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Blocking access to nest boxes during the non-breeding season does not affect their use by Eastern Bluebirds (*Sialia sialis*) the following spring

Bloquear el acceso a las cajas-nido durante la temporada no-reproductiva no afecta su uso por *Sialis sialis* durante la siguiente primavera

Mark T. Stanback[1] and *Maxwell F. Rollfinke*[2]

ABSTRACT. High-quality cavities are important resources for cavity-nesting species. Even if non-migratory individuals are not territorial year-round, they might be expected to inspect potential nest sites well before the next breeding season. To test whether blocking access to nest boxes for resident Eastern Bluebirds (*Sialia sialis*) during the non-breeding season decreases the probability of nest box use the following spring, in each of two winters we manipulated ~40% of > 300 nest boxes in North Carolina, USA, so that the bluebirds could not inspect them until about 30 days before egg laying begins in the population. If preventing inspection of nest sites by bluebirds during the non-breeding season denies them critical information, we expected that nest boxes that remained available to bluebirds during the entire non-breeding season would have higher subsequent occupancy than those boxes that were unavailable . Moreover, we expected that nest boxes that remained available during the non-breeding season would have earlier first eggs if birds monopolizing these boxes were able to start breeding earlier. In each year and for both years combined, we found no significant difference in occupancy of nest boxes that remained open during autumn and winter (77.8% occupied) to those that were either plugged or temporarily given a smaller, bluebird-proof hole for that time (80.4% occupied). Similarly, we found no difference in first egg date (FED) between treatments in either year or for both years combined (available boxes: mean FED = 30.32; unavailable boxes: mean FED = 31.29). These results suggest that most Eastern Bluebirds make decisions regarding the placement of their nest in the month prior to egg-laying. Because birds were unmarked, we were unable to determine the role of experience. For instance, some birds may have used the same box from the previous year regardless of its accessibility during the winter.

RESUMEN. Las cavidades de alta calidad constituyen recursos importantes para las especies que nidifican en cavidades. Incluso si los individuos no migratorios no son territoriales durante todo el año, podría esperarse que inspeccionen los sitios potenciales de nidificación mucho antes del inicio de la siguiente temporada reproductiva. Para evaluar si bloquear el acceso a las cajas nido de *Sialia sialis* durante la temporada no reproductiva disminuye la probabilidad de que utilicen esas cajas durante la primavera siguiente, durante dos inviernos manipulamos aproximadamente el 40 % de más de 300 cajas nido en Carolina del Norte, EE. UU. De este modo, impedimos que los individuos pudieran inspeccionarlas hasta aproximadamente 30 días antes del comienzo de la puesta de huevos en la población. Si impedir la inspección de los sitios de nidificación durante la temporada no reproductiva privara a los individuos de información crítica, esperábamos que las cajas que permanecieran disponibles durante toda la temporada no reproductiva presentaran una mayor ocupación posterior que aquellas cajas que no estuvieran disponibles. Además, esperábamos que las cajas que permanecieran disponibles durante la temporada no reproductiva presentaran una fecha de puesta del primer huevo más temprana, si las aves que las monopolizaban podían comenzar a reproducirse antes. En cada año y considerando ambos años en conjunto, no encontramos diferencias significativas en la ocupación entre las cajas que permanecieron abiertas durante el otoño y el invierno (77,8 % ocupadas) y aquellas que fueron bloqueadas o que recibieron temporalmente una abertura más pequeña durante ese período, inaccesible para los individuos (80,4 % ocupadas). De manera similar, no encontramos diferencias en la fecha del primer huevo (FED) entre los tratamientos, ni en cada año ni considerando ambos años en conjunto (cajas disponibles: media de FED = 30,32; cajas no disponibles: media de FED = 31,29). Estos resultados sugieren que la mayoría de los individuos toman decisiones respecto de la ubicación de su nido durante el mes previo a la puesta de los huevos. Debido a que las aves no estaban marcadas individualmente, no pudimos determinar el papel de la experiencia. Por ejemplo, algunas aves podrían haber utilizado la misma caja que el año anterior independientemente de que hubieran tenido acceso a ella durante el invierno.

