Choice of Bluebird Nest Box: A Potential for Ecological Traps?

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The Eastern bluebird has become accustomed to using nest boxes as a substitute for natural cavities. We compared two popular nesting-box models in order to determine whether nest-box design influences breeding success and offspring quality, and whether bluebird pairs exhibited any preference for different boxes. Thirty-seven pairs of Gilbertson and Peterson nest boxes were installed throughout the University of Florida campus and monitored weekly over two clutch periods in one breeding season. Temperature buttons were installed in the boxes. Offspring data were recorded on the first day of incubation, and then again 5 and 12 days after hatching. Bluebirds chose both box designs equally, but we detected a significant effect of box type on mean number of hatchlings and number of chicks fledged (first clutches and overall but not for second clutches). The Gilbertson nesting birds produced more young than the Peterson boxes, suggesting that less-than-ideal box design could compromise fitness of parents and offspring. Therefore, box designs should be tested more widely to clarify the best choices for bird conservation.

INTRODUCTION

The Eastern Bluebird

THE Eastern bluebird (*Sialia sialis*; EABL) is a small-to- medium sized passerine bird in the Thrush family (Turdidae). The EABL prefers breeding in cavities found on open land or forest-edge habitat. In the 1960's and 1970's, anthropogenic decline in available nest-sites, (attributable to disturbances such as deforestation and introduced species competition), caused a significant decline in EABL populations throughout the SE United States. In response, enthusiasts began installing nest boxes, and EABL became accustomed to using them as a substitute for natural cavities (Davis & Roca, 1995).

Nesting Boxes

Nesting boxes provide a unique opportunity to study avian responses to environmental variables while fostering public education about avian ecology and conservation. However, the effects on nesting success of different nest-box designs have not been assessed. Factors affected by nest-box selection and placement that could influence reproductive performance include box orientation, surrounding vegetation, and variations in standard nest box dimensions (Horn et al, 1996; see also Lockwood, Moulton, & Scott, 1993; see also Rohrbaugh and Yahner, 1997). Also, the climate within nest boxes can influence avian reproduction, and slight variations in microenvironment caused by box design could have significant impacts on growing birds (Navara and Anderson, 2011).

Purpose and Hypothesis

We tested the hypothesis that box type would influence nesting preference and reproductive performance in Eastern bluebirds. We selected two popular nest-box models for testing. Our data would apprise both bluebird enthusiasts and researchers of any consequences associated with EABL using either of these nest boxes. Our predictions included:

- EABL will exhibit preferences for one or the other nest-box model if presented with choices.
- Breeding success will vary with different box designs.
- Temperature is a likely mechanism underlying any differences between the boxes during egg/chick development, and should vary between box designs.

METHOD

Nest Box Design and Installation

37 pairs of Gilbertson and Peterson nest boxes were installed throughout the University of Florida campus, mainly in agricultural fields and student gardens. Within pairs, the two boxes, one Gilbertson and one Peterson, were installed 30 meters from each other, at the same height, facing the same direction, and over bare ground (not < 5 feet of vegetation exceeding 3 feet in height; Rohrbaugh and Yahner, 1997). Box pairs were placed more at least 100 meters apart to assure independence.

Procedure and Measurments

Box pairs were monitored for activity at least once a week between late February and late July, 2013. Upon initial egg sighting, temperature buttons were placed underneath nesting material, and were programmed to record the temperature every 5 minutes, for a total of three weeks. Temperatures were only collected during the first clutch. Upon clutch completion, the mass of each egg was recorded.

On the 5th day after hatching we recorded hatchling mass, and on the 12th day after hatching we recorded hatchling mass, wing chord, and tarsus length. All abandoned and predated clutches were noted. Parametric statistical analyses were conducted in Statistica (Statsoft Inc., 2010); p-values < 0.05 were taken as significant.

Figure 1. Gilbertson box model (left) and Peterson box model (right)

RESULTS

Nesting Box Selection

Both box types were selected equally, as shown in Table 1. Of the 37 box-pairs, bluebirds occupied both box types in 15 box-pairs. In 5 box-pairs, only the Gilbertson box was occupied, and in 5 other box-pairs, only the Peterson model was occupied. 7 box-pairs were unoccupied.

Eggs, Chicks, and Fledglings Produced

We found no significant difference between box types in mean number of eggs for Clutches 1 or 2. Mean number of hatchlings was significantly greater in the Gilbertson boxes for Clutch 1 ($F = 8.0$, $p = 0.01$), but not Clutch 2 ($F = 1.8$, $p = 0.27$). Mean number of fledglings was significantly greater in the Gilbertson boxes for Clutch 1 ($F = 7.2$, $p = 0.02$), but not Clutch 2 ($F = 1.8$, $p = 0.27$; Table 1).

