BIOLOGY OF THE MOUNTAIN BLUEBIRD IN MONTANA

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It is generally believed that the Eastern Bluebird (*Sialia sialis*) has been declining in numbers over its range for the past several decades (see Amadon, 1966). Although no exact censuses exist, many observers are convinced that there has been a similar decline in the populations of the Mountain Bluebird (*Sialia currucoides*) in Montana. Since this opinion is so widely held, the possibility of a decrease in the numbers of Mountain Bluebirds must be seriously considered and is worthy of investigation. In addition, data on all aspects of the biology of this species are fragmentary. Therefore, I studied the Mountain Bluebird from 1961 to 1963 for various periods between March and October near Calvert, southern Cascade County, Montana, in order to investigate its breeding biology and, if possible, to identify factors that might affect its population level.

In order to insure the presence of a breeding population during the years of study, 29 nesting boxes were erected between 1960 and 1963. The inner dimensions were 5 × 5 × 8 inches (length × width × height) with an entrance hole 1.5 inches in diameter 6 inches above the bottom of the box. The boxes were placed 4 to 5 feet above the ground on fence posts, utility poles, and trees. Each was readily accessible and was usually examined at intervals of not more than one week during the nesting season. A coding system was devised to provide the following information about each box: year of occupancy (61, 62, or 63), serial number of box (1 through 29), whether the observations were of a first (a) or second (b) brood, and if the box was used by a new pair (1) or by a pair including a new mate of a bird already nesting in the box in the same year (2). For example, the designation 62-5b-2 identifies observations made in 1962 at box number 5, involving a second brood produced by a pair in which one member had not previously occupied the box in 1962. Omission of the third (a, b) or fourth (1, 2) elements of the code means that the information is not relevant or is not known.

Both Fish and Wildlife Service bands and colored plastic bands were used. By trapping adults in nest boxes during the nest-building period through the nestling period and by banding nestlings, data were obtained on 126 bluebirds, 27 pairs, and 21 nests.

STUDY AREA

The study area (fig. 1) was located 2.5 miles south of Calvert, Cascade County, Montana, in the foothills of the Little Belt Mountains at an elevation of about 5000 feet and 33 miles south of Great Falls. It included approximately 460 acres containing floristic elements of Upper Sonoran and Transition life zones. The Upper Sonoran included cultivated grain and hay fields as well as native grassland. Transition Zone vegetation was dominated by Douglas-fir (*Pseudotsuga menziesii*) and limber pine (*Pinus flexilis*). The area was crossed by utility and fence lines. The early-spring environment is severe at Calvert because of frequent cold and snow. Freezing temperatures and frequent snowstorms occurred through mid-May, and on occasion there were several inches of snow. In late March of 1963 there was approximately a foot of snow on the level and six-foot drifts on the Canyon, East, and West ridges. The last snow did not melt until mid-June.

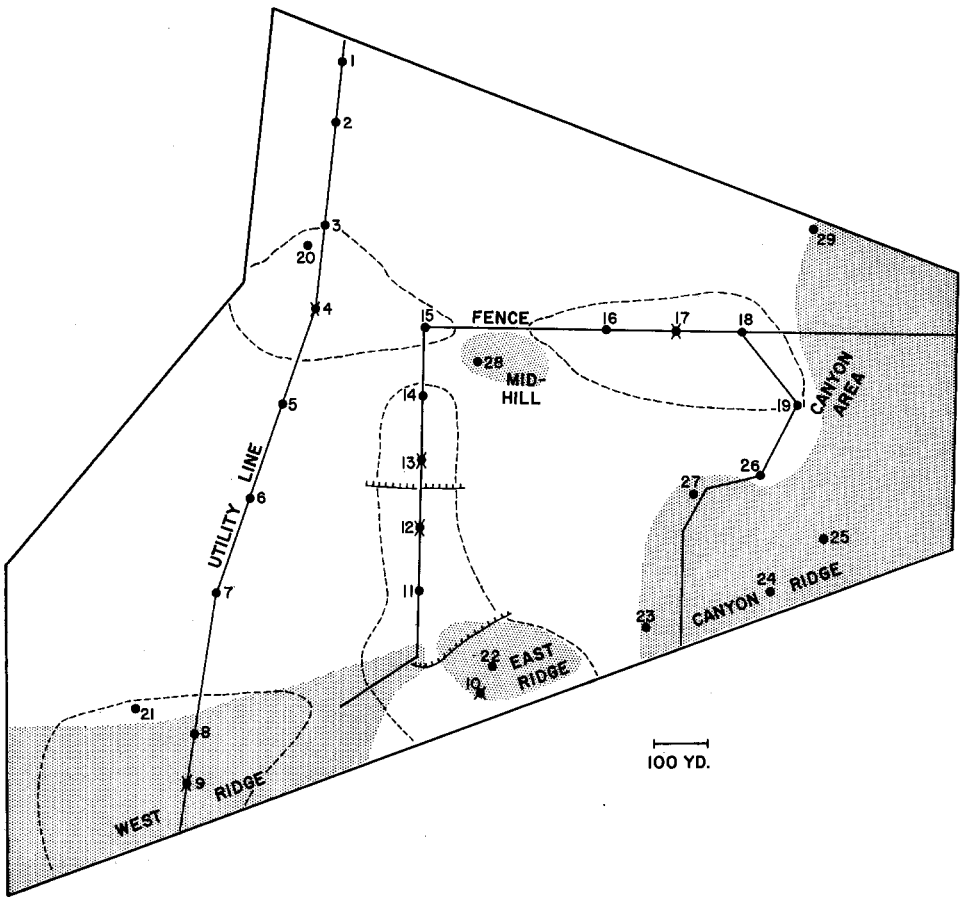

Figure 1. Study area in 1962. Stippled areas represent Transition Zone vegetation; blank areas, Upper Sonoran Zone; hachured lines, definite territorial boundaries determined by observed intraspecific conflict; dashed lines, approximate territorial boundaries determined by observed foraging trips; numbers and dots, nest boxes; numbers and crossed dots, active nest sites in 1962.

SPRING MIGRATION

Dawson and Bowles (1909:261) at Chelan, Washington, in what they termed a typical season, reported flocks of male Mountain Bluebirds preceding flocks of females by more than 30 days. Criddle (1927:40) reported that in Treesbank, Manitoba, the males arrived only a few days before the females. At Calvert only one spring flock was seen; it contained 15 males on 30 April 1960, following a late and severe snowstorm. In the course of the research period proper, single birds and groups of up to six birds of both sexes were seen shortly after arrival. Median arrival date in 1962 for spring migrant males was 8 April (31 March–16 April), and for the females, 25 April (31 March–20 May). A female seen on 31 March along with the first males was unusually early.

