The Effects of Shade and Ventilation Combinations to Alleviate Temperature Problems in Bluebird Houses

By Leif Marking & Fred Craig, Brice Prairie Conservation Association and Cindy Koperski, Wisconsin Department of Natural Resources

Photos by Leif Marking

Introduction–The Eastern Bluebird *(Sialia sialis)* is a cavity nesting songbird that now relies primarily on artificial nest cavities for successful reproduction. Manmade nest boxes are superior to natural cavities because they tend to be drier and better ventilated, and predation is nearly eliminated. This human effort has successfully increased bluebird populations in recent years.

The Eastern Bluebird breeds throughout the states and provinces (except Newfoundland) east of the Rocky Mountains and from southern Canada to the southern coast of the United States (Zeleny 1976). Therefore, bluebirds experience a wide variety of temperature and climate. Nesting activities naturally occur earlier in the warmer southern regions and later in northern states where cold temperatures persist in April and sometimes in May. In mid Wisconsin, cold spring temperatures are often responsible for egg hatching failure and mortality of nestling bluebirds inside nest boxes. Then, at that same latitude, heat cycles in mid summer can drive temperatures to 100° F or more, which can threaten heat mortality inside of the boxes.

Proper incubation of bluebird eggs requires temperatures that range from 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 above are considered lethal (Zeleny 1968; Stokes and Stokes 1991). The female bluebird develops a brood patch on her breast that is void of feathers and down, and this more efficiently transfers her body heat to the eggs for proper incubation and to the newly hatched nestlings to keep them warm. Incubation begins after the last egg is laid and generally requires 13 to 15 days for hatching. Newly hatched bluebirds have little down to keep them warm, so the female broods them in cold weather for the first week or so to maintain body temperatures sufficiently to sustain normal metabolism and growth. The young nestlings grow fast and develop into fledglings in an average of 18 days. Therefore, the design and construction of bluebird nest boxes is important to maintain optimum conditions for incubation of eggs and survival of young bluebirds despite the adverse weather conditions throughout their extensive range.

Zeleny (1968) monitored temperatures in 32 bluebird nest boxes with various treatments to alleviate high temperatures in June and July. His boxes were North American Bluebird Society(NABS)-style with four inch by four inch bottoms that were six inches below a one and one-half inch round entry. The temperature rise in dark color painted boxes was significantly greater than that in white or light color painted boxes. Wood construction material was superior to plastic or metal, and thicker wood (3/4 inch) was more efficient than thin wood (3/8 inch) for insulating against high temperatures. Ventilation was effective for decreasing the temperature by two to three degrees F. Double roofs that offered some shade were ineffective for preventing high interior temperatures. The most efficient structure was a simulated natural cavity of oak with two inch thick walls. He concluded that many bluebird nest failures, especially second and third broods, are probably due to excessive heat resulting from the use of improperly made or improperly located nest boxes.

More recently Beale (2004) monitored temperatures inside unoccupied cedar NABS-style bluebird nest boxes that were natural, painted white, or painted black. She concluded there were no significant differences in temperatures due to these colors, although her data were limited to 11 days of recording, and the maximum ambient temperature at Warsaw, Virginia was 92° F. Bluebirds thrive at that ideal latitude the year around. Despite the lack of statistical significance, the temperatures in the unoccupied black boxes were consistently higher and on one occasion just under the critical temperature of 107° F.

Marking, Craig, and Koperski (2006) reported some preliminary results on effects of shade, insulation, and reflective materials on temperatures in cedar boxes. 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 colored paint increased temperatures significantly over the standard box; dark colors should never be used on

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bluebird boxes. They concluded that non-vented boxes are satisfactory in northern latitudes where black flies are prevalent, but vented boxes are preferred in hotter climates.

Little attention has been given to altering extreme temperatures in bluebird nest boxes. Thus our present experiment was designed to evaluate box modifications to maximize egg and fledgling survival. We investigated the use of non-vented cedar boxes to prevent cold mortality in spring and the effects of different sizes of shade treatments in combination with ventilation to prevent heat mortality in summer. Treatments involved simple procedures and materials readily available to most home owners.

Materials and Methods-- Nest boxes were constructed of western cedar lumber that was 7/8" thick and rough on one side. The NABS-style house without air vents was used as a standard for comparison, since the Brice Prairie Conservation Association (BPCA) used that design for bluebird production. Two standard houses and seven other similar style houses with modifications were mounted on 7 foot steel T-type fence posts covered with 5 foot sections of 1 ½ inch PVC pipe for predator control as standard procedure. Houses were mounted to the posts facing east with a single U-bolt and placed 5 feet apart in full sunlight in a bluebird habitat (Figure 1). Oval entries were covered with ¼ inch mesh hardware cloth to prevent bird entry. The location was on a ridge at elevation near 1,300 feet above sea level in Hamilton Township of La Crosse County HWY S, Wisconsin.