Data collected over the entire breeding season, not separated by clutch number, showed that mean clutch size did not differ significantly between boxes ($F = 2.1$, $p = 0.24$). However, the mean number of hatchlings was significantly different ($F = 7.6$, $p = 0.01$), and mean number of fledglings was significantly different ($F = 6.9$, $p = 0.02$; Figure 1). The Gilbertson box produced significantly more hatchlings and fledglings than the Peterson box, and clutch sizes from box-type to box-type did not differ significantly enough to explain the difference in hatching results. Figure 2 shows the success of each of the two box types over the course of nesting, hatching, and fledging.

Table 1. Mean Number of Nests, Eggs, Hatchlings, and Fledglings Per Box Type and Clutch

	Box Type	Nests Total	Mean # Eggs	Mean # Hatchlings	Mean # Fledglings
Clutch 1	Gilbertson	13	4.62	4.10*	4.00*
Clutch 1	Peterson	11	4.60	2.89*	2.67*
Clutch 2	Gilbertson	5	4.17	3.67	3.67
Clutch 2	Peterson	6	4.00	2.50	2.00

*Significant differences ($p < 0.05$)

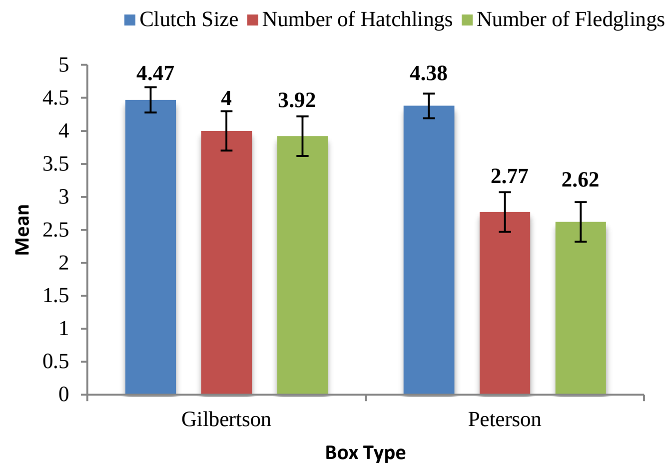

Figure 2. Mean (± 1 SE) Clutch Size, Number of Hatchlings, and Number of Fledglings Throughout Season, per Box Type

Patterns in Egg and Chick Mass

We found no significant difference between the box types in mean egg mass for either Clutch 1 or 2 (see Table 2). The mean 5th day chick mass was significantly greater in the Gilbertson boxes for Clutch 1 ($F = 6.911$, $p = 0.02$), but not Clutch 2 ($F = 1.06$, $p = 0.38$). The mean 12th day chick mass was not significantly different between boxes for either Clutch 1 or 2. We found no significant difference in egg mass or chick mass (day 5 and 12 post hatching).

Table 2. Mean Egg Mass, 5th Day Chick Mass, and 12th Day Chick Mass Per Box & Clutch

	Box Type	Mean Egg Mass	Mean 5th Day Chick Mass	Mean 12th Day Chick Mass
Clutch 1	Gilbertson	2.85	21.25*	28.13
Clutch 1	Peterson	2.76	15.45*	28.30
Clutch 2	Gilbertson	3.05	13.88	23.54
Clutch 2	Peterson	2.47	19.69	23.27

*Significant differences ($p<0.05$)

Tarsus and Wing Measurments

Mean tarsus length did not differ significantly between box types throughout the breeding season ($F = 0.6$, $p = 0.44$), although mean wing-chord length was significantly larger in Gilbertson boxes ($F = 10.4$, $p < 0.01$), as shown in Figure 2.

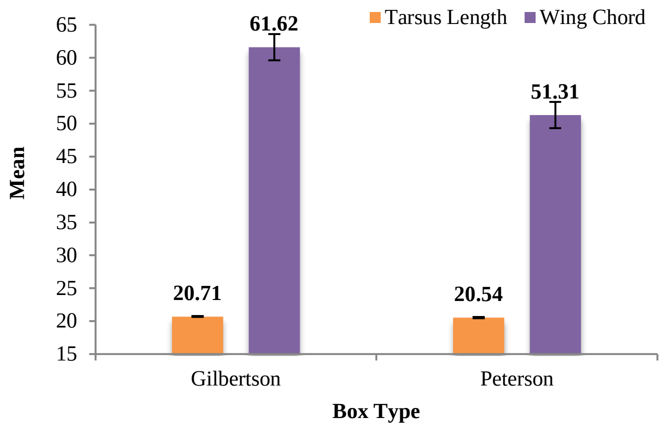

Figure 2. Mean (± 1 SE) Tarsus and Wing Chord Length by Box Type

Temperature Effects

Incubation and hatchling nest temperatures were not statistically different between the box types, but measurementss suggest that Peterson boxes were consistently warmer during Clutch 1. For this analysis, only Clutch 1 data was used (see Procedure and Measurements).

