REPRODUCTION OF MOUNTAIN BLUEBIRDS IN SOUTHCENTRAL MONTANA

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Mountain Bluebirds (*Sialia currucoides*) occupy an extensive breeding range in western North America (Bent 1949). They breed in a greater variety of habitats, including the Upper Sonoran, Transition, Canadian and Hudsonian life zones, than other members of the genus (Power 1966, Herlugson 1978, Pinkowski 1979a). Although Ponderosa Pine (*Pinus ponderòsa*) savannas are often used by breeding Mountain Bluebirds (Pinkowski 1979a), there are apparently no published reports of the reproductive biology of the species in Ponderosa Pine-dominated habitats. Here I report results of a 3-year study of Mountain Bluebird reproductive biology in a Ponderosa Pine savanna in southcentral Montana.

STUDY AREA AND METHODS

The study area is about 19 km north-northeast of Shepherd, Yellowstone County, in southcentral Montana, on unglaciated sedimentary plains with rolling topography formed primarily by erosion. Altitude is about 1200 m and annual precipitation averages 330 mm.

Ponderosa Pine savanna dominated the study area. Common shrubs were Big Sagebrush (*Artemisia tridentata*), Rocky Mountain Juniper (*Juniperus scopulorum*) and Skunkbush Sumac (*Rhus trilobata*). Common grasses included Bluebunch Wheatgrass (*Agropyron spicatum*), Blue Grama (*Bouteloua gracilis*), Prairie Junegrass (*Koeleria cristata*) and blue grass (*Poa* sp.). Broom Snakeweed (*Gutierrezia sarothrae*) and Small Soapweed (*Yucca glauca*) were common forbs. This habitat was similar to the *Pinus ponderosa/Artemisia tridentata* habitat described by Jorgensen (1979).

I studied the reproduction of Mountain Bluebirds during the summers of 1967, 1968 and 1969. Prior to the 1967 nesting season, 16 bluebird nest boxes were placed on the study area; these boxes were repaired as required. The nest boxes had inner dimensions of 12.7 x 12.7 x 20.3 cm, with an entrance hole diameter of 4.1 cm located 13.3 cm above the bottom of the box. Boxes were placed 1.3 to 1.6 m above the ground on living Ponderosa Pines (14) or fenceposts (2) along a triangularly shaped route about 2.25 km long. One natural nest, in a hollow stump, was included in this study.

The nests were checked every few days between late March and late July-early August. A nesting attempt was defined as a nest receiving at least one egg. Clutch size referred to completed clutches with incubation underway. The date of clutch completion was the day the last egg was laid in the clutch. If not observed directly, this date was calculated by assuming a 13-day incubation, with incubation beginning on the day the last egg was laid (Power 1966). Nest success was defined as the proportion of nesting attempts producing at least one fledged young. Bias in calculating nest success or nest density inherent in studies involving nest searches, as discussed by Miller and

Johnson (1978), was not a factor in this study, since only the nest boxes and one natural cavity were checked for nests.

Nesting attempts were divided into early and late nesting with a clutch completion date of 1 June separating the two groups. In 1967, however, when a late spring storm delayed the nesting, 12 June was used as the date of separation. "Late first broods" and "second broods," distinguished by Power (1966), were lumped in this study because Mountain Bluebirds may move on and off the area during the nesting season and may renest in another box, as observed by Pinkowski (1977) in the Eastern Bluebird (*Sialia sialis*).

Mean values were tested for statistical difference by using two-tailed t-tests and frequency data were compared statistically with chi-squared tests using 2x2 contingency tables corrected for continuity (Snedecor and Cochran 1967).

RESULTS

ARRIVAL DATES AND NEST BOX UTILIZATION

In 1967, four male Mountain Bluebirds were observed on 20 March. On my second visit, 25 March, eight males and three females were seen. I saw six males on 30 March 1969. These dates are probably near the date of first arrival on the study area because male Mountain Bluebirds usually arrive a few days in advance of the females (Criddle 1927). Each year of my investigation, 11 early nesting attempts were made on the study area (Table 1).

