Effects of Occupancy and Venting on Temperatures Inside Bluebird Nestboxes

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***SUMMARY** — The Eastern Bluebird breeds throughout the states east of the Rocky Mountains, and experiences a wide variety of temperatures and climate. Cold temperatures in Wisconsin are often responsible for egg hatching failure and mortality of nestlings inside nestboxes. Heat cycles in summer can drive temperatures to 100° F or more and threaten mortality of nestlings inside boxes. We recorded temperatures inside nestboxes in order to identify procedures to improve survival in cold and heat conditions. Non-vented boxes offer more protection to eggs and nestlings during spring cold cycles, while vented boxes provide more protection to nestlings during summer heat cycles. We recorded lethal cold conditions in an occupied box on May 8 to 10, 2010 with temperatures of 33 to 36° F accompanied by persistent rainfall and wind. Lethal heat (107° F) was not experienced, although the presence of five mature nestlings added a remarkable 14.2° F to the interior of the occupied box with ambient temperature of 79.1° F. Consequently, ambient temperatures over 93° F would likely cause heat mortality of advanced nestlings in standard non-vented boxes. In non-occupied boxes in August, we recorded 101° F while vented boxes averaged more than 10° F cooler. The convertible NABS-style box is ideal because the vents can be closed in spring and easily opened onsite during summer heat cycles.*

INTRODUCTION

The Eastern Bluebird breeds throughout the states east of the Rocky Mountains, and its range extends north to the Canadian provinces and south to the Gulf of Mexico (Zeleny 1976). Therefore bluebirds experience a wide variety of temperature and climate conditions. Nesting occurs earlier in the warmer southern regions and later in the northern states where cold temperatures often persist in April and sometimes in May. In Wisconsin, cold spring temperatures are often responsible for egg hatching failure and mortality of nestlings inside nestboxes. At that same latitude, heat cycles in summer can drive temperatures to 100° F or more, which can threaten heat mortality inside the nestboxes.

Proper incubation of bluebird eggs requires that they be maintained at temperatures of 95 to 106° F, the temperature range of female bluebirds. Temperatures below this range may slow or impair normal embryonic development, and temperatures of 107° F or higher are considered lethal to eggs and hatchlings (Zeleny 1968; Stokes and Stokes 1991). Therefore, the design and construction of bluebird boxes is important in order to maintain temperature conditions for incubation and survival of nestlings despite the adverse weather conditions throughout their extensive breeding range.

Marking, Craig, and Koperski (2006) reported some preliminary results on effects of shade, insulation, and reflective materials on temperatures in cedar nestboxes. Their results suggest that the standard non-vented NABS-style cedar box offers protection from early spring cold temperatures, while the vented box was cooler during cold cycles and significantly cooler during heat cycles. Shade, insulation, and reflective treatments did not significantly decrease temperatures during heat cycles, although slight differences were observable. Furthermore, brown paint increased box temperatures significantly over the standard box; dark colors should *never* be used on bluebird boxes. They also concluded that non-vented boxes are satisfactory in northern latitudes, but vented boxes are preferred in hotter climates.

Marking, Craig, and Koperski (2007) further investigated different-sized shade treatments combined with venting and non-venting of NABS-style bluebird houses. The shade treatments decreased the temperatures only slightly during the four hottest days of July and August; the average decrease was 4.2° F for the standard vented box and 4.8° F for the box with 24 square inches of shade. The vented boxes were consistently cooler than non-vented boxes by an average of about 2° F and by as much as 6° F cooler than ambient during heat cycles in July and August. During the April 16 cold cycle all boxes (vented and non-vented) remained 2 to 3° warmer than ambient temperature, and during June heat cycles all boxes remained approximately 3° F cooler than ambient temperature.

Box vents are essential in warmer climates to dissipate nestbox heat. The 2008 temperature study by Marking, Craig, and Koperski (2010) demonstrated that the internal temperatures of vented boxes in summer heat were consistently cooler than both ambient air and in non-vented boxes. By contrast, in the cold of spring, the vented box temperatures closely followed the ambient air temperatures while the non-vented boxes were sometimes cooler than ambient air and vented nestboxes during warming periods due to their insulating characteristics. In Wisconsin the non-vented boxes are desirable in the early spring when cold temperature can be accompanied by extended periods of wind and rain, but there are some situations where vents would be desirable, especially during summer heat cycles. The convertible boxes used in that study were ideal because ventilation for any house was available as desired.

