BULLETIN OF THE

OKLAHOMA ORNITHOLOGICAL SOCIETY

VOL. 36 DECEMBER 2003 NO. 4

EASTERN BLUEBIRD NEST BOX USE, INTERSPECIFIC COMPETITION, AND PREDATION AT TISHOMINGO NATIONAL WILDLIFE REFUGE

DOUGLAS R. WOOD[1] AND KRIS PATTON[2]

[1] *Department of Biological Sciences, Southeastern Oklahoma State University, 1405 North 4th Avenue, PMB 4068, Durant, OK 74701-0609; E-mail: dwood@sosu.edu*

[2] *Tishomingo National Wildlife Refuge, 12000 South Refuge Road,Tishomingo, OK 73460; E-mail: Kris_Patton@fws.gov*

Abstract.—We examined Eastern Bluebird *(Sialia sialis)* nest box use at the Tishomingo National Wildlife Refuge from 1999 to 2002. In 1999, 25 nest boxes were installed and monitored for use by all species during 2 nesting seasons. In 2001, we installed 20 additional nest boxes and monitored all 45 nest boxes for 2 more nesting seasons. We monitored 178 bluebird nests with a mean clutch size of 4.5 eggs. Among successful nests, mean number of eggs hatched/nest (3.9) and number of fledglings/nest (3.9) were the same. Brood reduction appeared to occur during incubation. We documented several interspecific competitors for bluebird boxes and 7 brood parasitism events by Brown-headed Cowbirds *(Molothrus ater)*. Predators accounted for the loss of 150 bluebird eggs and 71 nestlings. Although nest losses occurred, Eastern Bluebird boxes were highly successful at Tishomingo National Wildlife Refuge.

Introduction.— Conservation biologists and concerned citizens frequently erect nest boxes for Eastern Bluebirds *(Sialia sialis)* (Kibler 1969, Pinkowski 1979). In the United States, Eastern Bluebirds experienced annual population declines of 4.7% from 1966 to 1979 (Sauer et al. 2003). For the same time period in Oklahoma, Eastern Bluebirds experienced a more severe decline of 7.2% annually (Sauer et al. 2003). However, from 1980 to 2002, Eastern Bluebird populations increased 4.1% annually in Oklahoma and 3.2% annually throughout the United States (Sauer et al. 2003).

Eastern Bluebirds typically lay 4–5 eggs (range 2–7) and have a 12–14-day incubation period (Peakall 1970, Pinkowski 1977). Bluebird chicks typically fledge after 15–20 days (Pinkowski 1977, Carter 1981). Although Eastern Bluebirds readily use nest boxes, this does not guarantee successful reproduction. Numerous species compete for and usurp bluebird nest boxes (Pinkowski 1975). Carolina Chickadee *(Poecile carolinensis)*, European Starling *(Sturnus vulgaris)*, House Sparrow *(Passer domesticus)*, Prothonotary Warbler *(Protonotaria citrea)*, and Tufted Titmouse *(Baeolophus bicolor)* can fledge young from bluebird boxes. Other interspecific competitors include ants, bats, snakes, and wasps. Predators such as rat snakes *(Elaphe* spp.), raccoons *(Procyon lotor)*, squirrels, and ants have

successfully depredated bluebird nests (Hurst 1980, de Waard 1984). Further, several researchers have documented Brown-headed Cowbirds *(Molothrus ater)* as brood parasites of bluebird nests (Pinkowski 1974, Woodward and Woodward 1979, Carter 1981).

Our objectives were to install nest boxes for Eastern Bluebirds and examine nest-box use, reproductive success, interspecific competition, and nest loss at Tishomingo National Wildlife Refuge, Oklahoma.