Table 3. Daytime and Nighttime Temperatures (C°) for Clutch 1

	Mean Daytime High	Mean Daytime Low	Mean Nighttime High	Mean Nighttime Low
Gilbertson	31 (4)	17 (8)	25 (5)	15 (8)
Peterson	32 (2)	23 (3)	30 (2)	22 (3)

DISCUSSION

Breeding Success

We found that nest-box design has a significant impact on the breeding success of EABL. Although birds nesting in both box types had similar clutch sizes, Gilbertson boxes produced significantly more hatchlings and fledgling chicks throughout the breeding season. Furthermore, mean 5^{th}-day chick mass was significantly greater in Gilbertson boxes for Clutch 1.

Gilbertson-nesting birds produced more young, especially in the first clutch. We expected to see a decline in nesting productivity in Clutch 2 because parental care is energetically expensive for birds and, as a general rule, effort invested in later clutches declines in species that undertake more than one nesting per season (Lack, 1947). In species where both parents invest in young, as is the case for EABL, conflict is higher between progeny in later broods (termed "inter-brood conflict") leading to poorer quality offspring. This has been linked to the fact that earlier broods receive more parental investment (Parker, 1985) than later, lesser-quality broods. This could explain the lack of difference between box type productivity in Clutch 2 (Fig. 4).

Temperature

Multiple F-tests considering several components of daily temperature (mean, high, low) over incubation and hatchling periods within Clutch 1 showed that there were no significant temperature differences between the two box models in Clutch 1. However, because of the high variance in temperature measures, larger sample sizes may be needed to detect statistical differences using F-tests. Indeed non-parametric ranks tests suggest consistently higher temperatures in the Peterson model, and means varied by more than 5 C°. Butler et al. 2009 detected a significant effect of only 0.6 C° on hatching success in American Kestrel (*Falco sparverius*) nest boxes. Therefore, differences in reproductive success may, at least in part, be attributed to temperature differences; more data are certainly needed to characterize the effects. We were careful to place the two box types in each pair either both in shade or both in sun. Additionally, both box models have shade overhangs and are well ventilated. Therefore, if there is indeed a real temperature effect, it likely derives from the box design.

Impact of Box Shape

Difference in reproductive success may be due to a relationship between box shape and chick development. Hatchlings raised in Gilbertson nest boxes had significantly larger average wing chords than those raised in Peterson boxes, reflecting more advanced wing development at a stage when mobility is critical to survival. Whereas tarsus growth is already highly developed after the first week, wing growth and feather development is concentrated to the second week of hatchling development (Pinkowski, 1974). For this reason, wing chord may serve as an indicator of nutritional limitation midway through development (when chicks are larger and can crowd each other in the nest). Greater crowding in the narrow-bottomed Peterson boxes could have hindered access to food by Peterson-raised chicks during deliveries by the parents, or it could have caused greater intra-brood conflict; both mechanisms would intensify food limitation as chicks got larger, but further study is needed.

Future Work

Given that the birds selected both box types at equal frequency when given an obvious choice, this raises the possibility that a poorly-designed nest box could act as an ecological trap. An ecological trap is a resource that is relatively unsuitable or dangerous to a species but that provides the same cues as one that is adequate or safe to use (Schlaepfer et al, 2002). In our study, findings suggest that bluebirds were attracted to nest boxes regardless of the design or the reproductive consequences. Given that native breeding birds have many limitations on their reproductive success imposed on them by human actions (habitat conversion, feral cats, invasive species, etc.), it is important to be sure that nest boxes provided for them are not one of those limitations.

If one peruses the Internet for bluebird nest boxes, many untested designs with untested features can be found alongside recommended designs promoted by the North American Bluebird Society (NABS). Among other designs, both the Gilbertson and Peterson are recommended by NABS (http://www.nabluebirdsociety.org/nestboxes/nestboxplans.htm). Our data provides evidence that 2 different boxes, while equally attractive to EABL, can have different success, further work is needed to test all approved box designs side-by-side to determine, for different regions, perhaps, the best choices; which nest-box design maximizes reproductive success. Such tested and approved boxes should then be promoted to users. This will be especially important where large numbers of one or two box types are used throughout extensive areas lacking in natural cavities; in such cases as these, the only available nest site may produce a population sink (Rogers 2011.

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