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Effect of Nest Box Temperature Mitigation Treatments on Nest Success and Nestling Condition in a Southeastern Population of Eastern Bluebirds (Sialia sialis)

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Introduction

- Surface temperatures are predicted to rise up to 1.6°C by the year 2040 due to anthropogenic climate change (Masson-Delmotte et al. 2021).
- Temperature plays a crucial role in the incubation, development, and survival of avian species (Hepp et al. 2015). Extreme temperatures can negatively affect embryo development and offspring growth, immune function, thermoregulation, and survival (Coe et al. 2015, Berntsen and Bech 2015).
- Secondary cavity nesting birds, unable to excavate cavities of their own, rely on previously excavated or natural cavities, though artificial nest can increase nesting opportunities in areas lacking suitable nesting sites.
- Artificial nest boxes experience more variable and extreme temperatures compared to natural cavities (Maziarz et al. 2017, Rowland et al. 2017) which may lower reproductive success and/or reduce survival due to the increased energetic demands at extreme high and low temperatures (Conway and Martin 2000).
- However, design components of artificial nest boxes, including color, insulation, and direction of the entrance opening can influence nest microclimate (Butler et al. 2009, Larson et al. 2019, Navara and Anderson 2011) and, thus, may be useful in mitigating the differences in microclimate conditions between natural cavities and nest boxes.
- Determining which aspects of nest box construction produce an optimal nest microclimate has become an important consideration to ensure reproductive success in our changing climate.

Objectives

1. Examine the effects of three nest box design attributes (paint, foil insulation, and entrance orientation) on nest box temperature.
2. Determine the influence of nest box design and nest box temperature on nest success, nesting growth rate, and nestling health.

