Wilson Bull., 107(2), 1995, pp. 289–295

EASTERN BLUEBIRDS ARE ATTRACTED TO TWO-BOX SITES

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ABSTRACT.—In early March, just prior to the onset of the breeding season, responses by Eastern Bluebirds (*Sialia sialis*) to playbacks of the territorial song of conspecifics are more likely on sites with two nest boxes rather than one. One or two boxes were placed randomly at potential territorial sites during early winter; so responsiveness is not explained by territoriality of the previous season. Explanations for our observations include that bluebirds prefer potential territorial sites with two boxes because of increased habitat quality or that bluebirds locate two-box sites more readily than one-box sites. We infer from our result that potential territorial sites with two nesting boxes are more attractive to bluebirds than sites with only one nesting box. *Received 6 Sept. 1994, accepted 1 Dec. 1994.*

Nest site limitation is common for secondary cavity nesting species, which do not excavate their own cavities but use cavities produced by other species or those created by death and disease of trees. For Eastern Bluebirds (*Sialia sialis*) limited availability of cavities suitable for breeding accounts for the reduction of their populations in many areas (Zelany 1976), as suggested by the increases in their numbers in areas where nest boxes are provided. Besides affecting the overall numbers of nesting bluebirds, variation in nest site numbers and distributions is expected to have other effects on the behavior of bluebirds, including effects on the sociographic mating pattern and genetically effective mating system (Gowaty 1980). Here we describe an experiment designed to evaluate if variation in number of nesting boxes on a potential territorial site affects the "attractiveness" of potential territories to bluebirds.

We reasoned that if potential territories with more than one cavity suitable for nesting are more attractive to bluebirds than potential territories with one cavity, bluebirds should show evidence of earlier settling or stronger territoriality on two-box than on one-box sites. We therefore predicted that (1) responses to playbacks of territorial song will be greater on two-box than on one-box sites, (2) the difference in time between the onset of playback and response by bluebirds will be less on two-box than on one-box sites, and (3) onset of nesting activities will be earlier on sites with two nesting boxes than on those containing a single nesting box.

METHODS

In January 1985, we erected nest boxes on 43 sites on Clemson University properties in Pickens and Anderson counties in northwestern South Carolina. PAG chose sites for place-

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ment of nesting boxes within well-known study areas if those sites had been used as territories successfully by bluebirds anytime during the field seasons of 1977–1982. Thus we were confident that the sites at which we placed boxes were suitable for nesting by bluebirds. We assigned these sites randomly to two treatments such that each study area had approximately equal numbers of sites submitted to each treatment: at 20 of the sites we erected only a single nesting box. At 23 sites we erected two boxes within 24 m ($\bar{x}$ = 17.3 m ± 3.37 SD) of one another, distances that easily allow defense of both boxes on a site by a lone male or a pair of bluebirds.

During the first week of March before nesting activity had begun, we conducted playback trials at each site, using a recorded territorial song of an adult male bluebird. We set the tape player within 10 m of nesting boxes on one-box sites or midway between the boxes at two-box sites. We allowed tapes to play for a maximum of 10 min at each site. If bluebirds approached within 10 m of the boxes during the ten-minute period and behaved as though they were aware of the tape, i.e., if they approached the tape player, sang, or wing-flicked and chattered near a nesting box (Krieg 1971), we scored the trial as a response. If no bluebirds appeared by the end of the 10 min period, we scored the trial a "non-response." For bluebirds which responded to the tape, we also recorded their numbers and sexes and the latency of response from the time we started the tape. We censused all nesting boxes at least twice a week to determine occupancy and dates of onset for nest building, egg laying, hatching, and fledging.

All statistical tests are two-tailed. We derived power of tests from tables in Cohen (1988). We report power for small (Student's *t*, d = 0.2; *G*-test, w = 0.1) and large (Student's *t*, d = 0.8; *G*-test, w = 0.5) effect sizes as discussed by Cohen (1988).

RESULTS

Response to taped territorial calls was significantly associated with the number of boxes on a site (Fig. 1). At two-box sites, we recorded 13 responses, while at one-box sites there were only two responses (G = 11.123, df = 1, $P < 0.001$). The two responses at one-box sites were by males and females together. Three (23%) of the responses in two-box sites were by males alone; the others were by both males and females.

Overall (N = 15), the mean latency to response was 1.94 ± 2.36 min. However, there was no statistically significant difference in latency for birds that responded at one-box ($\bar{x}$ = 1.0 min) or two-box ($\bar{x}$ = 2.1 min) sites (Student's t = −0.5937, df = 13, P = 0.5629; but power for larger effect ≤0.3). When we assigned latencies (= 11 min) for non-response trials, the latency for one-box sites (N = 20) was $\bar{x}$ = 10 min ± 3.1 SD and $\bar{x}$ = 6 ± 4.9 SD for two-box sites (N = 23), a significant difference (Student's t = 3.1844, df = 41, P = 0.0025).