Methods.—Research was conducted at the Tishomingo National Wildlife Refuge (NWR) in Johnston County in south-central Oklahoma from 1999 to 2002. Tishomingo NWR (6,700 ha) consists of bottomland and upland hardwood stands, plum thickets, grasslands, row crops, and standing water. In March 1999, 25 nest boxes were installed on wooden fence posts along primary roads in the headquarters area at Tishomingo NWR. Nest boxes were placed adjacent to grassy, wooded, field, and shrub habitats with numerous perch opportunities (Pinkowski 1978, Parren 1994). Metal shields were attached as predator deterrents (Neal et al. 1998). In March 2001, 20 additional nest boxes, with electrical fencing for predator deterrents, were installed along primary roads and adjacent to row-crop fields planted for migratory waterfowl.

Nest boxes were monitored weekly during the 1999–2002 breeding seasons (late March–early August). We recorded clutch size, number of eggs hatched, number of fledglings for all species using nest boxes, nest losses, and Brown-headed Cowbird brood parasitism. Analysis of variance models were used to test for differences in mean clutch size, mean number of eggs hatched, and mean number of bluebirds fledged among years (SPSS 1999). If a significant main effect was detected, a least significant difference (LSD) means separation test was performed to examine differences among years (SPSS 1999).

Results.—We monitored 178 nests with complete clutches in 1999–2002. There was no difference in bluebird mean clutch size among years ($F_{3, 174} = 0.15$, $P = 0.93$; Table 1). Of the 178 nests, 131 hatched ≥1 egg. We detected an overall difference in the mean number of eggs hatched/nest among years ($F_{3, 127} = 4.3$, $P = 0.006$). An LSD means separation procedure determined that the mean numbers of bluebirds hatched/nest in 2001 and 2002 were greater than mean numbers hatched/nest in 1999 and 2000 (Table 1). However, no differences were detected in the mean numbers of bluebirds hatched/nest in 2001 and 2002 or 1999 and 2000 ($P > 0.05$; Table 1). Of 131 nests in which eggs hatched, 104 fledged >1 young. Mean number of bluebirds fledged/nest differed among years ($F_{3, 100} = 3.7$, $P = 0.014$), with more fledged/nest in 2001 and 2002 than in 1999 and 2000 (Table 1). No differences in the mean numbers of bluebirds fledged/nest were detected between 1999 and 2000 or between 2001 and 2002 ($P > 0.05$; Table 1).

We observed large numbers of unhatched eggs annually, which differed among years ($F_{3, 101} = 6.98$, $P < 0.001$; Fig. 1). More unhatched eggs were detected in 1999 and 2000 than in 2001 and 2002 ($P < 0.05$). We observed 15 nestlings that hatched but died during the nestling stage (Fig. 1).

Table 1. Number of nests, mean clutch size, and standard error *(SE)* of Eastern Bluebird nests at Tishomingo National Wildlife Refuge, 1999–2002.

Variable / Year	No. of Nests	Mean Clutch Size	*SE*
Clutch Size			
1999	31	4.5	0.13
2000	47	4.4	0.16
2001	43	4.5	0.15
2002	57	4.5	0.12
No. Hatched			
1999	22	3.4	0.25
2000	32	3.5	0.25
2001	35	4.3	0.17
2002	42	4.1	0.17
No. Fledged			
1999	16	3.4	0.29
2000	24	3.5	0.26
2001	33	4.1	0.19
2002	31	4.3	0.19

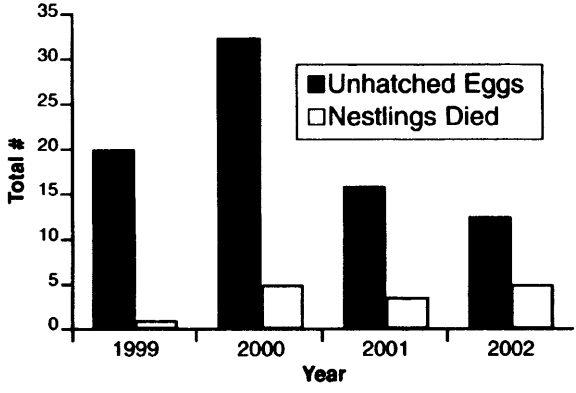

Fig. 1. Annual number of unhatched Eastern Bluebird eggs and nestling mortality in nest boxes at Tishomingo National Wildlife Refuge, Oklahoma, 1999–2002.

