. On the contrary, inferior immatures, particularly females, which are smallest and weakest, should accumulate fat whenever possible, in case the dominant individuals deny them the access to food. Therefore the immatures must visit the feeders more

frequently and thus they have a greater chance of being retrapped. Moreover, adult birds, as more experienced, can be more efficient in avoiding mist-nets, which experience the younger individuals still do not possess.

Surprisingly, we found no influence of the size of human settlements on duration of the period between the capture and the first recapture. We expected that due to limited access to the food sources, and hence probably more obligatory use of the feeders where the trapping was conducted, this period would be shorter in villages. Birds wintering in the cities are more numerous than in the villages, which should additionally increase the probability of the recapture (Tryjanowski et al., 2015c). They also have a larger choice of food sources, particularly bird feeders (e.g. Polakowski et al., 2010; Tryjanowski et al., 2015a). Individuals once trapped can therefore easily move to alternative feeders, which should reduce their retrapping probability in comparison to the rural areas. Lack of such differences may suggest that the urban birds are more strictly devoted to their feeders, perhaps because of greater competition caused by higher density of birds using the feeders. On the other hand, the village birds may exploit natural food sources, available in the habitats around the settlements, and thus have a similarly large choice as the urban birds. Moreover, a study by Jokimäki and Kaisanlahti-Jokimäki (2012) suggested that single-family house areas and villages are better for birds in comparison with the cities due to resource predictability, which may further reduce the differences between cities and villages. To study this problem in detail, further research is needed, including a variety of urban and rural areas, which would test various environmental factors possibly affecting feeder site fidelity and recapture probability. One of such factors, that could strongly change the birds' behavior, may be the weather conditions, especially snow cover (Golawski and Dombrowski, 2011), which was not studied by us.

In conclusion, the most important factor determining the length of the period between capture and recapture seems to be the sex and age of birds. Immatures with inferior social status must forage more intensively and thus they are more likely to be recaptured in the nets. More experienced and dominant adults can afford less frequent visits in the feeders and accumulate fat loads sufficient just for survival of the cold winter night (Gosler, 2002). The influence of the environment – rural vs urban – was not proved to be significant. However, this issue requires further studies which would consider a greater number of factors, including weather.

Contribution of the authors

AG, MP conceived and designed the study. MP, PF, KrS, KaS, GK, DK collected field data. AG and JK performed statistical analyses and wrote parts of the manuscript (methods, results). MP, PF, KrS, KaS, AC wrote parts of manuscript and gave comments on the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

All the procedures performed in studies involving animals were in accordance with the ethical standards of the institution or practice at which the studies were conducted. All the birds were ringed according to the rules of the Polish bird ringing scheme. They are determined by superior regulations, i.e. the nature conservation act (Ustawa z dnia 16 kwietnia 2004 r. o ochronie przyrody, (Dz. U. z 2013 r. poz. 627, z późn. zm.), the regulation on bird ringing (Rozporządzenie_Ministra_Środowiska z dnia 14 marca 2006 r. w sprawie obrączkowania ptaków (Dz. U. Nr 48, poz. 350), and the rules of the Polish Bird Ringing Centre. The last-mentioned rules (www.stornit.gda.pl/reg_kco.php) set out the details of the standard ringing procedures.

Declarations of interest

None.

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