To our knowledge there has not been any research reported on temperatures inside of boxes occupied by nesting bluebirds. We have experienced some heat mortality with ambient temperatures around 100° F in the past. That suggests that in the presence of older nestlings the inside temperatures could increase by as much as six or seven degrees, and a vented box in this situation may save the nestlings from heat mortality. The present study was designed to monitor, compare, and report temperatures in occupied boxes, non-vented non-occupied boxes, vented non-occupied boxes, and the ambient temperature.

MATERIALS AND METHODS

We constructed nestboxes from western red cedar lumber that was 7/8 inches thick and rough on one side. All nine boxes were constructed as standard non-vented boxes and one box at each location was vented on site (Figure 1). They were mounted on 7-foot steel T-type fence posts covered with 5-foot sections of 1½-inch PVC pipe for predator control. We mounted houses to the posts with a single U-bolt and placed about eight feet apart facing east in full sunlight (Figure 2). We covered oval entries on control boxes with1/4-inch-mesh hardware cloth to prevent bird entry. We set up three groups of houses at different locations. Each group consisted of one standard non-vented box to be occupied, one vented control box, one non-vented box, and one ambient air temperature tube.

Since bluebirds are territorial and generally are reluctant to nest close to other cavity nesters as well as their own kind, the box placement was planned to deceive them. Initially, the four mounting posts were installed at three different ideal nesting locations. On April 15, 2010 the box to be occupied was mounted to the center post and the ambient temperature tube was placed on a post to the east so it could serve as a perch for adults attending the nest. We placed the two non-occupied (control) boxes on posts on either side of the box to be occupied. However, if nesting or re-nesting did not occur, we removed the control boxes until the occupants had laid their eggs. That procedure enhanced their bonding to that box. We mounted temperature recorders to the rear left corner in each box to approximate the level occupied by the nestlings.

Figure 1. Convertible NABS-style boxes are vented on-site by lowering the side panels one-half inch.

Figure 2. Group 1 test site with ambient temperature mount as perch (left), occupied box in center, standard control on left, and vented control on right.

Temperatures were recorded hourly from April 15 to August 31, in all houses with HOBO Pendent Temperature Data Loggers (Onset Computer Corporation). The ambient temperature was recorded similarly in a 3-inch by 12-inch PVC open-ended pipe mounted vertically at the same height as prescribed by the National Weather Service. This ambient temperature setup immediately became a useful perch for the attending adults. We conducted this study in western Wisconsin near the city of La Crosse.

Software for data analysis already existed at the La Crosse office of the Wisconsin Department of Natural Resources and the Brice Prairie Conservation Association also obtained software, so we coordinated the processing of the temperature data. The hourly temperature data graphs display peak cold cycles, such as in April, and peak heat cycles, such as in July and August. We used the minimum and maximum temperatures recorded during these cycles to calculate and compare temperatures in occupied and non-occupied boxes and the ambient temperature.

RESULTS

The Group 1 site has had bluebirds nesting there in the past and they readily occupied the open box in mid April. The male bluebird was reluctant at first with the two control boxes on site and spent a few days checking them out. Once he understood those boxes could not be entered he joined the female in preparing a nest. They had five eggs on April 23, which hatched on May 9 and 10 (Table 1). On May

14 the hatchlings were all dead, and the concerned adults were active as the nest and nestlings were removed. They apparently died at 2 or 3 days of age following four days of cold, windy, and rainy weather. Although the temperatures didn't go below freezing, the minimum ambient temperature was 33.0° F on May 8, 34.8° on May 9, 36.3° on May 10, and 37.6° on May 11. Temperatures inside the occupied box were one to two degrees warmer in the presence of the female brooding the young until May 11 when the inside temperature decreased to less than ambient and the nestlings had obviously perished. These weather conditions were lethal to these and many other very young nestlings in our region.

By May 22 the adults had built a new nest and on May 29 there were five eggs in the nest attended by the adults. Four eggs hatched on June 9 but two of them disappeared that first week leaving only two nestlings. Their disappearance was likely due to an avian predator and could have been the parents for unknown reasons. The two remaining youngsters fledged successfully on June 26. There were no threats of heat mortality during that nesting period, and there was no more nesting activity at that site.