We observed nest-box use by avian and non-avian competitors. Carolina Chickadee, Carolina Wren *(Thryothorus ludovicianus)*, Tufted Titmouse, and White-breasted Nuthatch *(Sitta carolinensis)* nested successfully in bluebird boxes (Table 2). Prothonotary Warblers used nest boxes but failed to fledge any young. In 2000, we observed 2 big brown bats *(Eptesicus fuscus)* roosting in nest boxes and 1 white-footed mouse *(Peromyscus leucopus)* nest was removed from a nest box. We observed several species of ants and wasps in nest boxes, which appeared to preclude use by bluebirds during the breeding season.

Table 2. Nest characteristics of non-target bird species using nest boxes at Tishomingo National Wildlife Refuge, Oklahoma, 1999–2002.

Species	No.	Clutch Size	No. Hatched	No. Fledged
Carolina Chickadee	8	6.0	5.3	5.3
Carolina Wren	1	5.0	5.0	5.0
Tufted Titmouse	1	5.0	5.0	5.0
White-breasted Nuthatch	1	5.0	5.0	5.0

Eastern Bluebirds occasionally incubated Brown-headed Cowbird eggs. On all 3 occasions, bluebirds incubated and fledged an entire clutch of cowbird nestlings, and no bluebird eggs were observed. In 1999, bluebirds fledged 4 and 5 cowbirds from 2 boxes. In 2000, bluebirds in one of the same boxes raised a clutch of 5 cowbirds. We observed 4 other incidents of cowbird parasitism; however, the host bluebirds abandoned the parasitized nests. No cowbird parasitism was observed in 2001 and 2002.

We documented numerous predation events that resulted in the loss of 150 bluebird eggs and 71 nestlings (Table 3). Flooded nests accounted for 8% of eggs lost. Fire ants accounted for 9% of bluebird eggs lost. Similarly, 9% of bluebird eggs were lost to snakes, which we observed in the box and presumably consumed the eggs. The remaining 74% of bluebird eggs disappeared from the nest with little evidence. Fire ants accounted for 20% of the nestlings lost, whereas 80% disappeared without evidence of predation.

Discussion.—Eastern Bluebirds at Tishomingo NWR produced 178 nests with complete clutches in 1999–2002. We did not detect annual differences in clutch size, and mean clutch size (4.5 eggs/nest) was comparable to the 4.6 eggs/nest for bluebirds in Pontotoc County, Oklahoma (Carter 1981). Similarly, Crowell and Rothstein (1981) observed 4.31 eggs/nest in Oklahoma and Arkansas, and Pink-

Table 3. Causes of Eastern Bluebird egg and nestling mortality at Tishomingo National Wildlife Refuge, Oklahoma, 1999–2002.

Mortality Factor	No. of Eggs	No. of Nestlings Lost
Predators		
Unknown	111	57
Snakes	14	0
Ants	13	14
Flooded	12	0
Total	150	71

owski (1977) reported 4.5 eggs/nest in Michigan. Although clutch size was consistent among years, the number of eggs hatched/nest varied among years. Approximately 1 more egg hatched/nest in 2001 and 2002 than in 1999 and 2000 (Table 1). Although the cause of the increase in hatched eggs/nest in 2001 and 2002 was not clear, an increase in the number of nest boxes (i.e., greater sample size) may have influenced this result. In all cases, however, the number of eggs hatched/nest was less than the number of eggs laid. Thus, brood reduction appeared to occur during the incubation phase of the bluebird nesting cycle. Similar to our results, Carter (1981) observed a 25% loss of bluebird eggs during incubation in Oklahoma, which supports the hypothesis that brood reduction occurs during incubation.

