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PERSONALITY AND PREDATION RISK IN URBAN-NESTING MOUNTAIN CHICKADEES

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PERSONALITY AND PREDATION RISK IN URBAN-NESTING MOUNTAIN CHICKADEES

by

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ABSTRACT

Urbanization is changing natural landscapes worldwide, pushing species to quickly acclimate or adapt if they are to survive in urban environments. Urban living means dealing with an increase in chemical pollutants, higher rates of pathogen transmission, and different predator landscapes than are found in rural environments. Mountain chickadees (*Poecile gambeli*) are considered urban adapters, readily nesting in both urban and rural environments without suffering apparent reproductive costs. However, whether urban-nesting chickadees are successful in these environments due to differences in personality between urban and rural birds remains untested. For example, urban birds may exhibit low neophobia and high boldness, allowing them to better cope with the challenges of urban environments. To test for differences in anti-predator behaviour and neophobia between urban and rural birds, we examined the behavioural responses of urban- and rural-nesting mountain chickadee females that were presented with a predator (squirrel model) and a novel object (red plastic cup) at the nest. We found that urban-nesting mountain chickadees displayed less neophobic behaviour than the rural-nesting mountain chickadees, readily re-entering the nest and essentially ignoring the novel object on the nest box. Urban-nesting mountain chickadees in our study also displayed more aggressive behaviour than rural-nesting mountain chickadees when presented with a model of a predator. Together, these results suggest that bolder, less neophobic birds may disproportionately settle in urban environments, a pattern that may aid in mountain chickadees' ability to readily and successfully nest in urban environments.

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INTRODUCTION

Urbanization is rapidly altering the landscape of the natural world, affecting how species interact and survive within it (Grimm et al. 2008, Mayorga 2020). Changes in the landscape present new challenges for animals in the form of increased anthropogenic interactions, exposure to new species as competitors or predators, and the alteration or destruction of traditional habitat (Gilbert 1991, Lepczyk 2017). Each species' ability to adapt to these urban habitats depends on life history traits, such as diet, sociality, and breeding behaviour (Kark 2006). Animals can be grouped into three primary categories based on their success in urban environments (Blair 1996). Urban exploiters or dwellers are found at greater frequency in urban areas compared to non-urban areas. By contrast, urban avoiders are species that are most successful in rural habitats and are absent from urban areas; they do not adjust well to the challenges of urbanization. Urban adaptors or utilizers are species that succeed equally in both urban and rural habitats and are found in similar frequencies in both habitats (Blair 1996, Lepczyk 2017).

Many bird species have had a high degree of success adjusting to and/or exploiting urban landscapes (Isaksson 2018, Kark 2006). Nesting opportunities in urban areas tend to favour cavity-nesting birds, as man-made structures often have cavities similar in size to those used by cavity nesters in rural environments (Isaksson 2018, Kark 2006, Lepczyk 2017). Birds inhabiting urban areas can also utilize the varied food sources presented by urban environments (Rycken 2022). Earlier bud burst in urban areas provides access to food early in the year, and humans provide food in the form of bird seed and refuse (Caizergues et al. 2022, Hajdasz et al. 2019). Because of the differences between rural and urban landscapes, bird species that occupy both habitats are sometimes characterized by phenotypic differences between urban and rural populations, such as

colour variation between urban and rural great tits (*Parus major*; Andersson et. al 2015, Isaksson 2018, Møller 2015, Kozlovsky 2015).

For urban utilizer and exploiter species, which are able to persist or even thrive in urban environments, there are some potential costs (Stephens et. al 2021). costs. Elevated pollution levels in urban areas have been shown to affect which species can persist in urban environments (Andersson et al. 2015, Isaksson 2018, Grimm et al. 2008). In addition, pathogen transmission occurs at a higher rate in urban areas due to higher bird densities and an increase in human-bird interactions (Isaksson 2018). Urban environments also have different predator landscapes; there are lower frequencies of natural predators, but more introduced predators, such as cats (Caizergues et al. 2022, Isaksson 2018). The different predator pressures in urban and rural landscapes can lead to variation in anti-predator responses in birds living in the two types of habitats (Smith 2021).