SONG

Vocalizations include *alarm*, *signal song*, *flight call*, *mechanical alarm* or *beak snapping*, and *nestling food call*, as well as *advertising song* (for definitions, see Van Tyne and Berger, 1959:137–142).

Contrary to Weydemeyer's (1934:164) observations, I could hear all sounds except *nestling food call* and *mechanical alarm* several hundred yards away. As noted by Allen (*in* Bent, 1949:283–284) and Wheelock (1904:507), *advertising song* resembles that of the Eastern Bluebird (*Sialia sialis*). *Signal song*, *alarm*, and the *nestling food call* also resemble vocalizations of that species.

Only the males gave *advertising song*. Song perches were usually conspicuous: a fence post in the open; a large rock; or the top of either a dead or living tree. The location of song perches seemed to be influenced by the presence of adjacent territories. Thus two males would frequently be seen answering each other's song along the common borders of their territories. However, much *advertising song* was heard near the center of territories. While singing from fence posts, males did not confine themselves to single perches but moved frequently from post to post about their territories.

Except during cold weather song was most intense and frequent in the spring, before males had acquired mates. In cold weather males sang only during the warmer parts of the day. When it was warmer males sang loudest and most frequently in the morning and evening. The unmated male bluebird was one of the last birds of any species to become silent at dusk, ceasing to sing only when it was almost completely dark. Exceptionally, at 2300 on the night of 2 June 1961, a bird nesting at box 61-19a was heard singing. The song period lasts until the later stages of the nestling period, reviving again during the early stages of the second brood.

Advertising song served the dual functions of mate attraction and establishment and maintenance of a territory. The best example of the attraction function was displayed by male 30-186119. This male had two broods in 1961 (61-19a and 61-19b). In 1962 he was not observed until 13 May. He first attempted to nest at 62-13-1. His future mate (also an adult banded in 1961) was nest-building at 62-4. Her mate disappeared, and she then moved to 62-13-1, being seen there on 13 May. She laid six eggs but was killed on about the second day of incubation, probably by a Sparrow Hawk (*Falco sparverius*). Male 30-186119 moved to 62-17-1, the Canyon Region of the study area, near his nests of 1961, and was seen there on 27 May. He attracted a new unbanded mate, who was then captured and banded, but she was driven off by Tree Swallows (*Iridoprocne bicolor*) after a week. He acquired a third unbanded mate, subsequently banded, on 18 June, but she was found dead on the nest on the fourteenth day of incubation. He finally succeeded in nesting with a fourth mate. She was observed for the first time on 28 June, and raised five young. Both the third and fourth mates used the nest built by the second female. Between mates this male sang intensely and frequently throughout entire days as he patrolled the periphery of his territory.

TERRITORY

The Mountain Bluebird's territory is of Berger's (1961:198) "Type A," that is, a large breeding area wherein courtship, copulation, nesting, and food-seeking occur. Although bluebirds were occasionally seen flying radially several hundred yards away from their nest boxes, it is unclear if these flights extended beyond the territorial limits. Generally, those pairs utilizing nesting boxes on fence or utility posts

confined their activities to flight up and down the fences or utility lines, and to areas in the immediate vicinity. Pairs using boxes attached to trees remained in the nest's immediate vicinity. "Territorial limits" had meaning only when territories were clearly defined along the borders of another territory (fig. 1). The smallest territory, noted in 1961, was situated between two other territories and was only approximately 100 yards wide, while other territories (such as 62-17) had no clear boundaries at all, and the resident bluebirds occasionally flew relatively great distances from their nests, up to about one-quarter mile away. Because boundaries were impossible to determine except where intraspecific conflict was seen, it was not possible to determine accurately the area of a given territory.

In early spring, unmated males and pairs that had not yet begun to nest ranged widely, usually flying from nest box to nest box. Defense of these areas was weak, and newly arriving males or pairs would encroach upon and occupy large portions of them. In 1961 one large area occupied initially by one pair eventually accommodated three pairs. At least four other pairs initially occupied nearly equally large areas: The canyon pairs (see fig. 1) frequently travelled from box 16 to box 19 before building a nest in box 17. This range also covered parts of the Canyon Ridge and Mid-hill. Pair 62-4 covered the area between 62-1 and 62-5 and 62-15. Pair 62-9 ranged from 62-7 to 62-9 and most of the West Ridge. Stable territories were established both as the result of intraspecific conflict and the beginning of nesting, which centered the birds' activities about one nest box. However, not all pairs followed this pattern. Pairs 62-13-1, 62-13-2, 62-10-1, and 62-10-2 had border adjustments, but the sizes of their defended areas remained about the same throughout the breeding season.

Several nesting territories were dissolved. Territory 62-4 dissolved when the male was killed or the field surrounding the nesting box was plowed. After the death of his first mate, male 30-186119 moved to the Canyon area from the Mid-hill. The female at 62-10-1 deserted immediately after being banded although she was incubating six eggs. Her mate apparently made no attempt to attract a replacement mate but also left. The banded pair that was seen for several weeks in the Canyon area disappeared due to unknown causes before male 30-186119 and mates arrived. Pairs 62-10-2 and 62-13-2 both arrived paired at Calvert in June, suggesting that they had had nesting territories elsewhere and had deserted them.

It appeared to me that Transition Zone nesting sites were more disputed than Upper Sonoran Zone nesting sites, and that resistance by an established pair against intrusion by other bluebirds or Tree Swallows was considerably stronger in the Transition Zone. Saunders (1921:169) also noted a greater bluebird population in the Transition Zone than in the Upper Sonoran. Possible reasons for this include more food, more perches, and more cover for newly fledged young (see Discussion).

TERRITORIAL DEFENSE

Nesting territories were defended by both sexes, the males more actively defending the territorial periphery while the females more vigorously defended the nest sites. The bluebirds' territorial aggressiveness was primarily defensive; intrusion upon other pairs' defended areas was uncommon.

Mechanisms of territorial defense included: (1) the males' *advertising song*; (2) conspicuous presence on the defended areas, making adjacent pairs aware of the area's occupation; and (3) three stages of fighting behavior: "flying-in-pursuit," "hovering display," and "striking" (after Lack, 1946).