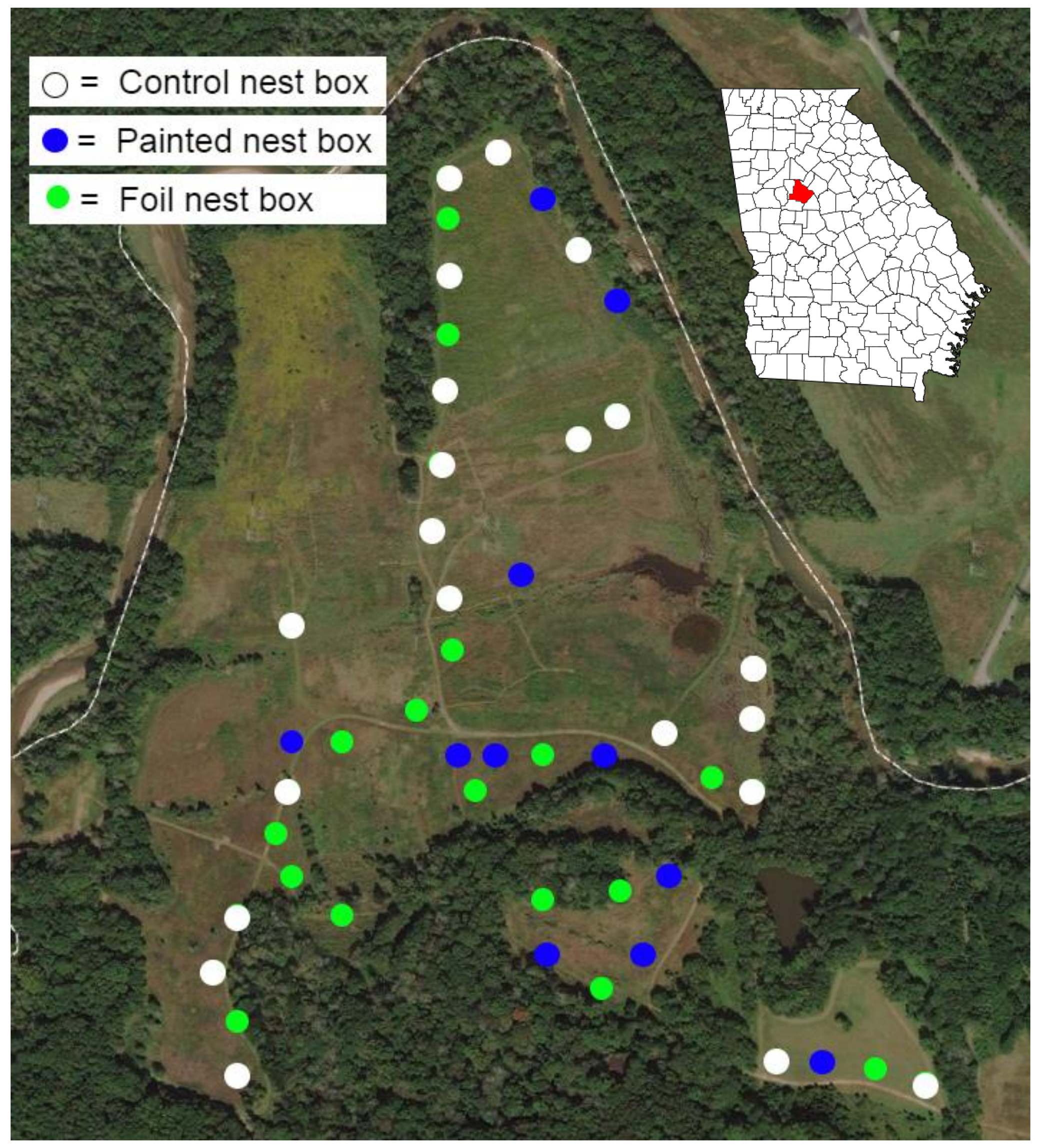

Figure 1. Location of Panola Mountain State Park in Georgia (inset) and nest box locations (dots) in the study location.

Study Site

- Panola Mountain State Park is located in the Piedmont province of north central Georgia, USA (Fig. 1).
- Nest boxes were placed throughout a 180-acre grassland restoration area bordered by the South River to the West, North, and East (Fig. 1).

Methods

- 50 nest boxes were monitored approximately every 3-4 days from April 1 – August 19, 2020 and 2021 to record nesting activity and determine transition dates (start date, incubation start, nestling start, fledge date).
- Nest boxes were either treated with white paint (n=11, Fig. 2a) or a foil heat shield, (n=16, Fig. 2b), or left as a control (n=23, Fig. 2c).
- Within each treatment, entrance orientation was stratified across the four directions (N=12, S=11, E=12, W=15), within about 20 degrees from cardinal.
- Nest box temperature was recorded every 60 min throughout the breeding season with iButton datalogger placed on the internal side wall (Fig. 2c).
- Nestlings were individually marked with plastic color bands at 3-4 days old (Fig. 7a) and growth rate was determined by measuring nestling mass (g) and tarsus length (mm).
- Nestling health was determined using blood hemoglobin content (Fig. 7c) from a blood sample taken from a toenail clip at 10-14 days old.

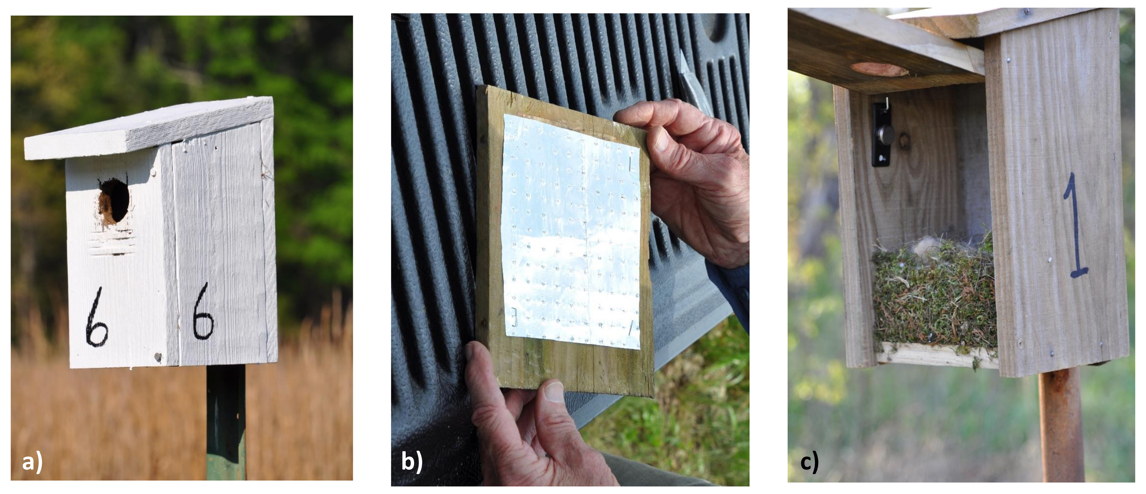

Figure 2. Heat mitigation treatments at PANO; a) white paint, b) foil on underside of nest box top, c) control. c) also shows the location of the iButton datalogger inside nest boxes.