Key Words: *cavity nest; Eastern Bluebird; nest box; non-breeding season*

INTRODUCTION

Cavities provide species with nest sites that are safer from both predators and extreme weather than cup nests (Lack 1968, Martin 1993). However, cavity nests also present real challenges to birds. Appropriate cavities are often in short supply, meaning that individuals must compete with both heterospecifics and conspecifics for access to cavities (Newton 1994). Because of the intense competition that is typical for cavities in the northern hemisphere, cavity-nesting species must use different strategies to ensure access to appropriate nesting cavities during the breeding season. Year-round territoriality is one means by which non-migratory birds can maintain exclusive access to favored nest sites. However, year-round territoriality is not an option for many species. If resources necessary for non-breeding season survival are not distributed in such a way as to favor year-round territoriality, another option open to some species is guarding

[1]Davidson College, [2]College of William and Mary

nest cavities. Toucans, for example, have been observed to regularly visit potential nest sites during the non-breeding season, presumably in order to maintain "ownership" of such resources when breeding season arrives (Brightsmith 2005). A similar phenomenon has been observed in cockatoos (Reuleaux et al. 2022). Finally, even if inspection of cavities during the non-breeding season does not constitute guarding, it seems likely that inspecting potential nest cavities provides individuals with important information.

Although non-breeding season cavity inspection is obviously not an option for migrants, it seems possible that some resident cavity-nesters could benefit from such behavior. Eastern Bluebirds (*Sialia sialis*; hereafter EABLs) are cavity-nesters and readily use nest boxes (Gowaty and Plissner 2020). EABLs are known to visit potential nest sites throughout the non-breeding season (Gowaty and Plissner 2020), but it is unclear whether this behavior constitutes some form of cavity-guarding or whether such visits are simply to inspect cavities for potential food or predators or to scout out roost sites for winter. EABLs are also known to engage in cavity-guarding as well as mate-guarding throughout the breeding season as a defense against extra-pair copulations and brood parasitism (Gowaty et al. 1989).

We used an experimental approach to determine whether making nest boxes unavailable in the non-breeding season to local, non-migratory EABLs influences box use in the following breeding season. Specifically, we tested whether nest boxes that are altered to be unavailable to EABLs during the non-breeding season are less likely to be occupied or are used later the following spring than nest boxes that are continually available.

METHODS

We studied EABLs near the town of Davidson, Mecklenburg County, North Carolina (35°30′ N, 80°50′ W), where they are presumably year-round residents. We monitored over 700 nest boxes at sites within a maximum radius of 12 km from Davidson. These sites included a variety of habitats, both rural and suburban, although the experiment took place only at sites for which the majority of nest boxes attracted EABLs. Specifically, we conducted the experiment at nest boxes at six golf courses, two public parks, a corporate campus, hay fields on a farm, and the Davidson College campus.

At all of our sites, we used cylindrical woodcrete Schwegler 1B nest boxes (Schorndorf, Germany) pole-mounted at a height of 1.75 m and equipped with an Erva stovepipe-style predator guard. Each box had a floor area of approximately 105 cm² and was outfitted with a removable front plate containing a 38-mm diameter entrance hole. Nest boxes were approximately 200 m from one another. Because EABLs are multi-brooded and often reuse nest cavities for subsequent nests (Stanback and Dervan 2001, Stanback and Rockwell 2003, Gowaty and Plissner 2020), for this experiment we included only nests for which the first egg was laid within 50 days of the laying of the first egg of the year. All nest boxes were available for use by EABLs in the years before and after the experiment. We cleaned out all nest boxes after each nesting attempt. Although EABLs typically switch nest boxes or build a new nest after a nesting failure, it is possible that we missed some nesting attempts.

We used two different methods to make nest boxes unavailable during the non-breeding seasons prior to the 2021 and 2022 breeding seasons: plugs and small holes. In August 2020, we assigned 143 of 352 nest boxes (41% of experimental nest boxes) to be unavailable to EABLs during the non-breeding season (at each site, we typically made slightly less than every other nest box unavailable). Of the 143 boxes that we made unavailable to EABLs in late 2020, 27 were randomly fitted with either a cork or black rubber plug and 116 were given a front plate with a 26-mm entrance hole (too small for an EABL to fit through). The remaining 209 nest boxes retained their 38-mm entrance holes and were available to EABLs for the entire fall and winter. In early February 2021, approximately one month before the onset of egg-laying by EABLs, we made all previously unavailable nest boxes available to EABL. That is, we removed plugs from 38-mm holes and replaced front plates containing 26-mm holes with front plates containing 38-mm holes.