At the Group 2 site adult bluebirds adopted the open nestbox reluctantly, built a nest, laid the first egg on April 22, and then they abandoned the site. A few days later a nest appeared in an unplanned box about 300 yards from the chosen site. Assuming that was the same pair that abandoned the chosen test site, we installed the extra posts at the new site along with the tube that contained the ambient temperature logger. After four bluebird eggs were laid, the control boxes were also placed at the site. The occupied unplanned box was exchanged with the Group 2 box to be occupied containing the temperature logger. The nest and eggs were transferred also. Meanwhile the loggers remained in the control boxes. Those four eggs were incubated nearly two weeks when they were abandoned about May 15, and Tree Swallows built a nest over the four bluebird eggs. This may have been a nestbox competition situation.

At that time a different pair of bluebirds had adopted the Group 2 site for their nesting activities. We again installed all the posts at site 2 along with the ambient temperature tube, and when five bluebird eggs were present on May 30, the control boxes were placed on their posts. Those adults had bonded to the occupied box by then and didn't deviate from their normal nesting duties. Their five eggs hatched on June 6 and the nestlings fledged on June 22. On June 20 the maximum temperature reached 79.1° F in the ambient temperature tube, 93.3° F in the occupied box, 82.5° F in the standard control box, and 80.4° F in the vented control box (Table 1). The five nestlings were two days from fledging at this time. Even though 80° is not abnormal in Wisconsin summers, the presence

Table 1. Temperature (degrees F) inside bluebird boxes in three groups during nesting activity.

Date	Time	Occupants	Ambient	Occupied	Standard box	Vented box
		Group 1				
27 Apr	6:00 AM	5 eggs	37.2	38.0	37.9	38.4
08 May	6:00 AM	5 eggs	33.0	33.6	33.0	33.8
25 May	1:00 PM	Nest	94.1	88.0	88.5	86.5
22 Jun	1:00 PM	2 nestlings	95.8	88.7	84.5	81.8
12 Aug	1:00 PM	None	101.1	93.4	92.6	89.6
		Group 2				
28 Apr	6:00 AM	None	34.2	34.4	34.4	34.8
8 May	6:00 AM	None	32.6	33.0	32.8	33.4
24 May	5:00 PM	5 eggs	90.3	90.9	90.7	88.6
20 Jun	7:00 PM	5 nestlings	79.1	93.3	82.5	80.4
12 Aug	1:00 PM	None	100.6	97.6	96.7	91.2
		Group 3				
28 Apr	6:00 AM	5 eggs	34.2	37.9	33.6	33.6
08 May	6:00 AM	5 eggs	33.4	36.5	33.4	33.6
29 May	3:00 PM	5 nestlings	92.7	98.3	91.6	88.1
27 Jun	3:00 PM	4 nestlings	96.3	99.1	94.9	90.7
12 Aug	1:00 PM	None	101.5	95.6	94.4	90.7

of five mature nestlings added a remarkable 14.2° F to the interior of the occupied box. At the same time, the standard unoccupied box increased 3.4° while the vented control box increased by only 1.5° over the ambient temperature.

The Group 3 site was located about 300 yards downhill from the other two sites in an old mowed pasture with a wild apple tree immediate to the east for the adults to perch and hunt insects. Bluebird nesting activities started in mid April and continued in the presence of the control boxes; five eggs were present in the nest on April 30. All five eggs hatched in 14 days, and the nestlings fledged on June 2. As these nestlings matured the maximum temperature was recorded on June 29. The ambient temperature was 92.7°, the occupied box temperature was 98.3°, the standard non-occupied box was 91.6°, and the vented non-occupied box was 88.1° (Table 1). The nestlings were three days from fledging at this time. Again, the presence of mature nestlings added heat to the occupied box, and the control boxes were actually cooler than ambient, especially in the vented box.

Group 3 adults did not resume nesting activities for 10 days so we removed the control boxes from the site. Twenty days after the first fledge the adults resumed nesting activity, and on July 4 there were four eggs in the nest. The control boxes were returned to their mounting posts on July 9. The four eggs hatched about July 14 and the four nestlings fledged on August 1. The maximum ambient temperature during maturation was 96.3° on July 27 when the nestlings were five days from fledging. Simultaneously, the temperature in the occupied box was 99.1°, while the temperature in the standard non-occupied box was 94.9°, and in the vented non-occupied box was 90.7° (Table 1). So again, the presence of nestlings added heat to a standard nestbox while the non-occupied standard box was cooler than ambient, and the non-occupied vented box was nearly 6° cooler than ambient.