Analysis

- We examined the effect that each nest box design attribute (heat treatment and entrance orientation) had on internal temperature (average daily max, average nightly min, and overall average) over the entire breeding season.
- We examined the effects of internal nest box temperature (average daily max, average nightly min, and overall average) and design attributes on nest success (yes, no), nestling growth rate (average daily increase in g and g/mm), and nestling health (hemoglobin measurements in g/mL averaged across all nestlings per nest).

Results

- 73 of 100 nest boxes were occupied at least once during the 2020 and 2021 breeding seasons, producing 137 successful fledges (Table 1).

Nest Box Design x Temperature

- Painted boxes exhibited cooler average (p<0.001) and daily high internal temperatures compared to foil and control boxes (p<0.001; Fig. 3).
- Painted boxes exhibited cooler nightly low temperatures compared to foil boxes (p=0.0015; Fig. 3).
- South facing boxes exhibit lower daily high temps. compared to W-facing boxes (p=0.0095) and exhibit lower average temps. than N-facing boxes (p=0.029) .

Table 1. Summary of 2020 and 2021 nesting data (occupancy, total number of eggs, total number of nestlings, and total fledges) for three nest box types

Treatment	Occupied (Total available)	# Eggs	# Nestlings (Hatch rate)	# Fledges (Fledge rate)
None	32 (46)	145	104 (72%)	71 (68%)
Paint	15 (22)	68	40 (59%)	21 (53%)
Foil	26 (32)	113	84 (74%)	45 (54%)
Total	73 (100)	326	228 (70%)	137 (60%)

Results cont.

Nest Box Temperature x Nest Success
- Boxes with warmer daily lows more likely to be successful (p<0.0001; Fig. 4).

Nest Box Temperature x Nestling Condition
- No effect of nest temperature (avg, high, low) during active nesting days on nestling growth rate or hemoglobin (p>0.05).

Nest Box Design x Nest Success
- Painted boxes were less successful compared to foil and control boxes (p=0.05; Fig. 5).
- Orientation had no effect on nest success (p=0.09).

Nest Box Design x Nestling Condition
- Paint and foil insulation had no effect of heat treatment on nestling growth rate or hemoglobin (p>0.05).
- Nestlings from E-facing boxes had higher growth rates compared to those from W-facing boxes (p<0.05; Fig. 6).