REPRODUCTION

The average date of clutch completion was influenced by the weather (Table 2). In 1967, one clutch was completed on 24 April, but a late spring storm caused other pairs to stop building and wait until late May to complete their clutches. In 1969, a snow storm and frost in early June destroyed many first clutches, resulting in earlier renesting. Under normal conditions, mean early clutches ($N = 21$) were completed on the study area on 11 May (21 April-28 May) and late clutches ($N = 8$) on 22 June (19 June-2 July).

Average clutch size for early clutches ($N = 31$) was 5.23 ± 0.67 eggs per completed clutch. This clutch size differed significantly ($P < 0.05$) from late clutches ($N = 18$), which averaged 4.72 ± 0.67 eggs. Hatching success of completed clutches was similar ($P > 0.3$) for eggs in early and late clutches (Table 1) and averaged 71% ($N = 222$). Human disturbance (capturing the female for banding) and predation were the most important causes of failure of eggs to hatch for early and late clutches, respectively, but the causes of failure varied from year to year (Table 3). The most common predators of bluebird eggs on this area were Deer Mice (*Peromyscus maniculatus*) (Swenson 1968) and House Wrens (*Troglodytes aedon*), which destroyed eggs in five and two clutches, respectively, and caused the abandonment of these clutches.

Of a total of 267 eggs examined on and near the study area, none were albinistic, compared to 8.3% of 108 eggs in northcentral Montana (Power 1966) and 6.1% of 837 eggs in Manitoba (Munro et al. 1981). Albinism was significantly less on my study area than on the other two areas ($P<0.005$). There was no statistical difference between the other two areas, however ($P>0.9$).

One nest was counted as two nestings, both failures. It contained 10 eggs, which were never incubated, on 18 June 1968. This nest was probably a "dump nest," with eggs contributed by two females, as has been previously observed in the Eastern Bluebird (Musselman 1935).

Table 1. Summary of Mountain Bluebird reproductive parameters in a Ponderosa Pine savanna in southcentral Montana.

Parameter	1967	1968	1969	Total
		EARLY NESTS		
Nesting attempts (A)	11	11	11	33
Successful nests (B)	7	7	4	18
Nest success (B/A)	64%	64%	36%	55%
Completed clutches (C)	10	11	10	31
Eggs laid (complete clutches) (D)	50	60(50)[a]	52	162(152)[a]
Clutch size (D/C)	5.00	5.45	5.20	5.23
Eggs hatched (E)	28	43	34	105
Hatching success (E/D)	56%	86%	65%	69%
Young fledged (F)	25	28(21)[b]	15	68(61)[b]
Nestling survival (F/E)	89%	49%	44%	58%
Fledglings per successful nest (F/B)	3.57	4.00	3.75	3.78
Fledglings per nesting attempt (F/A)	2.27	2.55	1.36	2.06
		LATE NESTS		
Nesting attempts (A)	3	8[c]	8	19[c]
Successful nests (B)	2	3	2	7
Nest success (B/A)	67%	38%	25%	37%
Completed clutches (C)	3	7	8	18
Eggs laid (complete clutches) (D)	13	33(18)[a]	39	85(70)[a]
Clutch size (D/C)	4.33	4.71	4.88	4.72
Eggs hatched (E)	8	14	31	53
Hatching success (E/D)	62%	78%	79%	76%
Young fledged (F)	8	13(9/9)[d]	10	31(27/48)[d]
Nestling survival (F/E)	100%	100%	32%	56%
Fledglings per successful nest (F/B)	4.00	4.33	5.00	4.43
Fledglings per nesting attempt (F/A)	2.67	1.62	1.25	1.63

[a]Number of eggs of known hatching success.
[b]Number of young fledged from nests with known hatching success.
[c]Excludes 3 nests of unknown outcome.
[d](Number of young fledged/Number of young hatched) for nests of known hatching success and outcome.

Table 2. Average dates of Mountain Bluebird clutch completion in southcentral Montana.