In interior British Columbia, Canada, urban mountain chickadees (*Poecile gambeli*) display less aggressive anti-predator responses towards snake models than rural mountain chickadees. When snake models were presented on top of nest boxes, Smith et. al (2021) found that mountain chickadees nesting in urban areas had, on average, lower anti-predator responses than mountain chickadees nesting in rural areas. Rural mountain chickadees quickly approached the nest and vocalized closer to the model than did urban conspecifics (Smith et al 2021). However, while snakes are known to prey on mountain chickadee young, they are not a common nest predator in the area in which this study was conducted, and the authors noted that the reaction to the snake model may have been due to neophobia rather than an anti-predator response (Smith et al. 2021). Neophobia, the fear of novel objects, is a well-studied personality trait in birds that varies consistently among individuals across contexts (Clemmons and Lambrechts 1992, Copper et al. 1978, Seferta 2001). Smith et al.'s experiment thus suggests that there are behavioural differences

between urban and rural chickadees but does not address whether difference is due to personality (neophobia) or environment (differences in predator exposure); thus, the underlying cause of the difference is still uncertain.

Personality may affect where birds choose to settle (Sol 2013). A bird that displays bolder personality characteristics, such as a quick approach to novel object, may be more successful in urban areas, where such behaviour can be rewarded with new food, water, and shelter opportunities (Atwell et al.2012, Seferta 2001). Exploratory, bold behaviour is likely most beneficial in urbanized environments, and tends to decrease in frequency the further birds are from an urbanized environment (Liebl 2012).

Personality, including traits such as neophobia or boldness, has a heritable component (Fidler et al. 2007). In great tits , a relationship has been found between polymorphisms of the *Drd4* gene, which is the gene responsible for regulation of dopamine receptors, and exploratory behaviour (Atwell et al. 2012, Fidler et al. 2007). If bold behaviour is both advantageous in urbanized habitats and heritable, mountain chickadees nesting in such habitats would be expected to have bolder personalities than their rural counterparts (Bonderud et al. 2017).

The aim of this study was to examine whether rural mountain chickadees have a stronger anti-predator response than their urban counterparts when presented with a squirrel predator model, while concurrently testing for differences in neophobia between urban and rural birds by presenting them with a novel stimulus—a red plastic cup. As noted above, Smith et. al found that rural birds had a stronger anti-predator response when presented with a potential predator model, but noted that because the model was a snake, and snakes are not common nest predators in the area, reactions may have been neophobic in nature rather than a reaction to a predator. In contrast, red squirrels (*Sciurus vulgaris*) are also known to prey on mountain chickadee nests and are

common in both rural and urban areas, so we chose to use a model of a red squirrel to represent a predator that is familiar to birds in both habitats (Clemmons and Lambrechts 1992, Isaksson 2018). We predict that urban birds will display bolder behaviour and will come closer to the predator model and remain closer while engaging in anti-predator behaviour, while the rural birds will be more cautious and vocal (Mahon 2010, Norris 2022). We also predicted that rural mountain chickadees will have a more adverse reaction to the novel cup stimulus because of their lack of exposure to novel objects which are more common in urban areas (Atwell et al. 2012, Jarjour 2019).

MATERIALS AND METHODS

Study species:

Mountain chickadees (*Poecile gambeli*) are small, year-round residents of mountainous regions in western North America (McCallum et al. 2020). They are often able to acclimate to new, urban landscapes, which puts them in the category of urban adaptors (Kozlovsky et al 2017). Possibly because of food supplementation, urban mountain chickadees have an earlier dawn chorus and nest roughly a week earlier than their rural counterparts (Hajdasz et al 2019, Marini et al 2017). This latter finding has been linked to the urban heat island effect and greater abundance of ornamental and non-native trees, which experience bud burst sooner than naturally occurring trees in rural areas. Earlier bud burst in turn causes earlier peak abundance of insects, which are a key food source for mountain chickadees (Hajdasz et al 2019). By having an earlier breeding period, urban mountain chickadees ensure peak insect abundance overlaps with the period of peak food demand from their young. Interestingly, studies have shown that despite these differences in timing, the reproductive success of rural and urban mountain chickadee populations is the same, suggesting that the urban population has adapted to the urban habitat (Hajdasz et al 2019, Marini et al 2017).

Data collection:

We monitored 25 active mountain chickadee nest boxes at study sites in Kamloops, BC, Canada (50°40.23′ N, 120°23.86′ W) throughout April-July of the 2022 breeding season during the pre-nesting, incubation, and nestling stages. Of the nests observed, 21 nests were selected for behavioural trials based on the presence of eggs, and trials were successfully completed at 14 nests (each had one novel object trial and one predator model trial). Seven boxes did not have trials completed due to mortality, birds not leaving the nest, and/or birds not appearing during the time of the trial. Urban nest boxes were located at Thompson Rivers University (TRU) as well as in the Aberdeen and Pineview neighbourhoods of Kamloops, and rural ones in Kenna Cartwright Nature Park, located within 5 km of the TRU campus.