Although none of the test sites had occupants in mid August, the highest temperature of summer was recorded at about 101° on August 12 (Table 1). Correspondingly, temperatures in standard non-occupied boxes were 2 to 9.5° cooler than ambient. Even more significant, the vented boxes at all three sites averaged more than 10° cooler than the ambient temperature.

DISCUSSION

The 2010 bluebird-nesting season in western Wisconsin was not far from normal temperature with the most significant exception being the cold temperatures May 8 to May 11. These days were accompanied by rain and wind. Although actual freezing temperatures were not recorded, the 33 to 35° F combined with wind and rain apparently chills the chicks to the point at which they cannot metabolize the food provided resulting in hypothermia and death. During these prolonged rainy spells the adults entering the box with food parcels add moisture to nesting material causing discomfort in the box. Generally, the very young nestlings that are brooded can often survive these harsh weather conditions, but as with our Group 1 nestlings, many may perish under those conditions. Fortunately, those kinds of conditions are unusual and we can expect better early nesting seasons in years to come.

Our previous temperatures studies have demonstrated that standard non-vented bluebird boxes are preferable in Wisconsin in spring and early summer because of the adverse weather conditions that are expected as normal for this latitude. The cedar boxes in this study insulate the interior from both heat and cold so the 7/8-inch thick cedar material is ideal for construction of these NABS-style boxes.

Constructing the boxes to be converted to vented boxes on site as needed by simply lowering each side panel would be particularly helpful as temperatures approach 95° or greater when there are nestlings in the box nearing the fledging stage. If they added 14° to that interior, as demonstrated in our Group 2 experiment, the inside temperature would exceed the 107° F lethal temperature. The Brice Prairie Conservation Association constructs all their boxes for members' use and for sale to be converted as needed to vented boxes. The material cost is the same, however this procedure requires six screws to fasten the sides and a few more minutes to drill the pilot holes needed in the conversion process.

The August 12 temperature of 101° F would certainly have been lethal to advanced nestlings in standard non-vented boxes and perhaps the vented boxes could not have saved them at temperatures over 100°. However, our data demonstrate that vented boxes at all three test sites decreased ambient temperature by an average of more than 10°. These 1/2-inch vents on both side panels under the roof exhaust the heat similar to the action provided by chimneys. The space above the entry hole serves as an attic to collect the rising heat, and air currents enhance the exhausting character of the vents.

CONCLUSIONS

- Temperatures above freezing, such as 33° to 35° F, can become lethal to very young nestlings when combined with extended periods of rain and wind.
- Some bluebirds are reluctant to nest in a box accompanied by two control boxes, but they will adapt to a box in the absence of control boxes and bond to their open box after their eggs are laid and continue their nesting activities despite the return of the control

boxes.

- With ambient temperature of 79.1° F the presence of five nestlings that were two days from fledging contributed over 14° F to the standard non-vented box. Younger nestlings also increased the temperature inside boxes, but to a lesser degree.
- Ambient temperatures of 95° and higher would most likely become lethal in non-vented boxes if the nestlings were two or three days from fledging.
- Vented boxes at all three test sites were cooler than the ambient temperature of 101° F by an average of more than 10° F. Optional venting would be advisable whenever ambient temperatures exceed 95° F and mature nestlings are present.
- The convertible NABS-style boxes were ideal for demonstrating their usefulness and efficiency in decreasing temperatures inside boxes, and to create venting onsite as desired.

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Left to right: Fred Craig, Cindy Koperski, Leif Marking

A Note on Winter Feeding

Evelyn Cooper

I don't feed mealworms, primarily because mealworms do not supply bluebirds with all the necessary nutrients and need added vitamins and minerals. Instead, I provide the banquet mix I concocted. It is easy to make and involves no hassle ordering and storing mealworms and buying vitamins, etc.

I use equal amounts (any amount such as 2 cups of each) crunchy peanut butter and lard (*not* shortening). I add alternately yellow corn meal and dry quick-cooking oats and keep adding and stirring until the mixture is not glistening. It is a crumbly mixture and that is how they love it. My bluebirds also eat stewed, chopped raisins (I do not put raisins in the mix because several species do not eat them). I have Pine Warblers, Chipping Sparrows, White-throated Sparrows, Carolina Wrens, and Tufted Titmice to dine at the table along with Cardinals, Red-bellied Woodpeckers, and Blue Jays.

This originally appeared in the Bayou Bluebird Nest News, the newsletter of the Louisiana Bayou Bluebird Society. It is reprinted here with permission.