Shade was provided in pairs by attaching ½ inch thick exterior plywood pieces that were 12, 18, and 24 inches square or 18 inches round centered over the roofs and mounted on one inch spacers to provide air flow between the roof and the shade material (Figure 2). Vents were provided in one of each paired shade treatment on July 1 to simulate when the black flies are no longer common in this area and when excessive heat may occur. These experimental boxes were constructed to create the ½ inch vents in place by simply removing the fastening screws from the front and back, lowering the two sides under the roofs, and replacing the screws to secure the box. Construction of these convertible boxes requires a little more time than using a powered nail gun, but it allows the choice of venting in place when desirable.

Figure 2. Standard bluebird box with 12 inch square shade material mounted with 1 inch wood spacers.

Temperatures were recorded hourly from April 15, 2007 to August 31, 2007 in all the houses with HOBO Pendant Temperature Data Loggers (Onset Computer Corporation). The ambient temperature was recorded similarly in a 2 inch by 12 inch PVC open ended pipe mounted at the same height as prescribed by the National Weather Service. HOBOware for Windows or Mac software and an Optic USB Base Station with coupler are required to operate the HOBO Pendant Loggers. Software for data analysis already existed at the La Crosse, WI, Department of Natural Resources office, so it was used to process the temperature data. The recorders were placed in abandoned bluebird nests in each house to simulate the approximate location of eggs or nestlings (Figure 3).

Figure 3. HOBO Pendant hourly temperature logger in nest.

Figure 1. Standard bluebird boxes with various shade treatments and ambient recording tube.

The hourly temperature data graphs showed peak cold cycles in April and May and peak heat cycles in June, July, and August. We compared temperatures of all treatment boxes during the peak cold and peak heat cycles to the standard ambient temperature. None of the boxes were vented until July 1 when one of each paired treatment was vented.

Results--Box number 1 served as a control or standard for comparison; its design is the box of choice for BPCA club members because the no vent system deters black flies from entering and killing nestlings. This is an important consideration in or near black fly habitat of freshwater rivers, creeks, or springs. The hourly temperature recordings resulted in more than 3,400 data points for each house;

the ambient temperature graph is illustrated in Figure 4. These data suggest there were several cold cycles in April and May, and several peak heat cycles in June, July, and August. We used these extreme cycles to evaluate difference of treatments to experimental boxes.

The lowest temperature recorded occurred on April 16 and was 34.4º F. All of the non-vented boxes produced a warming trend inside the boxes with temperatures ranging from 2.1 to 3.3º F warmer than ambient (Table 1). As the ambient temperature moderated to 38.4º F on May 17 the temperature differences were less noticeable perhaps because the box material warmed more during daylight hours. During the heat cycles in June these non-vented boxes provided some protection from the heat by decreasing the temperature by as much as 3.7º F in one case. The larger shade treatments seem to offer more protection from the cold as illustrated in Figure 5. Also, the 18 inch round shade offers as much protection as the 18 inch square treatment, and the round treatment offers less wind resistance and more visual appeal.

The highest temperature recorded occurred on July 8 and was 95.6º F. The vented boxes proved to decrease the temperatures more so than the non-vented boxes (Table 2). The differences in temperature decreases varied by as much as three degrees in some instances throughout the July and August heat cycles, but the averages suggest the vented boxes were at least two degrees cooler than non vented boxes. Notably, the vented boxes were as much as six degrees cooler than ambient temperatures. Also, the standard vented box

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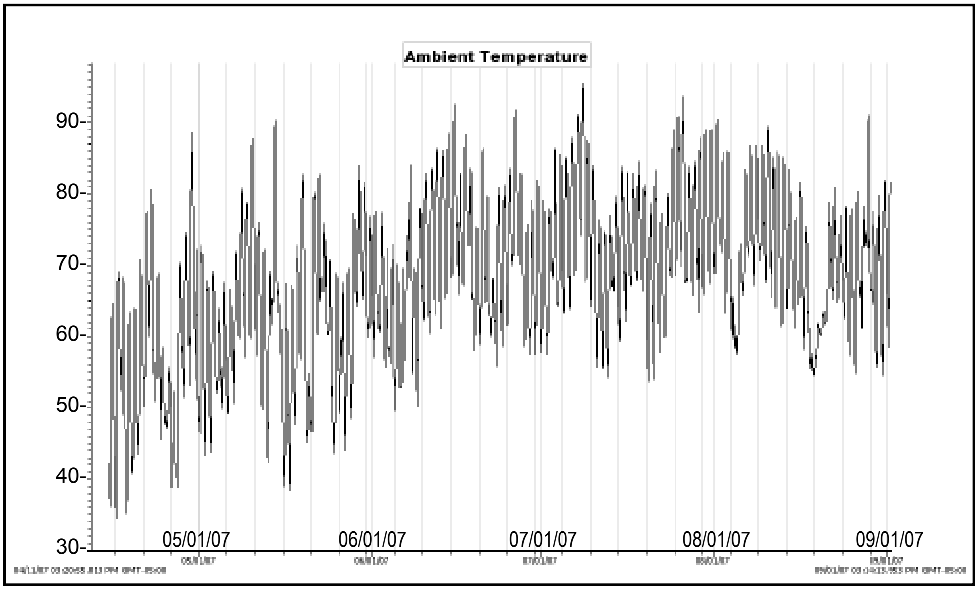