The first two have been discussed previously; fighting behavior is described here. "Flying-in-pursuit" was accomplished when a bluebird or bluebirds crossed into the defended area of another pair. The resident bird or birds would fly toward the intruders uttering *alarm* notes. The intruder or intruders did one of three things: fled the area, thereby ending fighting behavior; not retreated but evaded the defenders in the air; or, resisted the attack of the defenders.

A good example of the extreme of evading the defenders in flight was presented by a conflict between an unidentified family and pair 61-9b. The resident male flew toward the intruding male and the resident female toward the intruding female. The males chased each other for a few minutes and then rested on a utility line. After a few minutes they pursued one another several times around a large fir. The females also chased each other in circles at first, but later went into the next phase of defense, "hovering display" (see below). Although no physical contact was made, the intruders left after about 15 minutes with their four young, who were never attacked, probably because they remained away from the scene of conflict. The resident pair was then sufficiently aroused to drive its own first-brood fledgling (which had disappeared at the beginning of the conflict) off its second-brood territory when it reappeared. The fledgling again returned but was again driven off. Finally, the male and female continued to exhibit their excitement by "flying-in-pursuit" of one another for less than a minute. As a rule, however, "flying-in-pursuit" resulted in the quick eviction of intruders.

When "flying-in-pursuit" behavior was ineffective, the resident birds commenced "hovering display." This display was characterized by two bluebirds flying slowly toward one another, moving upward as they came closer. This differed from foraging hovering not only in function but also because in ordinary hovering the bird's position relative to the earth was more or less constant. Apparently the bright spectrum of blue and purple produced by the opening and closing of the wings, especially conspicuous in the male, served to intimidate rivals in the same way that bright markings on other species of birds may intimidate their rivals. In the case mentioned above, "hovering display" was sufficient to cause the intruding female to flee the nesting territory.

Pair 62-12a used "hovering display" and later "striking" when pair 62-13-2 attempted to take box 12 away from the resident pair, at that time between its first and second broods. The male of pair 62-13-2 was examining box 12 preceding the conflict; pair 62-12a resisted this, the male starting "hovering display" against the male of 62-13-2. Both acted identically prior to striking. The hovering males came into contact in midair, clutched with their feet, and fluttered to the earth clinging to one another. There they rolled on the ground, striking with their bills and continuing to clutch with their feet while the female of 62-13-2 hovered a few inches above them. No sounds were heard from either bird during hovering or striking, which occupied less than a minute. The males then separated and perched a few inches apart on a fence wire near box 12. After less than a minute they repeated the sequence, the "hovering display" again terminating in "striking" with the same female hovering over them. After the entire encounter, which lasted but a few minutes, pair 62-13-2 retreated to its own area. The female of 62-12a was attending to the young of her first brood, which had just fledged that day; this activity accounted for her absence during part of the conflict and the absence of conflict between the females.

Since intrusion upon defended areas was uncommon, fighting behavior was also uncommon, and only a few cases of "hovering display," and this one case of "striking," were recorded. It can be concluded that the frequency of bluebird intraspecific conflict is low. Pair 62-13-2 was, however, exceptionally aggressive, as shown by its attack on 62-12 and also by its attempts to usurp the territory of male 30-186119 while he was between mates 3 and 4 (see above). While I was color banding 30-186119 on 16 June 1962, pair 62-13-2 entered his territory and watched from a distance of about 30 feet. When I released 30-186119 he flew due east away from me with pair 62-13-2 in close pursuit. When male 30-186119 was directly over his nest box he turned and, uttering *alarm* notes, drove them west by "flying-in-pursuit" until he was near me again. Pair 62-13-2 flew back to its own area. Then 30-186119 flew east and disappeared near box 18. Earlier in the day he had evicted the pair from the southwestern periphery of his territory. In addition to being a display of unusual aggressiveness, this example also shows the psychological advantage accruing to a bluebird near the center of its defended area.

On a few occasions I experimented with skins of a male and female bluebird. Lack (1946:157) noted cases of Robins (*Erithacus rubecula*) attacking a stuffed robin for as long as 40 minutes. Some attempted to copulate with it, others perched on it, and one attacked the air where the dummy had been. No such violent reactions to the bluebird dummies were observed. The bluebirds quickly became indifferent to them, and most acted in the following manner. The male of 62-9 ignored the female mount (unfortunately it was not in good condition) as did all birds studied, although it was in his presence for 30 minutes. However, when a male dummy was put up near the nest box, the live male vocally *alarmed* but made no move against it. His mate temporarily showed a strong reaction to it. Three times she started to fly past it to feed her young but each time turned back to perch on the utility line overhead. On the fourth attempt she entered the box and fed. The dummy was then removed.

The most vigorous reaction was shown by pair 62-12a when the male dummy was set up on a stick about four feet high, a few feet in front of its nest box containing incubated eggs. When the female returned to the box, about a minute before the male, she hovered closely over the dummy, thus responding by "hovering display" as she would have to a live intruder. She then entered the nest, came out again, and hovered only a few feet away. She then entered her nest box and remained there. When the male returned, he hovered over the dummy twice, *alarming* as he did so. Then he sat on the fence in silence until the dummy was taken down. Other pairs sometimes stayed at a distance when the dummy was set up before the nest box. This was possibly indifference rather than a fear reaction.

PAIR RELATIONS

Prior to pair formation, males arrived and occupied territories containing one or more nest sites. Females usually arrived later, and thereafter pairs could be distinguished. The earliest date in 1962 on which a pair was recognized was 31 March, and the last date in 1962 on which a previously unmated male was known to have acquired a mate was 20 May. These dates are only approximate, since observations in 1962 were made principally on weekends before 1 June. No paired birds were seen to act antagonistically toward their mates with the single exception previously described.

All males were monogamous except one. This was male 30-196408 who nested

TABLE 1
USE OF NEST BOXES

Year	Houses available	Mountain Bluebirds	Tree Swallows	House Wrens	Mountain Chickadee	Rodent	Not used
1960	10	1	4	0	0	0	5
1961	17	9	6	0	0	0	2
1962	22	5	11	2	1	1	2
1963	29	10	10	0	0	1	8
	Totals	25[a]	31	2	1	2	17

[a] Two additional pairs did not attempt to nest. Of those nesting, data were obtained on 21 nests.

at 62-10-2 in 1962 and returned in 1963 to have mates at 63-10 and 63-22. These boxes were only about 50 yards apart.

From earliest spring males occasionally made attempts at coition. These early attempts were repulsed. A typical early attempt was exemplified by pair 62-12a. The male chased his mate and nearly caught her in flight, but she turned sharply. He followed, and both perched next to one another on a wire fence. These attempts were common and frequently repeated.