Year	First Clutches	Second Clutches
1967	24 May (11)[a]	22 June (2)
1968	10 May (11)	22 June (6)
1969	11 May (10)	10 June (6)

[a]Sample size

Table 3. Causes of Mountain Bluebird egg hatching failure in southcentral Montana.[a]

	Number of Eggs					
Year	Laid	Hatched	Dead Embryo or Infertile	Predation	Human Disturbance[b]	Desertion[c]
			EARLY CLUTCHES			
1967	52	54[d]	12	19	12	4
1968	50	86	4	0	10	0
1969	55	62	5	9	15	9
Total	157	67	7	10	12	4
			LATE CLUTCHES			
1967	13	62	0	38	0	0
1968	33	42	0	27	0	30
1969	39	79	10	10	0	0
Total	85	62	5	21	0	12

[a]All eggs, including those in incomplete clutches.
[b]Female was captured and banded.
[c]Female was not captured.
[d]Figures in this column, and in all columns to the right, are percentages.

Table 4. Causes of Mountain Bluebird nestling mortality in southcentral Montana.

	No. of Young		Mortality Factor			
Year	Hatched	Fledged	Weather	Predation	Accident	Unknown
			EARLY BROODS			
1967	28	89[a]	0	0	0	11
1968	43	49	0	9	0	42
1969	34	44	41	0	12	3
Total	105	58	13	4	4	21
			LATE BROODS			
1967	8	100	0	0	0	0
1968	9	100	0	0	0	0
1969	31	32	55	13	0	0
Total	48	56	35	8	0	0

[a]Figures in this column, and in all columns to the right, are percentages.

Table 5. Comparison of the frequency of clutch sizes and young fledged by clutch size in Mountain Bluebird nesting attempts in southeastern Montana (early clutches only).

Clutch Size	Frequency (%)[a]	Young fledged per successful nest
3	3	2.00
4	3	2.00
5	61	4.56
6	32	3.29

[a]N = 31.

Average brood size at fledging for first broods (N = 18) was 3.78 ± 1.56 young and for second broods (N = 7) was 4.43 ± 0.79 young. These brood sizes were not significantly different ($P>0.3$). Nestling survival was similar for both periods ($P>0.9$) and averaged 58% (N = 153). Adverse weather was the most commonly identified cause of nestling death for both brood periods, but it was a factor only in 1969 (Table 4), when a snow storm struck in early June and the area received heavy rains in late June. Deer Mice were the probable predators which destroyed two broods (Swenson 1968).

The number of young fledged per nesting attempt (Table 1) was higher for early nests (2.06) than late nests (1.63), but the difference was not significant ($P>0.2$). During this study, I observed a total of 33 early nesting attempts and 22 late attempts, including attempts of unknown outcome. Assuming that as many bluebird pairs entered the study area as left it to renest, and that each late attempt was a renest, each pair renested an average of 0.67 (22/33) times. The average pair produced 2.06 young from the first nesting and 1.09 young (0.67 attempts x 1.63 young/attempt) from the second nesting, or 3.15 young per year.

The most common early clutch size on the study area (5 eggs) was the most productive in terms of young fledged (Table 5). The reason that clutches of five were more productive than clutches of six was that survival of nestlings was significantly lower ($P<0.001$) in broods of six (67%, N = 30) than in smaller broods (94%, N = 72). Only nestlings in successful nests were considered in this comparison.

MOVEMENTS AND SITE FIDELITY

I banded 1 adult male, 19 adult females and 89 young during this study. Because the birds were not color-marked, movement data could only be obtained by recapturing banded birds. Recaptures of two adult females suggested that the female Mountain Bluebirds returned to the study area the following year, but not necessarily to the same nest site. One female was banded as an adult in nest 1 in 1967, recaptured in nest 8 in 1968 (330 m from nest 1) and in nest 3 in 1969 (335 m from nest 8). Another female, banded as an adult in nest 4 in 1967 was recaptured in nest 14 in 1968 (390 m from nest 4). These nest sites averaged about 350 m from the nest used the previous year. This distance is very similar to Pinel's (1980) finding that six Mountain Bluebirds, banded as adults, were recaptured an average of 400 m from the site of banding in the aspen parklands of Alberta. In 1969, different females used nest 4 for the first and second nestings, even though the first attempt was successful.