We checked all nest boxes weekly starting in early March of both years. In most cases we found nests during the laying period and were thus able to easily calculate the first egg date (hereafter FED): i.e., if a nest was found with 3 eggs on 10 April, we assigned that nest a FED of 8 April). If a nest contained a complete clutch when eggs were first encountered, we used nest construction data, hatchling ages, and/or final nestling measurements to calculate FEDs. We worked under the assumption that EABLs laid a single egg each day (Gowaty and Plissner 2020). Although the earliest FED differed by only a single day in the two years of the experiment (9 March 2021 and 8 March 2022), we adjusted the FED to reflect the number of days since the earliest FED of each year.

During August 2021, we made 40% (133) of 330 nest boxes unavailable to EABLs (72 with plugs, 61 with 26-mm holes). No nest box manipulated prior to the 2022 breeding season received the same treatment it had prior to the 2021 breeding season. We omitted from the analyses particularly problematic boxes. For example, at some boxes, passers-by removed plugs sometime during the fall or winter. Because we did not know the timing of such removals, we excluded these boxes from the analyses. Additionally, because EABLs are not dominant to many other cavity nesters (Hersey 1933; M.T.S., *unpublished data*), we excluded from the analysis those nest boxes occupied by Tree Swallows (*Tachycineta bicolor*), Tufted Titmice (*Baeolophus bicolor*), House Sparrows (*Passer domesticus*), or Southern Flying Squirrels (*Glaucomys volans*). Because EABLs are dominant to both Carolina Chickadees (*Poecile carolinensis*) and Brown-headed Nuthatches (*Sitta pusilla*) (Stanback et al. 2019), we assumed that nest boxes containing the nests of these species did not have EABLs that wished to use them. Consequently, we tallied such nest boxes as empty/available.

We measured the potential role of cavity inspection indirectly. Rather than observing the activity of birds during the non-breeding season, we simply recorded whether there was a difference in occupancy of nest boxes that were available versus not available during the non-breeding season. We analyzed the two years of the study separately as well as pooling the data. We hypothesized that EABLs would not inspect boxes they could not enter (see also Stanback et al. 2019). Consequently, we predicted

that if inspecting cavities is an important non-breeding season activity, we should see greater occupancy of "available" versus "unavailable" boxes during the subsequent spring. We made no a priori predictions regarding the occupancy of the different types of "unavailable" nest boxes (plugged versus small-hole boxes).

Nearly all nest boxes in the study were occupied by EABLs either in the spring or summer prior to both years of the study. Because we assigned nest boxes to treatments haphazardly prior to the 2021 breeding season (and systematically prior to the 2022 breeding season), it seems unlikely that we introduced any bias in treatments and the eventual use of the nest boxes.

Because of the high eventual occupancy of nest boxes, it is possible that we would not observe a difference in the occupancy of "non–breeding season accessible" and "non–breeding season inaccessible" nest boxes. However, if inspection during the non-breeding season leads to earlier nesting, we hypothesized that the relative FEDs of nests in "available" nest boxes would be significantly earlier than the relative FEDs of nests in nest boxes that had been "unavailable" during the non-breeding season. Typically, for both EABLs (Siefferman and Hill 2005) and other avian taxa (Morrison et al. 2019), older/more experienced/higher quality individuals tend to breed earlier than lower quality individuals (e.g., first year birds) who are presumably more likely to establish breeding territories immediately prior to nest-building. We made no a priori predictions regarding the FEDs of nests in plugged versus small-hole nest boxes.

We used two-tailed Fisher's exact tests to compare occupancy of nest boxes that had been available and unavailable during the fall and winter. We used 2-tailed Student's *t*-tests to compare the relative FEDs of nests in nest boxes that had been available and unavailable during the non-breeding season.

RESULTS

In the first year of the study, 25 of 140 nest boxes (17.9%) that were not available in the fall and winter were not used in the subsequent spring by EABLs, compared to 42 of 201 unused nest boxes (20.9%) that were available in the fall and winter. This difference was not statistically significant (Fisher's exact P = 0.580). Although there were some differences between the two years of the study, we found no differences in nest box occupation: in the second year, 28 of 130 unavailable nest boxes (21.5%) were not used in the spring while 45 of 190 nest boxes (23.7%) available in the fall and winter were not used by EABLs in the spring. Again, this difference was not significant (Fisher's exact P = 0.686).