The few times copulation was observed no prior sound was heard from either the males or females. In precopulatory display the females held their bodies horizontal with heads raised, wings slightly lowered, and tails raised, while on an elevated perch. Males simply flew up to their mates and mounted them. On one occasion a male was seen to lower his breast to a level with his feet and while calling, raise his head rapidly, while perched next to the female. Between what appeared to be copulations, males often made unsuccessful attempts but were repulsed by the females.

NEST SITE

Early in the breeding season, males explored the nest boxes in their territories. If accompanied by a female, the male almost always entered the box first. Mateless males with more than one nest box in their territories never confined their activities to any one of them; but pairs, soon after forming, centered their activities on only one box and began nest building. From this I concluded that females make the choice of the nest site.

On 1 April 1963 nest boxes 16 to 18 were nailed in place, and the nest box at position 19 was replaced because it had a broken roof. Moments prior to the replacement of this last box, it was being explored by a pair of bluebirds that fled to the area of the Mid-hill when I replaced the box. Almost immediately after its replacement this same pair was seen flying to nest box 18, the male and female calling loudly to each other. This pair then explored this newly found nest site in an intensely excited fashion, each member going in and out of the nest box many times in the course of a few minutes, calling to each other loudly and constantly. This activity continued for nearly 10 minutes. However, this pair never nested on the study area.

Several males behaved unusually at various times. Male 62-10-1 tried to enter a shallow knothole in a tree trunk. An unbanded male at box 10 walked on the box's top to the tree trunk to which the box was nailed, and to a depression in that

tree trunk, strained hard against it, seemingly trying to walk through it, lost his balance, backed away, and tried again. He then flew to the other trunk of the tree to which the box was nailed and tried to climb into a depression there. An unbanded male in the Canyon area tried to enter a crevice in a cliff. He clung upright and then succeeded in pushing himself into a niche about three inches deep so that only his tail protruded. An examination of all three sites revealed no food, indicating that the birds were not foraging. Criddle (1929:41) described similar behavior and concluded that the males were examining potential nest sites. However, the males he observed were accompanied by females, while those at Calvert were alone.

Bird boxes were the only nesting sites used at Calvert during this study, although other types of nest sites were observed elsewhere in Montana. These included hollowed tree trunks and utility poles, eaves, and between the horizontal beams of bridges. The last-named site is not uncommon in western Montana (table 1).

Van Tyne and Berger (1959:340) describe symbolic nest building as occurring when one or both sexes pick up, manipulate, or carry nesting materials. At Calvert expressions of this behavior pattern were observed on six separate occasions. A typical example of this was furnished by pair 62-4. The male and female landed on the ground below their nest box. Then, while the female watched, the male went through all the motions of picking up nest materials, but did not actually pick up anything. He then went into the box for several seconds, came out, and repeated this sequence several times while the female stayed on the ground.

This ceremony may account for Wheelock's (1904:507) statement that the males help build the nest. However, observations at Calvert indicate that only the female builds. The manner of construction was exemplified by a pair that built in 1961. The male sat on the fence near the box while the female picked up grasses within a few feet of the box and carried them in, rapidly returning for a new supply. She made more than a dozen trips within 15 minutes carrying two or three pieces each time. The male flew from perch to perch, closely watching her activity, but he did not assist her. The entire proceeding was accompanied by much excitement on the part of both birds. Nest building required between four and six days. The median date for nest completion of five first-brood nests in 1962 was 2 May.

Headstrom's (1951:166) description of Mountain Bluebird nests—mostly dried grass, sometimes lined with feathers—adequately describes the Calvert nests except that in two of them pieces of aluminum radar chaff were found. Nests were cup-shaped and placed near the back of the box. These cups were just large enough for the female to cover the eggs snugly. Nests were well-flattened by first-brood young and frequently filthy with excrement, but they were remodeled and cleaned for second broods and for use in subsequent seasons.

EGGS AND INCUBATION

One egg was laid each day until the clutch was complete. The median date for completion of the clutches of the early first clutches in 1962 was 16 May, and for the four late first clutches it was 21 June. A distinction is made between "early" and "late" first broods (Lack, 1948) since the latter refers to broods of pairs that were not the original occupants of the nest boxes in which they subsequently nested. Early clutches consisted of six eggs each in all but one case, while late first clutches and second clutches had five eggs each. Table 2 summarizes data on clutch size and success.

TABLE 2

NESTING SUCCESS, 1961 AND 1962

Nest no.	Approx. date clutch completed	No. eggs laid	No. eggs hatched	No. young fledged	Remarks
			Early first broods		
61-4a	Before 5-23	6	6	6	
61-12a	5-15	6	6	6	
61-13	5-31	6	6	6	
61-14	5-28	6	6	4	2 young fledged prematurely and died
61-19a	5-27	6	6	6	
62-4	——	0	0	0	Pair deserted, cause unknown
62-9	5-18	6	6	5	1 young hatched 1 day late and starved
62-10-1	5-13	6	0	0	Pair deserted when banded
62-12a	5-11	6	6	6	
62-13-1	5-19	6	0	0	Incubating female killed by predator
62-17-1	——	0	0	0	Pair deserted, cause unknown
61-6a	5-15	5	2	2	3 albino eggs infertile
			Late first broods		
62-10-2	6-14	5	5	3	2 young collected
62-13-2	6-29	5	4	0	Young died in nest, cause unknown
62-17-2	6-6	5	0	0	Incubating female killed by predator
62-17-3	7-5	5	5	5	
			Second broods		
61-3b	6-24	5	5	1	4 young collected
61-9b	6-25	5	2	2	3 albino eggs infertile
61-10b	Before 7-25	5	5	4	1 young killed by *Calliphora* larvae
61-19b	6-6	5	5	0	Pair deserted when banded
62-12b	6-25	5	5	5	
21 nests, Total		104	80	61	
16 nests undisturbed		77	59	53	

Normal egg color is a very light blue, and Bent (1949) states that Mountain Bluebird eggs are pure white "much less often than those of eastern bluebirds." Laskey (1939) found that albinistic eggs comprised 9.1 per cent of the total number laid by Eastern Bluebirds and that these eggs frequently hatched. During the present study nine whitish eggs (8.3 per cent of the total number laid) were found. In 1960 two white eggs were found infertile in a clutch of five laid by an unbanded female; the three normally colored eggs hatched. In 1961 a female, possibly the same one as in 1960, laid two clutches of five eggs each; three eggs were nearly white and were infertile in each of these clutches, but the two normally pigmented eggs in each clutch hatched. In 1962 the female of 62-17-3 laid four normal eggs and one very pale egg, and all hatched. This was the only case in which a whitish egg was fertile. In contrast, none of the normally pigmented eggs was infertile. Thus, this study found the frequency of white eggs to be about equal in these two species of *Sialia*, but with a strong indication that they are less viable in *S. currucoides* than are normally pigmented eggs.