Twelve (52%) two-box and nine (45%) one-box sites had early-season nests begun in boxes during mid- and late March. However, there was no apparent statistical association between the number of nest boxes on a site and the likelihood of early season use by bluebirds (G = 0.216, df = 1, $P > 0.50$; $\text{power}_{w=0.1}$ = 0.10, $\text{power}_{w=0.5}$ = 0.91). Over the entire field season (March–September), there were 94 nesting attempts in boxes on the experimental sites. Thirty-nine (41%) were in boxes on one-box

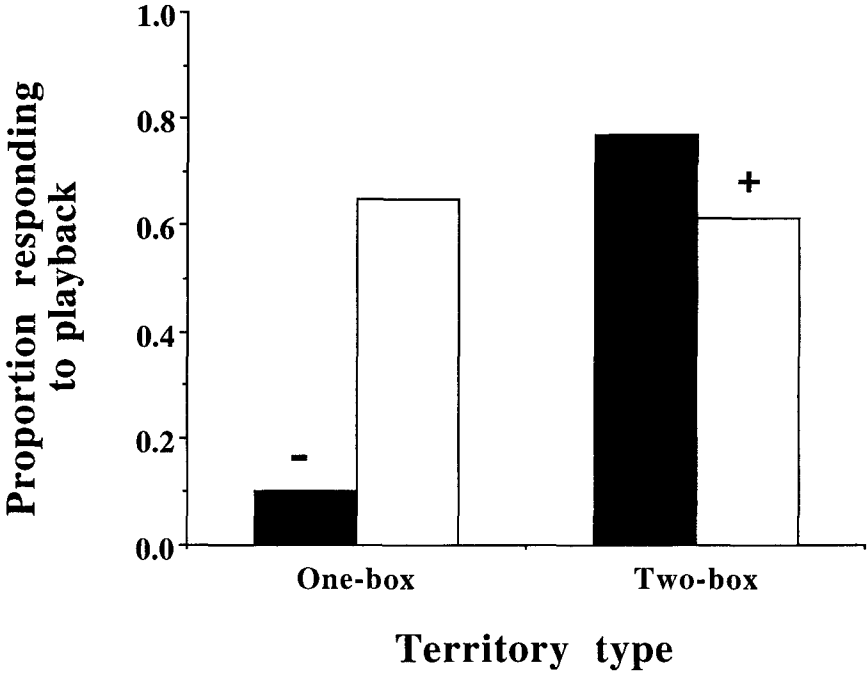

FIG. 1. Frequency histogram of observed (solid bars) and expected (open bars) proportions of playback trial responses by Eastern Bluebirds at potential territorial sites with one and two nesting boxes. The signs above the bars indicate the direction of the difference between observed and expected proportions.

and 55 (58%) were in boxes on two-box sites. The expected proportions were 47% and 53%, respectively, based on the numbers of each type of site, and the observed proportions were not statistically different from these ($G = 1.1494$, df = 1, $P > 0.50$; $\text{power}_{w=0.1} = 0.16$, $\text{power}_{w=0.5} > 0.99$).

Mean dates of onset of nest building and of the laying of first eggs were earlier for two-box territories, although these differences were not statistically significant (Table 1; $\text{power}_{d=0.2} = 0.09$, $\text{power}_{d=0.8} = 0.68$). We also found no statistical differences in the numbers of eggs laid and hatched or nestlings fledged (Table 1; $\text{power}_{d=0.2} = 0.16$, $\text{power}_{d=0.8} = 0.97$).

DISCUSSION

The single significant difference between one- and two-box sites that we observed was in responses to taped territorial calls played before the

TABLE 1
COMPARISONS OF PHENOLOGY AND DEMOGRAPHY FOR BLUEBIRDS NESTING IN ONE- OR TWO-BOX TERRITORIES

Variable	Treatment	N	$\bar{x}$	SD	t	df	$P > \|t\|$
Nest building begun[a]	One-box	18	12 March	36.4	0.505	37	0.617
	Two-box	21	6 March	38.9			
First eggs[a]	One-box	18	24 March	29.1	0.283	37	0.779
	Two-box	21	21 March	31.1			
Clutch size	One-box	39	4.2	1.69	1.589	92	0.116
	Two-box	55	3.6	1.86			
Brood size	One-box	39	3.2	1.78	1.205	92	0.231
	Two-box	55	2.7	2.08			
Number fledged	One-box	38	2.6	1.82	1.066	89	0.289
	Two-box	58	2.2	2.12			

[a] Includes dates for first nests only.

onset of breeding activities in early March. Because all of the sites had been used by bluebirds in previous seasons, the differences cannot be attributed to general habitat quality other than nest box number. Because most of the sites lacked nesting boxes, and were therefore uninhabited by bluebirds during the immediate two preceding seasons (1983–1984) and because sites were randomly assigned to one- or two-box treatments, the differences in responses cannot be attributed to previous-season territoriality. We assume that bluebirds were equally likely to have spent the fall and early winter on or nearby our experimental one- and two-box sites, because these boxes were erected randomly early in the winter period. However, our data may indicate stronger winter territoriality at two-box sites. We conclude that the likelihood of response by bluebirds to taped territorial calls is associated with the number of nesting boxes on a site.