We observed a relatively large number of unhatched bluebird eggs, both individually and entire clutches (Fig. 1). Unhatched eggs are fairly common in bluebirds and frequently are due to infertility. Zeleny (1981) estimated that 10–15% of bluebird eggs were infertile with different responses by the bluebird parents (i.e., abandonment or prolonged futile incubation). Bluebirds at Tishomingo NWR left unhatched eggs in the nest until hatching was complete (Pinkowski 1975) rather than removing them during the nesting cycle (Zeleny 1981).

Mean number of fledglings/nest paralleled the mean number of eggs hatched/nest within years. However, we observed approximately 1 more fledgling/nest in 2001 and 2002 than in 1999 and 2000. Regardless of year, bluebirds at Tishomingo NWR fledged more young/nest than the 2.62 fledglings/nest reported by Carter (1981). Although number of nest boxes increased in 2001 and 2002, mean clutch sizes were similar among years which suggested that other factors improved fledging rates in 2001 and 2002. Possible explanations may include more experienced adults, suitable abiotic factors, or increased food supply (Pinkowski 1977, 1979).

Although rat snakes and fire ants have been well documented as predators of bluebird nestlings (Laskey 1946, Hurst 1980), few observations of egg loss have been attributed to these predators (Carter 1981). We were unable to determine the cause of 74% of the eggs lost, although we suspect black rat snakes as the primary predator because nests appeared to be intact but eggs were missing (Wood 1996). Hurst (1980) documented fire ant predation of bluebird nestlings. In our study, 20% of nestlings were lost to fire ant predation. We were unable to conclusively determine which predators consumed the other 80% of nestlings lost, but rat snakes were the most likely candidate because the nestlings disappeared and nests were physically intact (Pinkowski 1975, Carter 1981). Snake guards, which consisted of metal plates wrapped around the nest box posts, appeared to have limited effectiveness because snakes were able to overcome them to consume bluebird nestlings.

From 1999 to 2002, we observed relatively infrequent usurpation of bluebird boxes by interspecific competitors. We documented 11 nests: 8 nests of Carolina Chickadees and 1 each of Carolina Wren, Tufted Titmouse, and White-breasted Nuthatch (Table 2). Erecting boxes in March, after many resident secondary cavity nesters had established territories or nests, appeared to limit nest–box usurpation and allowed bluebirds to nest with minimal competition from residents. In Oklahoma, Carter (1981) documented bluebird nest-box use by Carolina

Chickadees, Carolina Wrens, House Sparrows, and Tufted Titmice, but not White-breasted Nuthatches. We did not observe any House Sparrows using bluebird boxes at Tishomingo NWR. We observed bats roosting in bluebird boxes on 2 occasions. Similarly, Davis and Dourson (1991) observed a little brown bat *(Myotis lucifugus)* roosting in a bluebird box. We observed 1 white-footed mouse nest in bluebird boxes, which has previously been documented in Ohio (Hsu and Humpert 1988).

We observed 7 occurrences of Brown-headed Cowbird parasitism of bluebird nests. Parasitized bluebird boxes were adjacent to row-crop fields, which may have facilitated access to bluebird boxes. However, most bluebird boxes were adjacent to or near row-crop fields and were not parasitized. In 3 cases, multiple cowbird eggs were laid in a nest, and no bluebird eggs were recorded. Multiple cowbird eggs in nests are not uncommon, but few records exist for bluebirds incubating cowbird eggs exclusively. However, cowbirds rarely parasitize a nest before egg laying by the host; thus, the female cowbird may have removed bluebird eggs during laying (Wood and Bollinger 1997). Carter (1981) documented 12 cases of cowbird parasitism in Pontotoc County; however, he reported that cowbird parasitism had minimal impacts on overall bluebird nesting success. Similar to our results, Woodward and Woodward (1979) reported that 16% of bluebird nests were parasitized by cowbirds in Virginia. Of successfully parasitized bluebirds nests, only cowbirds fledged and bluebird nestlings died from starvation.

Literature Cited

Carter, W. A. 1981. Nesting of the Eastern Bluebird in Pontotoc County, Oklahoma. Bulletin of the Oklahoma Ornithological Society 14:9–13.