TABLE 3

INCUBATION AND BROODING RHYTHM OF FEMALES

Nest no.	Stage of incubation	Total observation period	Periods on nest				Periods off nest			
			No. of periods	Length, min		% of time eggs covered	No. of periods	Length, min		% of time eggs not covered
				Mean	Range			Mean	Range	
62-13-1	1–2 days	2 hrs 57 min	7	18.6	6–37	73.5	7	6.7	0.5–13.5	26.5
62-17-2	6	3 2	3	52.7[a]	24–84	86.8	3	8.0	7–9	13.2
61-14	7	3 5	4	41[b]	17–62	88.5	3	6.7	5–8	11.3
61-14	7	1 15	4	14.0	1–34	74.7	3	6.3	1–10	25.3
62-13-2	10	1 8	4	11.6	0.5–30	68.3	3	7.2	2.5–14	31.7
61-12	12–14	1 43	5	15.2	11–23	73.7	4	6.8	5–9	26.3
Totals and means		13 10	27	25.6	0.5–84	79.9	23	7.0	0.5–14	20.1
	Stage of brooding					% of time young brooded				% of time young not brooded
61-14	1 day	1 13	3	16.3	2–35[c]	67.1	2	12.0	12–21	32.9
62-10-2	3	1 9	6	6.2	2–13	55.0	5	6.2	3–12	45.0
62-9	5	1 21	4	9.8	3–17	48.2	3	14.0	6–18	51.8
Totals and means		3 43	13	10.7	2–35	56.8	10	10.7	3–21	43.2

[a] Long period due to Tree Swallow and House Wren disturbance.
[b] Long period due to rain.
[c] Long period due to last-laid egg of clutch still being incubated.

Generally incubation began on the day the last egg was laid; but in two cases incubation began with the penultimate egg. In these two cases the last egg hatched one day later than the other eggs in the clutches, and in one of these nests the youngest sibling did not survive.

The incubation period determined by observation of color-marked eggs in three nests lasted 13 days. All daytime observations showed only the female incubating, and a check during the night of 2 June 1961 showed that of four nests with eggs, all were being incubated by females, with the males roosting elsewhere.

Table 3 summarizes some observations on the incubation rhythm. During a typical day of the incubation period females could be seen going on and off the nests at relatively regular intervals. After entering the nest boxes, females would look out the entrances for a few seconds before settling down on their eggs. If a female were disturbed by her mate's *alarm* notes, *signal song*, or occasional landing at the entrance, or on the roof, or if she were disturbed by the observer, she would look out a number of times in a few minutes.

During periods off the nest a female would feed or perch, using "perch-feeding" (see below) more often than any other type of foraging. Females either fed near the nest or flew to some other section of the territory. Upon returning to the nest, females usually went directly to it, and seldom acted secretive. Males frequently accompanied their mates during off periods. Both sexes were very vocal during trips, giving the *signal song*. Occasionally the male of a pair would call his mate off the nest by perching at the entrance and calling, calling while flying by the house, or calling after he had perched nearby.

TABLE 4

RATE OF FEEDING AND ROLE OF SEXES IN FEEDING

Nest no.	Young in nest	Age of nestlings in days	Total observation period		Feedings, no. per hour			Feedings, no./hour/ nestling	Average time elapsed between feedings
			hrs	min	total	male	female		
61-14	6	1	1	13	4	4	0	0.7	15 min
62-10-2	5	3	1	6	12	12	0	2.4	5
62-9	6	4–5	2	12	8.6	4	4.6	1.4	7
61-13	6	7–8	3	0	22.7	7	15.7	3.8	2.6
62-12a	5	11–13	3	3	22.6	7.5	15.1	3.7	2.7
61-12	6	18–20	2	0	17.5	12.5	5.0	2.9	3.4
61-19a	5	21–22	3	0	10.7	3	7.7	2.1	5.6
Totals and average	5.7		15	34	14.0	7.1	6.9	2.4	5.8

HATCHING

Eleven hatchings were observed in part. In all cases the process required several hours. On hatching the egg cleaved into approximately three-quarter and one-quarter sections, the smaller section being the large end of the egg, which adhered to the hatchling's head. Then the bird pushed itself out of its shell. Contrary to Wheelock's (1904:507) observations, hatchlings were found to have a few strands of stringy, wet down; when dry the down was a blackish color. The adults removed the shells from their offspring, but the subsequent fate of the shells is unknown.

The median hatching date in 1962 for early first clutches was 29 May, and for late first clutches, 9 July.

NESTLING PERIOD

The females brooded their nestlings through the sixth day after hatching. The females' behavior and rhythm were similar to their behavior during incubation (table 3).

The food brought to the young appeared to be entirely animal, including larvae and flying insects. The male at nest 61-19b was seen bringing solid food every time he came to the nest containing one-day-old nestlings. When the female returned to the nest she was not observed to bring solid food. She may either have brought small pieces of solid food, not visible at a distance, or regurgitated food, as claimed by Wheelock (1904:507).

Visible food was not brought by the male and female of nest 62-10-2, when caring for three-day-old nestlings. However, by the time the young were five days old, the female at nest 62-9, feeding more than the male, was observed bringing visible solid food (table 4). The possibility of regurgitative feeding of young nestlings needs further investigation.