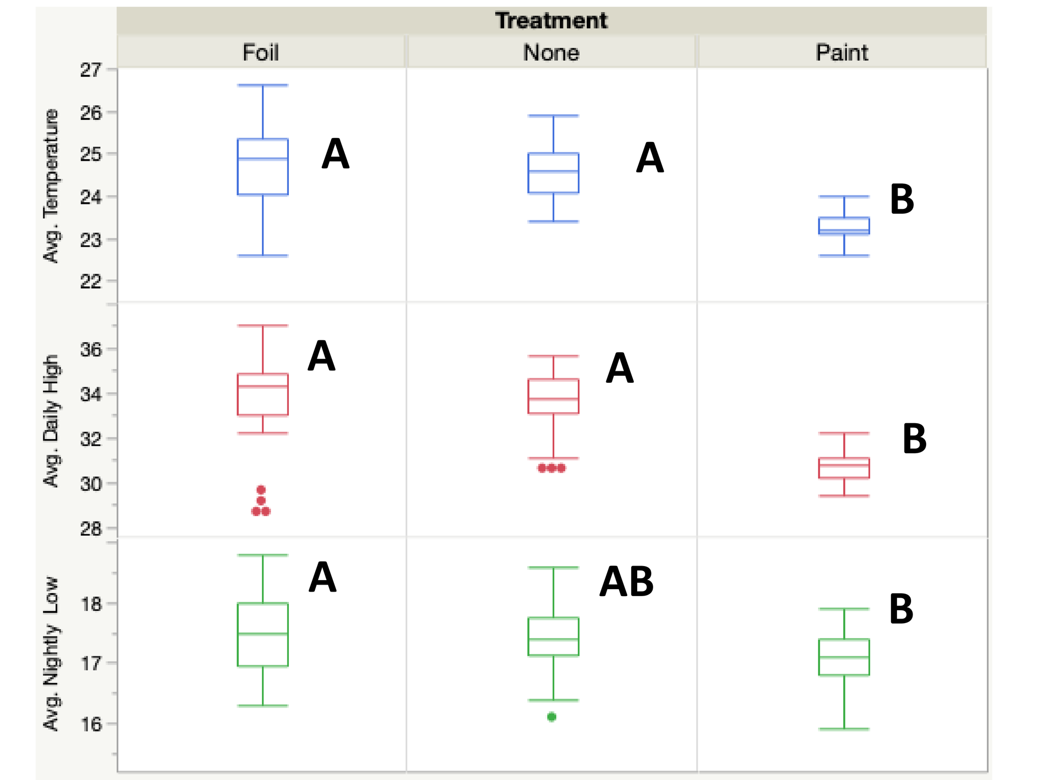

Figure 3. Average daily high temperature (red) ,average daily temperature (blue), and average daily low (green) from all nests between 05/24-06/28 during 2020 and 2021 for three nest box types. Letters are derived from Tukey's HSD test indicate which averages are significantly different.

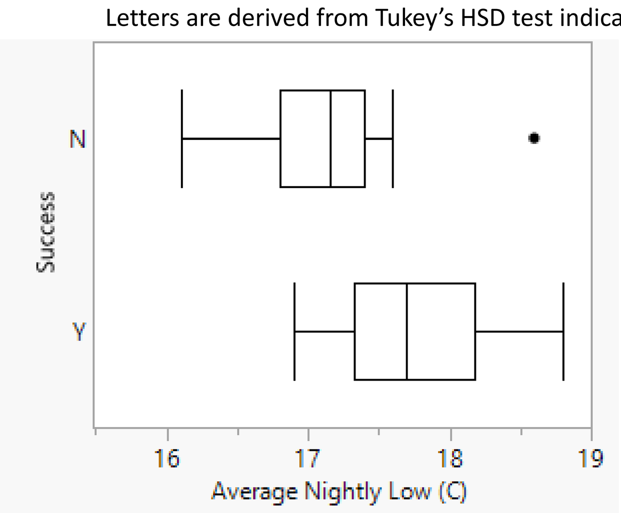

Figure 4. Nest success and nest box temperature during the 2020 and 2021 breeding seasons (p<0.0001)

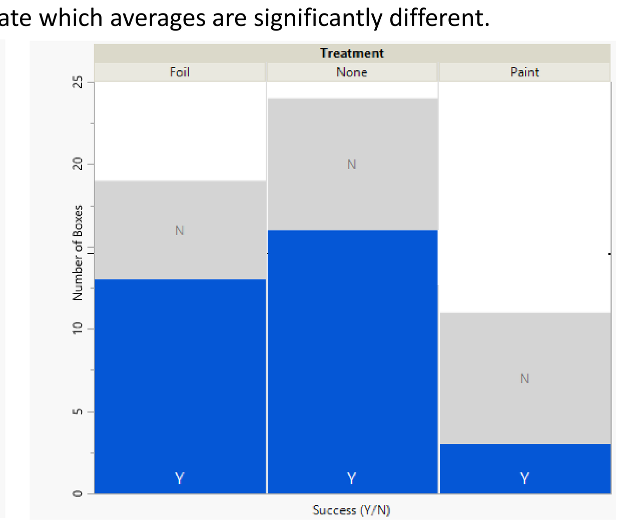

Figure 5. Nest success across three nest box types during the 2020 and 2021 breeding seasons (p=0.05)