Nest boxes were first monitored to determine if mountain chickadees were present. At boxes where mountain chickadees were observed, we looked for leg bands (colour bands, CWS identification bands, and/or passive integrated transponder tags) to identify birds from previous years and establish the gender of the members of a pair. For chickadees without bands, we monitored behaviour during the trial to establish which was the female and which the male, such as tracking which bird appeared to be in incubating. Additionally, we monitored boxes for nesting material (i.e., fur) and mountain chickadee occupation. Nest boxes were then monitored to determine the development stage of each nest (excavation, nest materials present, the presence of an open or covered nest cup). Once a nest cup made of fur was present in the nest box, we continued to check the box to determine the date that the first egg was laid.

Methodology for predator and novel object presentation generally followed Smith et al. (2021). Trials were performed 9 to 12 days after the appearance of the first egg. Since incubation lasts approximately 18 days from first egg date, this approach meant that trials occurred

approximately halfway through the egg incubation period. The two models used for the trials were an imitation stuffed squirrel as a predator object and a red plastic cup as a novel stimulus. Predator models were chosen haphazardly for each trial from a selection of four similar stuffed, imitation squirrels. Which of the models (cup or squirrel) was used first at each nest was chosen by coin flip. Before conducting each trial, we tied two 10-metre ropes to the base of the nest tree, laid out at an angle of roughly 90 degrees (from an imaginary line extending from the nest entrance; each rope was at approximately 45 degrees from this line), as shown in Figure 1. Each rope was flagged every metre to provide a visual reference that was used to estimate mountain chickadee distance from the nest box.

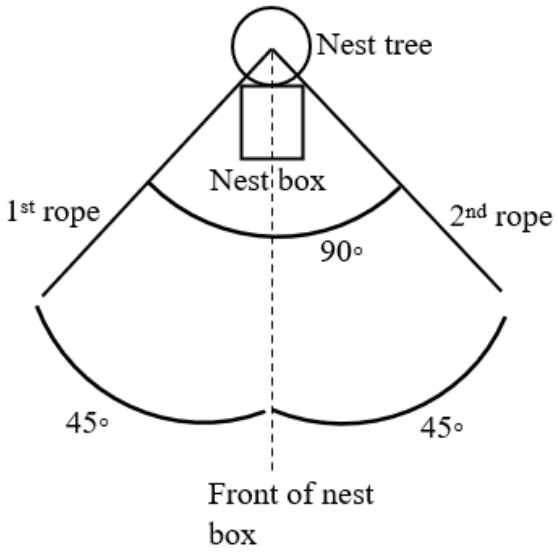

Figure 1. Measuring rope layout for mountain chickadee model presentation trials: two 10 m ropes tied to the nest tree (circle) and laid on the ground, each 45° from the nest box (square) on either side, 90° from each other. Dotted line stretches from the nest entrance.

The model was secured on the top of the nest with the use of pushpins (Figure 2). The main observer was positioned approximately 10 m from the tree with binoculars, a tie clip microphone, and an audio recorder which they used to record observations, songs, calls, and interactions with the model. A second observer was also positioned approximately 10 m from the nest tree also

equipped with binoculars. This observer classified birds as banded or unbanded and informed the first observer what bands they saw, if any, and assisted in initial location of the bird. A bird's gender was determined to be female if it was more attentive to the nest; any bands that were pre were later used to confirm gender. Observers were both hidden, most times in the same location unless cover did not allow sufficient camouflage.

Figure 2. Placement of squirrel model and novel cup stimulus on mountain chickadee nest boxes. Trials occurred one day apart, with the red cup as the novel stimulus and the squirrel as the predator model. Model placement order was alternated for each box.