Females became much more wary after banding; after being banded they left the nest box while I was still some distance from it. The difference in reactions to my approach between females which had been captured and those not previously captured that season was obvious. I captured 22 (71%) of 31 females completing early clutches but only 3 (17%) of 18 females completing late clutches, none of which had been captured previously that year. This difference is highly significant ($P<0.001$).

DISCUSSION

The observation of 11 early nesting attempts each year on my study area suggested that territorial behavior may limit the number of bluebirds using available nest sites and that all available territories were filled, as has been found in the Eastern Bluebird by Pinkowski (1979a). That this occurred the first year suggested there was a shortage of natural nest sites on the study area or that the boxes were preferred to the available natural nest sites. Subjective observations on my study area suggested that there was a relative shortage of adequate natural cavities. Several Mountain Bluebirds in the vicinity of the study area were found nesting in cavities that opened upward and one was quite exposed. This type of cavity is selected against by Eastern Bluebirds (Pinkowski 1976).

Both of the banded females recaptured in subsequent years had returned to the study area after nesting there unsuccessfully the previous year. This observation is in contrast to Pinkowski's (1977) finding that all 47 Eastern Bluebirds that returned to his study area had nested there successfully the previous year. Also, the significantly more wary behavior of females completing late clutches than that of females completing early clutches was most likely due to a large percentage of previously captured birds remaining on the area to renest. Although this conclusion is based on circumstantial evidence, I feel that it is strong enough to warrant the conclusion because of the marked change in female reactions to my approaches following banding. Pinkowski (1977) found that 66% of the female Eastern Bluebirds left his study area immediately after an unsuccessful nesting attempt, and that almost all successful birds stayed on the area.

Mountain Bluebirds on my study area apparently showed a stronger degree of nest site fidelity than that found in Pinkowski's (1977) study of Eastern Bluebirds. This difference is probably not due to behavioral differences between the species; Herlugson (1981) found that 68% of 22 successful female Mountain Bluebirds in Washington returned to the same territory and nest box the following year, compared to only two of five unsuccessful females. The apparent nest site fidelity in my area may have been due to a lack of suitable natural cavities. This theory was not tested, but was supported by general observations on the scarcity of adequate natural nest sites, the rapid occupation of territories (occupation of nest boxes was gradual on Pinkowski's study area), the apparently low rate of movement from the area during the nesting season, the return of females to the area even after nesting there unsuccessfully the previous year, and the occurrence of dump-nesting.

If the nest site fidelity was as strong as the evidence suggested, the determination of annual productivity per pair was probably accurate. This parameter is difficult to measure in most passerines (Pinkowski 1979b). I estimated that 67% of the pairs renested and produced an average of 3.15 young per pair per year. Power (1966) found that 50% of all successful pairs (31% of all pairs) renested on his study area and Rounds and Munro (1983) suggested that renesting was common. Estimating annual productivity as I did can greatly underestimate the actual productivity if movement from the study area for renesting is great and is biased towards unsuccessful pairs (Pinkowski 1979b).

Cody (1966), modifying Lack (1947), postulated that, in nidicolous species in temperate regions, the average clutch size is probably determined ultimately by the average maximum number of young which the parents can successfully raise, based on the average food supply available in the area and season in question. This theory is not supported by the results of some studies (e.g. Middleton 1979), but it is supported by the results of my study, since the most young were fledged from the most common clutch size on my study area (5 eggs). It appeared as though the adults may have had difficulty in providing enough food to rear broods of six as successfully as smaller broods. Mountain Bluebirds are very insectivorous, thus sensitive to shortages of insects, and they increase the amount of hovering, an energetically costly foraging behavior, during times of higher nutritional needs, such as when feeding nestlings (Pinkowski 1979a, Power 1980, Herlugson 1982).

ACKNOWLEDGMENTS

I am grateful to my parents, Frank and Eva Swenson, for their support and encouragement during this study. I also thank Benedict C. Pinkowski, Harry W. Power, John P. Weigand, Robert L. Eng, D. Paul Hendricks and Cameron Barrows for reading drafts of this paper and providing many helpful comments. This paper is dedicated to the memory of my friend and mentor, Don C. MacDonald.

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Accepted 22 July 1985