Figure 4. Hourly ambient air temperature data for April 15 – August 31, 2007.

Table 1. Actual temperature difference* in NABS-style bluebird boxes with no venting for coolest and warmest days before July 1, 2007.

* Positive if warmer than ambient		*Negative if cooler than ambient		
	April16	May 17	June 15	June 28
Ambient (deg F)	34.4	38.4	92.6	91.8
Shade box treatment				
(1) Standard	2.1	1.0	0.8	-0.7
(2) Standard	2.1	1.0	-0.4	-1.3
(3) 12” square	2.5	1.0	-1.5	-1.9
(4) 12” square	2.5	-0.6	-0.2	-0.9
(5) 18” square	2.7	0.2	-2.1	-2.4
(6) 18” square	2.7	0.4	-3.7	-3.3
(7) 24” square	3.3	0.6	-2.2	-2.2
(8) 24” square	2.9	0.4	-2.6	-3.3
(9) 18” round	2.7	-0.4	-2.1	-2.0

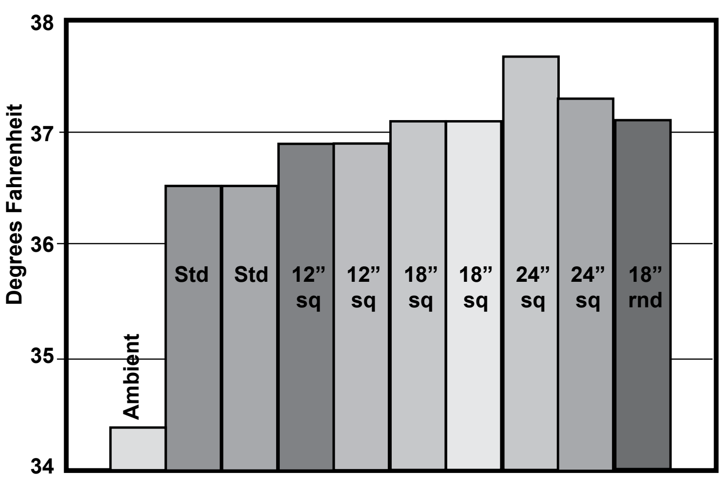

Figure 5. Actual low temperature for April 16, 2007 of all bluebird box treatments (unvented) and ambient air.

Table 2. Actual temperature difference* in NABS-style bluebird boxes with and without venting for warmest days after July 1, 2007.

* Positive if warmer than ambient			*Negative if cooler than ambient		
	July 8	July 26	Aug 1	Aug 28	Average
Ambient (deg F)	95.6	93.7	90.5	91.1	
Shade box treatment					
(1) Standard Unvented	0.2	-1.1	-0.7	-0.7	-0.6
(2) Standard Vented	-3.0	-5.9	-4.6	-3.3	-4.2
(3) 12” square Unvented	-1.1	-2.3	-1.7	-2.8	-2.0
(4) 12” square Vented	-2.7	-5.9	-5.1	-3.5	-4.3
(5) 18” square Unvented	-1.9	-3.4	-2.2	-3.3	-2.7
(6) 18” square Vented	-3.6	-6.1	-6.0	-3.7	-4.9
(7) 24” square Unvented	-1.3	-2.4	-1.8	-3.1	-2.2
(8) 24” square Vented	-3.4	-6.3	-5.5	-3.9	-4.8
(9) 18” round Unvented	-1.3	-2.8	-1.8	-2.8	-2.2