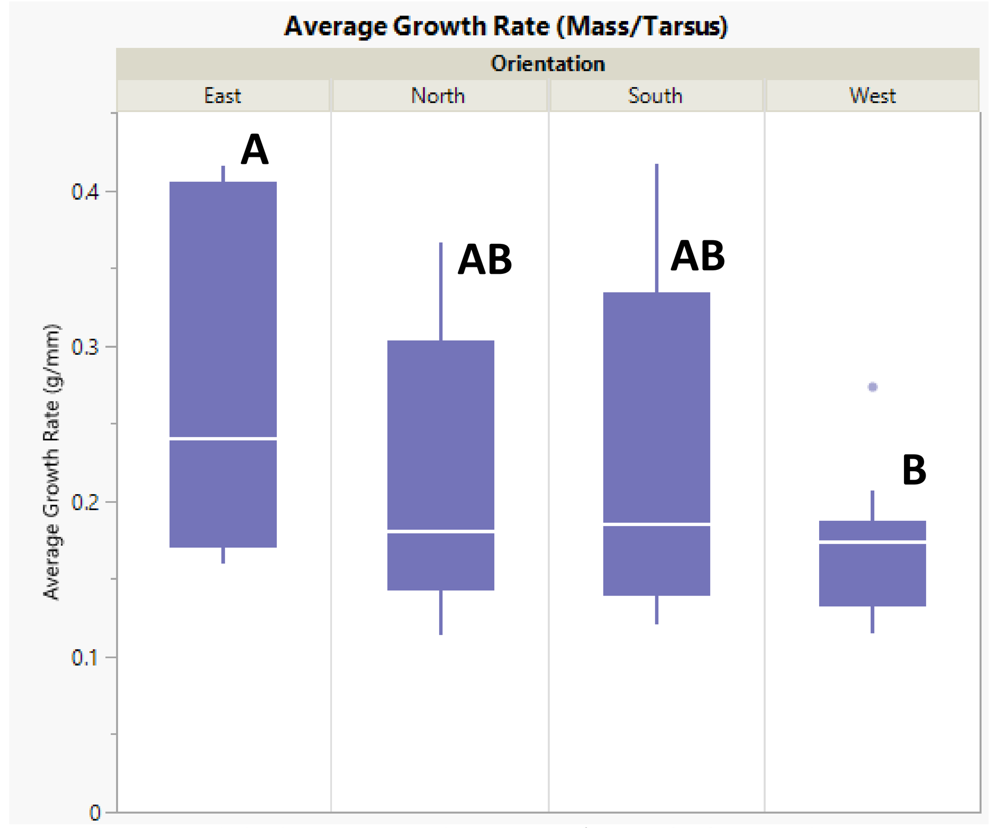

Figure 6. Average daily change in growth rate (mass/tarsus) for four nest box entrance orientations during the 2020 and 2021 breeding seasons. Letters are derived from Tukey's HSD test indicate which averages are significantly different

Discussion

- White paint applied to the exterior of nest boxes was effective in producing cooler thermal environments compared to control boxes. However, nest boxes that experienced cooler nightly low temperatures were less likely to be successful. Given that temperature was not shown to affect nestling condition, the lowered success may be due to changes in adult incubation behavior that increase predation risks (Martin et al. 2000).
- South-facing nest boxes provided cooler internal conditions compared to west-facing and north-facing boxes. This is likely due to the placement of boxes within the study site, as most of the south-facing boxes (8 of 11) are bordered by tall vegetation on their northern edge, which may be be cooling the internal nest box temperature, irrespective of the treatment.
- Nest box temperature did not affect nestling weight or hemoglobin levels. This may indicate that nest box temperatures were not hot enough to detrimentally affect nestlings. Temperatures over 37 C result in cell death and/or delayed development (Conway and Martin 2000) and our average highs were slightly below that (Fig.3). Conversely, this may suggest that Eastern Bluebirds in the southeast are physiologically adapted to handle high temperatures.
- Painted nest boxes were less successful compared to foil and control boxes. This may be associated with the cooler nightly temperature conditions within the painted boxes, however given the lack of significant difference in average daily low between control and paint boxes, and the unequal sample size between treatments (Table 1.) additional data is needed to confirm this relationship. Additionally, the treatment itself, independent of temperature, may increase visibility to nest predators, lowering nest success.
- Orientation of the nest box entrance did not affect nest success. However, since nestlings from east-facing nest boxes exhibited higher growth rates than nestlings from west facing boxes, it may still be beneficial to orient nest boxes facing east as it may result in healthier fledglings with a greater overwinter survival likelihood.

Figure 7. a) banded bluebird nestling, b) checking for bluebird eggs, c) testing hemoglobin levels from a nestling

Next Steps

- Given that no measures of temperature in foil boxes were significantly different than control boxes during 2020 or 2021, we are discontinuing the foil heat shielding for the 2022 breeding season.
- The number of painted nest boxes will be increased and nest monitoring will be repeated for another breeding season in 2022 to increase sample size, reduce the influence of any seasonal effects, and provide additional power for statistical data analyses.

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