Crowell, K. L., and S. I. Rothstein. 1981. Clutch sizes and breeding strategies among Bermudan and North American passerines. Ibis 13:42–50.

Davis, W. H., and D. Dourson. 1991. Little brown bat, Myotis lucifugus, living in a bluebird box. Bat Research News 32:4.

de Waard, D. 1984. Of bluebirds and snakes. Sialia 6:65–67.

Hsu, M., and M. J. Humpert. 1988. Use of artificial cavities along Ohio interstate highways by bluebirds (Sialia sialis) and mice (Peromyscus sp.). Ohio Journal of Science 88:151–154.

Hurst, G. A. 1980. Did fire ants destroy two broods of bluebirds? Sialia 2:139, 168.

Kibler, L. F. 1969. The establishment and maintenance of a bluebird nest-box project—a review and commentary . Bird-Banding 40:114–129.

Laskey, A. R. 1946. Snake depredations at bird nests. Wilson Bulletin 58:217–218.

Neal, J. C., W. G. Montague, D. M. Richardson, and J. H. Withgott. 1998. Exclusion of rat snakes from red-cockaded woodpecker cavities. Wildlife Society Bulletin 26:851–854.

Parren, S. G. 1994. Orientation and spacing of nest boxes used by eastern bluebirds and tree swallows. Sialia 16:127–129.

Peakall, D. B. 1970. The eastern bluebird: its breeding season, clutch size, and nesting success. Living Bird 9:239–256.

Pinkowski, B. C. 1974. Cowbird parasitism of a bluebird nest. Jack-Pine Warbler 53:45.

Pinkowski, B. C. 1975. A summary and key for determining causes of nesting failures in eastern bluebirds using nest boxes. Inland Bird Banding News 47:179–186.

Pinkowski, B. C. 1977. Breeding adaptations in the Eastern Bluebird. Condor 79:289–302.

Pinkowski, B. C. 1978. Feeding of nestling and fledgling eastern bluebirds. Wilson Bulletin 90:84–98.

Pinkowski, B. C. 1979. Nest site selection in Eastern Bluebirds. Condor 81:435–436.

Sauer, J. R., J. E. Hines, and J. Fallon. 2003. The North American breeding bird survey: results and analysis, 1966–2002. Version 2003.1. United States Geological Survey, Patuxent Wildlife Research Center, Laurel, Maryland.

SPSS, Inc. 1999. SPSS® Base 9.0 Applications Guide. SPSS Inc., Chicago, Illinois.

Wood, D. R., and E. K. Bollinger. 1997. Egg removal by Brown-headed Cowbirds: a field test of the host incubation efficiency hypothesis. Condor 99:581–587.

Wood, L. D. 1996. Protecting nest boxes from snakes (and other climbing predators). Sialia 18:7–10.

Woodward, P. W., and J. C. Woodward. 1979. Brown-headed Cowbird parasitism on Eastern Bluebirds. Wilson Bulletin 91:321–322.

Zeleny, L. 1981. How bluebirds react to infertile eggs. Sialia 3:130–131.

Received 22 July 2003; accepted 18 August 2003.

Index of Bird Names

Vol. 36, 2003

The *Bulletin of the Oklahoma Ornithological Society* (ISSN 0474-0750) is published quarterly in March, June, September, and December in Norman, Oklahoma. Co-editors, Bryan Coppedge (to whom manuscripts should be directed), Science and Mathematics, Tulsa Community College, 7505 West 41st Street, Tulsa, OK 74107-8633; Jeffrey F. Kelly, University of Oklahoma; and David M. Leslie, Jr., U.S. Geological Survey. Subscription is by membership in the Oklahoma Ornithological Society: $5 student, $10 regular, $15 family, $15 or more sustaining, per year; life membership, $200. Direct questions regarding subscription, replacement copies, back issues, or payment of dues to Don Glass, OOS Membership/Circulation Chair, P.O. Box 2931, Claremore, OK 74018.