Once the squirrel model or novel object had been placed, we waited for the female mountain chickadee to return to within 10 m of the nest before starting the 3-minute trial. Only female behaviours were recorded for each trial. During the 3 minutes, we described the chickadee's behaviour verbally, including noting the number of close flights directed at the object atop the nest, the number of direct contacts, the distance of the bird to the model at all times, if the bird entered the nest, and the number and type of vocalizations (chicka-dee-dee calls or songs). Following the trial, the predator model was removed from the top of the nest box, the ropes were

collected, and nests were monitored from a distance of at least 20 m to ensure that one or both members of the pair re-entered the nest. If this was not observed within 10 minutes of the trial, we returned the next day to ensure incubation had resumed. After a minimum of 48 hours and up to a maximum of 72 hoursthe trial was repeated using the other type of model.

Following hatch, all adults were captured and banded if they were not previously banded.At this time, tarsus length, tail length, and wing cord length were recorded, and the gender of previously banded birds observed during the trials was confirmed.

Data analysis:

After transcribing the audio recordings, we determined numbers and types of vocalizations, number of close flights directed at the object, and number of times direct contact was made with the model. Time spent at each distance from the nest was consolidated into distances greater than or less than 5 m from the nest, (Table 1). A list of all behaviours recorded can be found in Appendix Table A1. Data was analyzed in RStudio using the lme4 package (R Core Team 2022). We conducted a Principal Component Analysis (PCA) in JASP to collapse variation in all of these variables into a single "aggressive response" variable for which each bird had a score (JASP Version 0.17.3 2023).

Variables that had low factor loadings on the first principal component (PC) and/or for which there was a low sample size were not included in the PCA; these included direct contact and attack which were only seen during one trial each (Appendix Table A1).

In our PCA, PC1 accounted for 62.5% of the variation in behavioural data while PC2 accounted for 23.6% of the variation; only PC1 explained more variation than chance (Table 2). Individuals with a high PC1 score acted aggressively towards the model, staying within close

proximity to it, alarm calling, taking a longer time to enter the nest, and spending less time within the nest after entering, while birds with a low PC1 score approached and quickly entered the nest, often without any alarm calling or interaction with the model.

Table 1. Description of observed behaviours used in PCA analysis.

Behaviour	Description
Time spent greater than 5m from the nest	Time during which the bird was within 5 m of the nest box, including in contact with the model or nest box
Time spent less than 5m from the nest	Time in which the bird was further than 5 m from the nest box
Number of alarm calls	The number of times the bird made an alarm call vocalization
Time latency to enter nest	The time it took the bird to enter the nest
Time spent in nest	The time that the bird remained in the nest once it had entered

Table 2. Results of principal component analysis of behavioral response.

	Proportion of variance	Eigenvalue	Variable	Factor loading
PC1	65.58%	3.28	Time spent greater than 5m from the nest	0.23
			Time spent less than 5m from the nest	0.49
			Number of alarm calls	0.34
			Time latency to enter nest	0.54
			Time spent in nest during the trial	-0.54

Using PC1 as the response variable, we conducted a linear mixed model with urban/rural habitat, squirrel/cup model type, and their interactions as fixed effects and nest box ID and mate presence as random effects to account for their potential impacts on the behavioural response.

Next, we ran a series of linear models to examine the influence of age, trial order, tarsus length, tail length, or wing chord length on behavioural response. . We then used a stepwise elimination procedure to remove non-significant terms and arrive at a final best fit model. Significance was set at an alpha value of 0.05.

RESULTS

The results of our linear mixed model of PC1 scores (overall behavioural response) revealed a significant habitat by model interaction ($df = 1, 12$; $F = 5.58$; $p = 0.018$) and a significant effect of model ($df = 1, 12$; $F = 26.26$; $p < 0.00001$), but no effect of habitat on its own ($df = 1,12$; $F = 0.13$; $p. = 0.72$) (Figure 3), indicating that the magnitude of the difference in response depended on both the stimulus presented during the trial and the habitat type acting together. When we examined each habitat independently, we found that mountain chickadees did not differ in their response to a squirrel decoy versus a novel object in rural habitat, though there was a marginal trend towards a stronger response towards the squirrel decoy ($F = 2.88$; $p = 0.09$). However, mountain chickadees in urban environments responded more strongly to the squirrel decoy than to the novel object ($F = 73.45$; $p < 0.00001$).

When we examined differences in anti-predator responses between habitats, we found no difference between urban and rural birds in their responses to squirrel models ($F = 1.25$; $p = 0.26$) but found that rural birds responded marginally more strongly to novel objects than did urban birds ($F = 2.76$; $p = 0.097$).