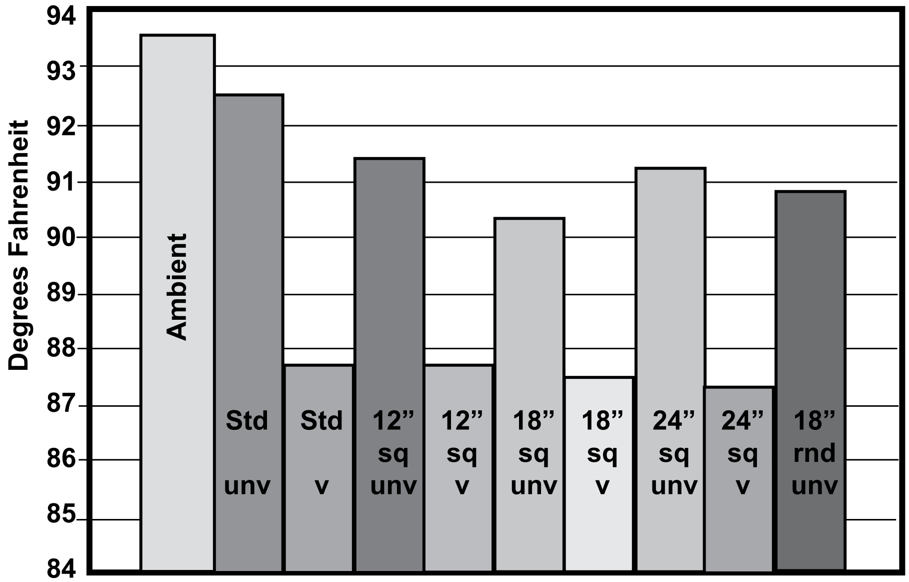

Figure 6. Actual high temperature for July 26, 2007 (v-vented, unv-unvented) for all box treatments and ambient air.

was nearly as cool as those vented boxes with shade treatments (Figure 6), so those shade treatments offered little protection from the heat.

Discussion and Conclusions-- Our data loggers were standardized prior to the start of the experiment, and all performed within the expected range of accuracy. They functioned throughout four and one half months on their original batteries. They are sensitive to one hundredth of one degree and recognized minute changes in temperature. These data loggers are ideal for this kind of temperature study.

So what nest box design is appropriate for maximum bluebird survival and production? The answer is going to vary depending on geographic location and ambient seasonal temperatures. The literature provides some examples of procedures to avoid heat mortality when potential high ambient temperatures are known or suspected. Zeleny (1968) reported that temperatures in dark- colored boxes may be as much as 12° F higher than in light-colored boxes of the same design and construction. Reviews in *Sialis* (http://www.sialis.org/heat.htm) suggest dark painted boxes can be 18 °F warmer than an identical light colored box. Therefore, do not paint bluebird boxes a dark color. The unpainted cedar boxes used in this study provide long life with good insulation against cold and heat.

Box vents are essential in warmer climates, but they can allow colder temperatures to impair embryonic development or growth and survival of young birds in the colder climates. In Wisconsin the non-vented boxes are desirable in the early spring, but there are some situations where vents would be desirable during the summer heat cycles. The convertible boxes used in this study were ideal because the ventilation can be applied on site whenever heat becomes a threat. Additional studies are needed to replicate individual treatments for statistical verification.

Members of the BPCA recorded 5,399 bluebirds fledged in 2007 with a production rate of 5.9 fledglings per box. These data and more are available on the BPCA website (briceprairieconservation.org). The box design was predominantly the NABS-style that was originally vented according to the design presented by Lawrence Zeleny (1976), the founder NABS. The vents were covered on most of our boxes three and four years ago when losses of nestlings to black fly infestation was observed during late June and early July. Also, cold temperatures in April and May have killed hundreds of nestlings and eggs during the past years, which reinforced the decision to discontinue venting the boxes. Contrarily, nestlings are rarely lost to heat in Wisconsin. Bluebird production and production rates have improved since non-vented boxes are used. However, non-vented boxes may be inappropriate for hot climates where black flies are not a problem.

The information developed from our study suggests:

✓The 2007 nesting season temperatures in La Crosse County were considered moderate, and neither cold nor heat interfered with bluebird reproduction.

✓During the April 16 cold cycle (34.4 ºF) all boxes remained 2 to 3 degrees warmer than ambient temperature.

✓During the June heat cycles (92.6 and 91.8 ºF) all boxes remained approximately 3 ºF cooler than ambient temperature.

✓The vented boxes were consistently cooler than unvented boxes by an average of about 2 ºF and by as much as 6º cooler than ambient during heat cycles in July and August.

✓The shade treatments decreased the temperature only slightly during the four hottest days in July and August; the average decrease was 4.2 ºF for the standard vented box and progressed to 4.8 ºF for the 24 inch shaded box.

✓The convertible venting system was a practical way to provide air vents on site by simply spacing the sides from the roof.

✓The T-type fence post mounting system was adequate to support the boxes with shade modifications throughout the nesting season.

✓All the experimental boxes remained dry inside despite the excessive rainfall and storms in August.

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Note: Leif Marking was a fishery research scientist for the U.S. Fish and Wildlife Service National Fisheries Research Center, La Crosse, WI for 32 years and published numerous technical articles in fishery journals.