When feeding nestlings, the adults either came directly to the nest to feed or else first perched nearby on an elevated object. If predators or humans were in the area, the adults would sometimes hold the food in their beaks several minutes before feeding. Occasionally under these circumstances, they would eat the food, but the drive to feed was very strong, and on several occasions members of two pairs fed their young while the observer was less than 10 feet from the nests. How-

TABLE 5
BODY WEIGHT OF NESTLINGS

Age of young in days	Nest no.	No. of young in each nest and weight in grams					Mean body weight (g)
		1	2	3	4	5	
0–2	62-13-2	4	4	–	–	–	4.0
3–4	62-12b	6	8	4	7	7	6.4
5–6	–	–	–	–	–	–	–
7–8	62-12b	12	14	10	14	12	12.4
9–10	62-12b	18	23	21	20	24	21.2
11–12	62-12b	25	24	25	23	22	23.0
13–14	62-12b	25	28	28	27	28	27.2
15–16	62-10-2	28	26	26	26	25	26.2
17–18	62-10-2	25.5	26	23	25	24	24.7
19–20	62-10-2	23	19	19	18.5	–	19.9

ever, this was done with evident nervousness on the part of the adults. While the females fed the nestlings fairly uniformly during any observation period, the males fed erratically. It was not uncommon for the male to feed several times within a few minutes and then not feed for 10 minutes or more. Thus, a male fed 100 per cent of the visible food to one-day-old nestlings, while he fed only 28 per cent of the food to 21- to 22-day-old nestlings.

An unusual feeding pattern was seen at times. The male flew toward the nest with food when the female was inside the box. She came out the entrance just as the male reached it. While the male moved to one side, she took the food from him and perched nearby, where she either ate it or waited for the male to leave, after which she fed the young.

Both parents removed fecal sacs from the nest. Only twice were adults seen to eat these; occasionally, they were dropped while the bird hovered, but usually they were carried to fence posts or tree limbs and deposited there, after which the bird wiped its beak on the post or limb. Certain posts or limbs on each nesting territory accumulated considerable amounts of dung on them before being washed off by the rains. But posts commonly used for singing or perching rarely had feces deposited on them. No feces were observed being removed from nests containing one-day-old young; one sac was observed being removed from three-day-old nestlings, and none was observed being removed from five-day-old nestlings. However, regular removal was observed after that until about 20 days of age. This may indicate that feces are eaten early in the nestling period. At the end of the period all nests were filthy with excrement, showing either that the feces lose their saclike form then, or else that the parents stop cleaning the nest.

In the removal of feces, as with feeding, the labor of the female is relatively greater than that of the male. Observations on a nest containing 11- to 13-day-old young showed that of 33 fecal sacs removed in a three-hour period, 20 were removed by the female.

Body weights of known-age nestlings are presented in table 5. A series of known-age nestlings, collected at two-day intervals, was preserved, and is deposited in the University of Montana Zoological Museum.

FLEDGLING PERIOD

Young normally fledged between 22 and 23 days after hatching. Median fledging date for early first broods in 1962 was 21 June and for late first broods, 28 July. Two broods, excited by handling, left the nest prematurely, although still not able to fly. At nest 62-14, six young left the nest when 16 days old; they scampered clumsily along the ground seeking cover. Five of these were recovered and replaced in the nest, but only four remained the next day. The other two were ignored by their parents and died; the remaining four successfully fledged at 22–23 days. The two nestlings of 61-6 (three eggs were infertile) both fledged at 19 days of age, and despite poor flying ability and lack of coordination, both survived several days, with one known to reach independence because of the parents' care. After these experiences, whenever nestlings were banded or weighed, they were quieted and prevented from fledging prematurely by covering the entrances of the boxes for about 15 minutes, thereby darkening the interiors. This technique prevented premature fledging.

When the young fledged naturally they left the nest able to fly only short distances. The young of each nest left one after the other, dispersing about the nest. When the young landed on the ground after their initial flight, the parents of the brood excitedly led them to cover. This was often a considerable distance. Thus pair 61-6 led its 19-day-old young one-third of a mile to the cover of the West Ridge, taking over two hours. The nestlings of 61-4 and 61-13 had to go even greater distances to reach cover. Thus Upper Sonoran Zone territories were deserted on the day of fledging when the young were led to cover in Transition Zone vegetation, while Transition Zone territories were not abandoned until the young had reached independence and continued to be occupied if there was a second brood. Lack of cover in the Upper Sonoran Zone is probably one of the major factors in the observed preference for Transition Zone nesting territories.

Parents led their young to cover by flying to them, perching by them, hovering over them, or circling them, flying a short distance in the desired direction, and repeating this sequence until the young followed. Often several of these trips were necessary before the young would fly. The fledglings begged frequently, and were fed occasionally. Fledging was accompanied by much parental vocalization, particularly *alarm*, *signal song*, and *mechanical alarm*. If danger threatened, the parents returned to their young, dived at them snapping their beaks (*mechanical alarm*) and *alarm* also, thus causing the young to remain motionless. At the end of the first day out of the nest, fledglings were much better coordinated and able to perch on elevated objects.

The parents always returned to the nest several times as though to make sure that all the young had fledged. One male (61-6) kept returning to the nest on the day of the premature fledging of his 19-day-old young for as long as 30 minutes at a time. This might have been because of inability of the male to respond properly to a new situation rather than due to an attachment to the nest.

Perhaps because of the excitement of fledging, the adults of nest 62-12a were very obvious in feeding the young, and the female led the observer to all six members of her brood. The male of this pair was shyer and fed the young less often and more discreetly, sometimes ignoring them for from 10 to 20 minutes.

Fledglings just out of the nest had much difficulty in flying. They usually flew only short distances before falling to the ground. I caught one that was unable

to fly out of tall grass into which it had fallen. However, if "launched" by hand they flew nearly twice as far and effected fairly graceful landings. After four days from the nest, or at 26–27 days of age, the fledglings of nest 62-12a flew fairly well and stayed close together but were still dependent on the adults for food. Throughout the entire postfledging period the male of nest 62-12a was the primary attendant because the female was incubating the eggs of a second brood.

POSTFLEDGING PERIOD

About 11 days after fledging (33–34 days old) the young of nest 62-12a were able to obtain their own food but were still attended by the male and soon became proficient in the three major types of bluebird feeding.

On about the fifteenth day after fledging (37–38 days old) the young of nest 62-12a seemed to fly perfectly except when landing on moving branches or tree tops. At this time the young were seen for the first time catching large insects and beating them upon perches before eating them. Thirty-one to 32 days after fledging (53–55 days old) the first-brood young of 62-12a were near the second brood nest containing nine-day-old young, even though the first-brood young had become independent of the male's guardianship between 22 and 28 days after leaving the nest (44–51 days old). A similar case was noted at nest 61-9, where the pair at 61-6, rearing its second brood, were accompanied by the single surviving offspring of the first brood. In neither case were first-brood juveniles seen to feed the second brood, as was observed by Mills (1931:8–9) with Mountain Bluebirds in Colorado and Laskey (1939:28) with Eastern Bluebirds in Tennessee.