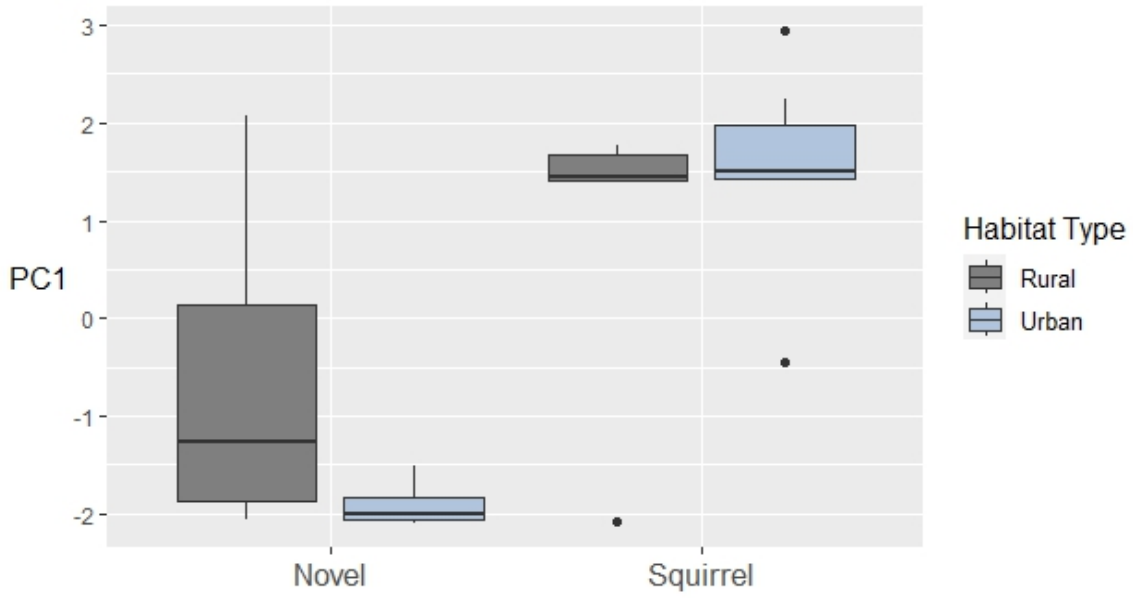

Figure 3. PC1 scores of rural and urban nesting mountain chickadees when presented with a novel stimulus (a cup) compared to a predator model (a stuffed squirrel) with rural nesting chickadees shown in grey and urban nesting chickadees shown in blue.

When we examined the effects of age, trial order, and body size on the behavioural responses to the stimuli, none of these factors were significant and none were retained in a final model.

DISCUSSION

In this study, we examined the behavioural responses of urban and rural nesting female mountain chickadees to models of a predator, (a model of a imitiation squirrel), and a novel stimulus (a red plastic cup). Both urban and rural nesting female chickadees responded strongly to squirrel decoys; however, the relative difference in their responses to the predator model vs the novel object varied markedly between habitats. Urban nesting mountain chickadees displayed a greater difference in their responses to the two objects presented, with rural birds showing relatively little difference in their responses to a predator or a novel object.

Our results echo previous findings on chickadees. In a study conducted in Ottawa, urban-nesting black-capped chickadees visited novel feeders significantly sooner than did rural chickadees; in other words, urban-nesting black-capped chickadees displayed lower levels of neophobia than their rural counterparts (Jarjour et. al 2019). In our study, urban-nesting birds had lower average PC1 scores, meaning they responded less aggressivelythan did rural-nesting birds when presented with the novel stimulus; the urban birds tended to quickly enter the nest and stay in the nest for the duration of the trial, with little to no apparent interest in the stimulus.That is, chickadees nesting in the urban habitat displayed less neophobic behaviour than did rural birds, which displayed aggressive behaviour when presented with the novel stimulus.

Bold behaviour can be described as exploratory and non-neophobic behaviour. Since these may enhance individual survival in urban areas, bolder birds may tend to settle in urban areas (Caizergues et al. 2022, Issakson 2018). However, for mountain chickadees, the evidence on this is mixed. In one study, rural mountain chickadees showed more aggressive, bolder behaviour when presented with a snake predator model than did urban conspecifics (Smith et. al 2021). A second study in which time to make contact with a novel versus a familiar feeder was measured, there was no difference between urban- and rural-nesting mountain chickadees (Kozlovsky 2015). The former study may suggest that rural birds have bolder personalities, while the latter suggests that personality does not vary between habitats. However, in our study urban-nesting chickadees displayed a greater difference in their response to the squirrel model versus the novel stimulus than did rural-nesting conspecifics.