For both years combined, ~80% of nest boxes were occupied by breeding EABL for both treatments. For unavailable nest boxes, 53 of 270 nest boxes (19.6%) were not used, compared with 87 of 391 nest boxes (22.2%) that were available (Fisher's exact P = 0.440).

Because most nest boxes were eventually used by EABLs in the springs following the manipulations, we compared the mean FEDs (relative to the first egg of the year) of nests in nest boxes that had been accessible all fall and winter versus those that had not been accessible. In the first year of the study, the mean relative FED of 116 nests in boxes that had been inaccessible during the fall and winter of 2020/2021 was 31.63 (SEM = 0.89). The mean relative FED of 159 nests in nest boxes that had been accessible during this period was 29.55 (SEM = 0.87). The FED difference between "available" and "unavailable" nest boxes was not statistically significant (t = 0.1.6304, df = 272, P = 0.104).

Similarly, we found no difference in the mean relative FED of EABL in the second year of the experiment ("unavailable" mean = 30.91, n = 102, SEM 0.99, versus "available" mean = 31.16, n =145, SEM = 0.73; t = 0.2062, df = 245, P = 0.837). Finally, the mean relative FED for "inaccessible" nest boxes in the two years of the experiment (combined) was 31.29 (SEM = 0.66); the mean relative FED for "accessible" nest boxes in the two years of the experiment was 30.32, SEM = 0.57, n = 304). This difference was not significant (t = 1.1095, df = 519, P = 0.268).

We then compared whether the type of inaccessibility influenced breeding decisions of EABLs in the two years of the study (combined). Of 103 nest boxes that had been plugged for the fall and winter, 82 (79.6%) had EABL nests the following spring; 21 did not. Of 165 nest boxes that received front plates with small entrance holes, 132 (80.0%) had EABL nests the following spring; 32 did not. This difference was not significant (Fisher's exact 2-tailed P = 0.876). We then compared the FED of EABL nests in nest boxes that had been plugged during the fall and winter versus those in nest boxes that had been unavailable to EABLs during the autumn and winter due to the small size of the entrance hole. The mean FED of the former was 31.29 (SEM = 1.13) days after the first egg of the year. The mean FED of the latter group was 31.30 (SEM = 0.81). This difference was not statistically significant (t = 0.0069, df= 215, P = 0.995).

DISCUSSION

The fact that we found no difference in occupancy and no difference in FED between nest boxes that were versus were not available during the non-breeding season suggests that non-breeding season nest site visitation by EABLs guarantees neither a nest site nor early breeding. Rather, it seems that the one month of accessibility we provided for all the nest boxes allowed enough time for birds to claim a breeding site and/or that visiting nest cavities during the non-breeding season provides other benefits (e.g., information about roosting). Although it is possible that EABL simply remembered where they had previously nested, these results suggest that non-breeding season inspection does not play an important role.

Additionally, we found no difference in EABL use of nest boxes that, during the fall and winter, were inaccessible because of plugged holes or too-small holes. This suggests that EABLs view both types of boxes similarly. Not surprisingly, smaller species such as the Carolina Chickadee (which breeds at the same time as EABLs) and the Brown-headed Nuthatch (which initiates egg-laying slightly earlier in the year than EABLs) can take advantage of a 26-mm entrance hole (Stanback et al. 2019). Although it is possible that the temporary presence of a smaller hole might attract these smaller species to target these boxes for later breeding, the fact remains that the larger EABL can generally usurp boxes with 38-mm entrance holes from smaller species (Stanback et al. 2019). Although it is possible that EABL simply remembered where they had previously nested, these results suggest that non-breeding season inspection does not play an important role.

Although the inspection of nest boxes during the non-breeding season could be due to other selective pressures (e.g., to assess the quality of cavities for potential roosting during inclement weather), our results suggest that installing nest boxes in early February provides EABLs in North Carolina with ample time to establish breeding territories prior to the onset of nest-building.

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Data Availability:

The data/code that support the findings of this study are available in Appendix 1. Ethical approval for this research study was granted by the Davidson Animal Care and Use Committee (protocol 02-21-122).

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Appendix 1. Data/code supporting the findings of this study.

Please click here to download file 'appendix1.xlsx'.