The adults of 62-12b drove the last of their first brood (a young male with bright wings) off their territory five times after he came near the nest box when he was 35–36 days from the nest (57–59 days old). The first four chases were of only a few yards and were executed by the male or female or both. On the last chase the male chased the young bird completely out of the territory. Similarly in 1961, the adults of 61-9 chased their first-brood juvenile off their territory after they had defended their territory against a trespassing family.

SECOND BROODS

There were four second broods in 1961 and one in 1962; 50 per cent of all pairs successfully raising first broods attempted second broods. All five second clutches were of five eggs; the median date for the completion of laying was 27 June. Nests 61-19 and 62-12 were used for both first and second broods. Pair 61-6 chose box 61-9 for a second brood; pair 61-12 chose box 61-10; and pair 61-4 chose box 61-3. In these latter three cases I had removed the old nests while in the first two cases I had not. The hatching and fledging dates for 1962 were 8 July and 31 July.

BANDING RETURNS AND NESTING SUCCESS

Although no young banded in 1961 returned in 1962, one banded in 1962 returned to nest in 1963; three of seven adults banded in 1961 came back to Calvert in 1962, and three of 12 adults banded in 1962 returned in 1963, including one female that was banded as an adult in 1961 and was therefore at least three years old. Three of the five returning adults, one male and two females, nested in the boxes they had previously occupied, and the others nested very close to their former nesting territories, indicating strong fidelity to the nesting area.

Although only a small sample of eggs and young were available for analysis, there is a strong indication of high nesting success. Of 16 nests that were relatively undisturbed (no desertions due to banding or collection of young), the hatching success was 76.6 per cent; the fledging success based upon the number of eggs laid was 68.8 per cent; and the percentage of successful nests (those fledging at least one young) was 68.7 per cent. Summarizing 33 studies of hole-nesting species in the New and Old Worlds, Nice (1957:305, 310) reported an average hatching success of 77 per cent, a fledging success of 66 per cent, and a nesting success of 66.8 per cent. In reporting upon five studies of the Eastern Bluebird, Nice (1957:308) noted a hatching success ranging from 63 to 80.1 per cent, and a fledging success from 44.5 to 72.7 per cent. Again, Nice (1951:315) noted an average 38 days in the nest (incubation plus nestling time) for North American hole-nesters, which is two days more than the time spent in the nest by the Mountain Bluebird. Therefore, low nesting success does not seem to be a probable cause of the alleged decline in numbers of this species.

AUTUMN FLOCKING AND MIGRATION

In early August bluebirds began forming flocks of five to 43 birds that were scattered along the road for several miles north of the study area. These early-autumn flocks consisted mostly of juveniles and a few females. Most adult females and males disappeared at this time for a few weeks, returning in late August. This corresponds to the time given by Ridgway (1907) for bluebird postnuptial and postjuvenal molts. By late August the flocks were composed of birds of all ages and both sexes. Most of the juveniles and females left Calvert in mid-September 1961, while the last males departed in late September and early October 1961. In 1962 no bluebirds remained at Calvert in early September following a series of severe, unseasonably early snowstorms.

FORAGING AND BATHING

Mountain Bluebirds have three distinct types of foraging behavior, used in the following order of frequency: "Perch-feeding," "hovering," and "flycatching."

"Perch-feeding" refers to feeding behavior in which bluebirds perch on an object such as a fence post, small bush, tree, or utility line, and fly a short distance to the ground, immediately below the perch or somewhere near it. There they seize the animal or vegetable matter, which is eaten on the spot unless young are being fed. The birds then resume their former perches or an adjacent one to look once more for food.

When "hovering," bluebirds mount into the air from three to 30 feet and then rapidly descend to the ground, seize their prey, and return to a perch to consume it.

"Flycatching" was used most frequently for foraging during the nestling period when food demands were greatest. This feeding behavior was of the type characteristic of many species of birds.

No bluebird was ever seen drinking fresh water; this need was probably satisfied by animal juices and green plant food.

Sun bathing and water bathing were each seen once. The male (62-12a) that was seen sun bathing did so during a temporary lull in a light rain. He landed on a boulder, stretched, holding out his tail and right wing, then both wings together, and finally flattened himself against the boulder. He held this pose until an uniden-

tified small bird flew over him, whereupon he resumed normal posture. Water bathing was indulged in by the male of nest 62-9. It had rained the night before, and a shallow depression in a limestone rock outcropping was filled with water. The male bathed three times, splashing vigorously each time and shaking the water off afterward, and then flew to the nearby utility line to perch and dry himself for a few seconds before bathing again.

PREDATORS AND COMPETITORS

Three cases of apparent predation were noted during the study. A group of plucked fledgling feathers was found a few feet from nest 61-12 after the young of the nest had fledged (17 June 1961). For several days prior to that an adult female Marsh Hawk (*Circus cyaneus*) was several times observed perching on the fence to which boxes 11 to 15 were attached, nests 61-12 to 61-14 being occupied. As the hawk fled whenever she observed me approaching her from a distance, it was impossible to observe any defensive actions the bluebirds may have taken against her.

Female 62-13-1, who had had two broods in 1961 and was incubating six eggs in her first brood of 1962, was apparently killed on 2 June 1962. Again a group of feathers was found, this time about 50 feet from the nest, near a wire fence indicating that she probably had been "perch-feeding" just before her death. Whereas the fledgling killed in 1961 was easy prey for any hawk, this female was experienced, beginning at least the third summer of her life. About this time a female Sparrow Hawk (*Falco sparverius*) was seen attacking a flock of Mourning Doves (*Zenaidura macroura*) in the area by rapidly flying only about 18 inches above the ground, and possibly she was responsible. Previously in late September 1961, a Sparrow Hawk had chased an adult male bluebird for about one-sixth of a mile but was easily outmaneuvered by the bluebird.

Male 30-186119's third mate of 1962 (the female cited above was his first mate of 1962) was found dead on her nest on what would have been the fourteenth day of incubation of her clutch of five eggs (18 June 1962). Her cloaca was distended about one-fourth of an inch, and her tail covered with feces. A small mammal may have been the predator in this case.

The day the young of nest 62-12a fledged, a group of Common Crows (*Corvus brachyrhynchos*) were perched above the hiding places of the fledged young. I frightened them off, but a few days later only three of the original six fledglings remained. While the crows were near the hidden young, the parent bluebirds *alarmed* constantly, did not feed the young, and kept the fledglings silent.

Bluebirds appeared to be indifferent to most predators in the area except for Pigeon Hawks (*Falco columbarius*). In late June 1961 a pair of these falcons was seen several times on the study area over a period of a few days. Whenever the Pigeon Hawks neared an active nest, the adults took cover, reappearing only after the raptors disappeared.