An earlier study by Smith et al. (2021) on the same population of mountain chickadees examined the response of urban- and rural-nesting mountain chickadees to the presentation of a

snake predator decoy. In contrast to our study, Smith et al. (2021) found that rural-nesting mountain chickadees exhibited a stronger anti-predator response to the snake decoy than urban-nesting mountain chickadees (Smith et. al 2021). The difference in results could be a result of the type of predator model used. While snakes do prey on nests of chickadees in some areas, they are not a common nest predator in our study area--in either urban or rural habitats. In contrast, red squirrels are common nest predators for mountain chickadees and are abundant in both the urban and rural parts of our study area. If both urban and rural mountain chickadees perceived the snake model as a novel object rather than potential predator, a higher aggressive response would be consistent with greater neophobia in rural-nesting chickadees. In contrast, the squirrel model may have been perceived as a recognizable nest predator for the birds nesting both the urban and rural portions of the study area, accounting for the differences between studies. Alternatively, this difference in behaviour could result from acclimation to novel stimuli, which would likely occur to a greater extent in urban birds.

Jarjour et al. (2020) notes that reduced neophobia in urban-nesting birds could be a result of acclimation to novel stimuli, rather than an evolved adaption to urban life. More controlled studies that account for environmental context and delve deeper into the genetics of birds in different habitats could provide a clearer picture on the role that personality and acclimation play in neophobic responses.

CONCLUSION

Urban-nesting mountain chickadees were more likely than rural-nesting mountain chickadees to approach and engage a predator model placed on the nest, while rural-nesting mountain chickadees displayed more neophobic behaviour, reacting to a novel object more aggressively than did their urban counterparts. This may be due to bolder birds disproportionately

settling and reproducing in more urbanized environments. However, future studies are needed to disentangle the effects of genes, which have been shown to play a role in personality (Fidler et. al. 2007) and environment (acclimation) in driving the differences in behavioural responses to novel objects across a rural/urban gradient.

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APPENDIX A

Appendix Table A1. List of all behaviours recorded throughout trials, indicating which were used in the PCA analysis.

Observation	Description	Included in PCA
Box ID	The nest box number where the trial was taking place	Yes
Location	Whether the nest box was located in a rural or urban location	No
Trial Number	If the trial was the first or second trial	No
Model	Whether the model used was the novel stimuli or the predator model	No
Time	What time of day the trial took place	No
Date	The date of the trial	No
Time spent less than 1 m from the box and on the box	How long the bird spent within 1 m of the nest box or in contact with the nest box	No
Time spent 1 m from the box	How long the bird spent within 1 m of the nest box	No
Time spent 2 to 5 m from the box	How long the bird spent within 2 to 5 m of the nest box	No
Time spent less than 5 m from the box	How long the bird spent within 5 m of the nest box, excluding time spent in contact with the nest box	No
Time spent less than 5 m and on the box	A cumulative measure of how long the bird spent within 5 m of the nest box, including time spent in contact with the nest box	Yes
Time spent 5 to 10 m from the box	How long the bird spent within 5 to 10 m of the nest box	No
Time spent greater than 10 m from the box	How long the bird spent over 10 m from the nest box	No
Time spent greater than 5 m from the box	A cumulative measure of how long the bird spent greater than 5 m from the nest box	Yes
Alarm call	The number of times the bird alarm called through the trial	Yes

Mate present	If the mate was present or absent during the trial	No
Time latency to enter the nest	The time it took the birds to enter the nest	Yes
Investigating	Number of times the bird appeared to be investigating the model	No
Hover	Number of times the bird hovered around the nest box	No
Time spent in contact with the model	How long the bird was in contact with the model	No
Attack	Number of times the bird attacked the model	No
Quivering	Number of times the bird displayed quivering behaviour during the trial	No
Time spent in the nest	How long the bird was in the nest during the duration of the trial	Yes
Time spent on the box	How long the bird was in contact with the nest box during the trial	No
Song	Number of times song was heard during the trial	No
Age	Age of the bird, recorded post trial	No
Bird weight	Weight of the bird, recorded post trial	No
Wing chord	Wing chord length of the bird, recorded post trial	No
Tail length	Tail length of the bird, recorded post trial	No
Tarsus length	Tarsus length of the bird, recorded post trial	No