Our data offer little or no support for our other two predictions. Latency to response did not differ on the two sites, an observation that may be due to the small numbers of birds responding on the one-box sites. On the other hand our experimental protocol defining the end of the trial after the tape had played for ten minutes may have been too short to discern most latencies associated with one-box sites. In fact, at one one-box site bluebirds did respond, but only after the tape had played for eleven minutes. At best, our prediction that latencies to response would be less in two-box sites is equivocably supported. Dates for first nest building activity and first eggs did not differ on one- and two-box sites, so our third prediction is clearly not supported. The onset of nest building and egg

laying probably depends on other environmental factors other than the number of nest boxes on a defended site, so failure to support our third prediction does not modify our observation that response to taped territorial calls was associated with the number of nesting boxes on sites representing potential territories.

Three possible explanations for this result occurred to us: (1) Bluebirds preferentially selected two-box over one-box sites as potential territories, so their responsiveness may have been evidence of winter territoriality or incipient breeding season territoriality associated with the quality of the sites. (2) Bluebirds found two-box sites more readily than one-box sites. (3) Two-box sites exerted a super-stimulus, such that stronger territorial defense was elicited at two-box sites than at one-box sites.

If bluebirds prefer two-box sites as potential territories, the preference may indicate that two-box sites, all else being equal, are potentially higher quality territories. Although higher territory quality could translate to higher reproductive success per breeding attempt, our data indicate that immediate reproductive success did not vary at one- and two-box sites. Quality of territory could be associated with additional mating opportunities for males, a prediction not supported by observations at these territories (Gowaty and Emlen, unpubl. data). Territory quality could be associated with additional nesting opportunities for males and females that might otherwise have to undertake a longer distance breeding dispersal if the suitability or quality of an original nesting site degraded or declined, a prediction also not supported by our current data (Gowaty and Plissner, in press). In any event, the hypothesis that two-box sites may represent higher quality potential territories than one-box sites predicts that two-box sites will be more vigorously contested than one-box sites.

Bluebirds may find two-box sites more readily than sites with only one box. At all seasons of the year (Allen 1988) and at all ages (pers. obs.) bluebirds examine cavities, a behavioral trait associated with nest-site limitation. If bluebirds imprint on the characteristics of nest sites and use old nest site characteristics in their searches for new nest sites, a two-box site might be more readily found in comparison to one-box sites in that potential cues might be doubled. This could be especially so for bluebirds whose natal site or previous breeding site was a nest box. Certainly if their searches for cavities are random searches and if an important cue to territory suitability is the presence of a cavity, sites with two nesting boxes will be found more readily than sites with one. This hypothesis predicts that territories on sites with two nesting boxes may suffer more intrusions by non-territorial birds than territories on sites with one nesting box.

The hypothesis that two-box sites elicit greater responsiveness because

the usual stimulus is doubled seems unlikely, because neither latency times nor response intensity seem to vary in one- and two-box sites; i.e., if birds responded at all, they seemed to behave similarly in one- and two-box sites. Responsiveness and response intensity, however, may be uncoupled such that the intensity of response is associated only with the characteristics of the intruder and not of the resource being defended. We nevertheless expect that latency should be coupled with responsiveness if the superstimulus hypothesis was true.

We conclude, then, that bluebirds respond to taped territorial song more when the song is played on potential territorial sites with two nesting boxes than they do on sites with only one box. We infer from this that two-box sites are more attractive potential territories than one-box sites. We are unable to attribute this attractiveness to preferences for higher quality territories or to the increased stimulus value of territories with two rather than one box. Indeed, our explanations for our observations are not mutually exclusive.

These hypotheses to explain our observations predict that territories on two-box sites will suffer higher intrusion rates by conspecifics than territories on one-box sites. Harris (1977) reported higher rates of territorial aggression by breeding resident Tree Swallows (*Tachycineta bicolor*) when nesting boxes were 1 m apart than when they were separated by 30 m. Also, Meek and Robertson (1994) observed more intrusions of Eastern Bluebird territories by Tree Swallows at territories containing two nesting boxes than at those with single boxes. In a study of nest guarding, Gowaty et al. (1989) found that both males and females remained closer to boxes during nest-building and egg-laying periods, when territories are most susceptible to usurpation and conspecific nest parasitism, but not during incubation or while nestlings were present.

Extrapolation from our observations also suggests that bluebirds may initially appear in greater numbers in areas with many rather than fewer nesting boxes. A test of this idea would vary the density of nesting boxes randomly over areas that currently have few or no bluebirds. The hypothesis would be supported if significant differences in the numbers of bluebirds initially nesting were found in areas with higher densities of nesting boxes. Finally, if bluebirds are more attracted to two-box sites than one-box sites, managers interested in attracting bluebirds might have greater success associated with potential territories containing two nesting boxes.

ACKNOWLEDGMENTS

We thank Tracey Williams for her help in conducting these trials, Steve Emlen and Natalie DeMong Emlen for their help in erecting nest boxes, and Dave Tonkyn, Mimi Wolok, and

Dick Conner for comments on the manuscript. This research was supported by grants from the National Geographic Society (3006-84) and The National Science Foundation (BSR-8417500), both to PAG.

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