On the Calvert area, the only significant competitors were Tree Swallows, which constantly harassed the bluebirds. All bluebird nest boxes in both study years attracted the attentions of swallows both preceding and during most of the nesting period. Swallows provided especially strong competition at nests 62-13-2 and 62-17-1. At the former nest, swallows managed to lay an egg and keep the bluebirds out, before I removed the swallows and the egg. This may account in part for the unusual aggressiveness of this bluebird pair toward other bluebird pairs, but it is paradoxical that the birds should be so aggressive toward others of their species and

yet unable to evict a pair of the smaller swallows. In the latter nest (62-17-1) Tree Swallows drove male 30-186119's second mate of the year off, after she had completed a nest. A series of incidents of the type likely to have driven her off occurred on 27 May 1962, as follows. The swallows first dove at the perched bluebird pair. The female bluebird then entered box 18, where the swallows were building a nest, followed by a male swallow. A fight ensued within the box with loud, unusual vocalizations coming from both, but especially from the bluebird. I approached the box, and the mate of each combatant *alarmed*. But neither bird left the box. The swallow was removed and the female bluebird banded. She was still in the vicinity a short time later, acting normally, and showing no signs of desertion because of the banding. However, she had disappeared by 2 June, and it was assumed that her departure was brought about either by swallows or predators. Even with male 30-186119's third mate, attacks by swallows continued until I removed the swallows.

Generally, attacks were not nearly so vigorous as the one mentioned above, but swallows commonly fought in groups of from four to eight birds. Bluebirds typically defended with one bluebird perching on the roof of a box while the other perched nearby and sallied out to chase swallows that came too close to the box. If a swallow swooped at the bluebird on the rooftop, that bluebird chased the intruding swallow. On one occasion a bluebird managed to grab a swallow's tail in flight, and both fell grappling with their feet until about one foot above the ground, when they broke apart and the bluebird chased the swallow away. Except for the one occasion of 30-186119's second mate, cited above, no bluebird was ever observed to be defeated by a swallow.

House Wrens (*Troglodytes aedon*) provided a different problem. They secured boxes 18 and 19 in 1962 after the swallows were removed, and male 30-186119 and his third mate concentrated their activities at nest 62-17. A punctured bluebird egg was found in nest 62-17-2, presumably the work of wrens, shortly after the wrens began nesting. Another punctured bluebird egg found in nest 62-13-2 never hatched, although other eggs in the clutch did. Whether wrens were responsible for puncturing this egg is not known, for the nest was quite far from boxes 18 and 19.

Mountain Chickadees (*Parus gambeli*) were not serious nest-site competitors, nesting only in 1962 in box 8, about 40 feet from nest 62-9. They were molested neither by the bluebirds at nest 62-9 nor by any swallows. This nest box was not favored by the other species since it was placed on a utility pole facing a group of Douglas-firs only about four feet away. The chickadees spent most of their time in these and other trees nearby.

Red-shafted Flickers (*Colaptes cafer*) chiseled at the doorway of box 62-33 but were driven off by the bluebirds.

No birds ever attempted to nest in box 29, but a rodent, probably a Bushy-tailed Woodrat (*Neotoma cinerea*), enlarged the entrance hole and nested in the box. Also a Deer Mouse (*Peromyscus maniculatus*) built a nest in box 5 in 1963 but was removed.

DISCUSSION

If there has been a sharp decline in the population density of the Mountain Bluebird over the past several decades, the cause of that decline is still obscure. As noted above, breeding success of this species compares favorably with that of other hole-nesting species. Other possible causes of a population decline include adverse weather, disease, chemical pesticides, nest-site competition, loss of nesting sites, and

TABLE 6
MEDIAN DATES FOR SUCCESSIVE STAGES OF NESTING IN 1962

Stage	Early first brood	Late first brood	Second brood
Clutch completion	16 May (4)[a]	21 June (4)	25 June (1)[b]
Hatching	29 May (2)	9 July (3)	8 July (1)
Fledging	21 June (2)	28 July (2)	31 July (1)

[a] Sample size shown in parentheses.
[b] Including 1961 data, 27 June.

the phenomenon of nest-site selection. Data are fragmentary on most of these points, but the last three interrelated possibilities merit brief comment.

Nest-site competition cannot be a major cause of the alleged population decline. Of the three species capable of posing serious competition throughout the Montana breeding range, the Tree Swallow and the House Sparrow have had static populations during the time of the alleged population decline. Also the House Sparrow is very uncommon outside of urban areas and away from agricultural buildings, where most bluebirds are found. While the Starling population has increased dramatically since the early 1940's in Montana (P. L. Wright, personal communication), it did not become common in central Montana until 1956, by which time the bluebird population was already low. Moreover, over great areas of the mountainous portions of Montana, the Starling is still fairly uncommon.

A lack of suitable nesting sites over the Mountain Bluebird's Montana breeding range is possible. In much of eastern Montana, recent years have witnessed fewer bluebirds along with fewer wooden outbuildings. But townspeople having nesting boxes have noted no bluebirds since the 1930's, and in western Montana, where vacant homesteader's shacks and outbuildings abound, nesting bluebirds are not often found.

The requirements for a preferred nesting site and territory of the Mountain Bluebird are difficult to determine precisely. In spite of the wide range of nesting sites (see above) known to be used by Mountain Bluebirds, this species is limited in the types of structures it will utilize for nesting, since use of unusual sites is very rare. Territories usually included a large area with open spaces, wherein the nest site was located, and an area of trees, brush, and cover. Apparently the open cover was principally utilized by the adults for feeding, and the denser cover for protection of the newly fledged young. In 1961 the three territories located entirely within the open grassland of the Upper Sonoran Life Zone were abandoned by the occupying pairs and their broods as soon as the young had fledged. In these cases the adults led their broods to areas of denser cover. Two of these three pairs had second broods but in areas which included better cover. Only one Upper Sonoran Zone territory (no. 13) was successfully occupied during 1962 and 1963.

In 1962 and probably in 1963 there was a surplus of adults in breeding condition on or near the study area. Several nest boxes and territories in the Transition Life Zone were occupied by a succession of pairs and by replacements for dead or deserted mates. However, many vacant nest boxes located in the Upper Sonoran Life Zone, which had been used in 1961, were not utilized in 1962 or 1963. More nest boxes were available in the Transition Life Zone in 1962 than in 1961.

This nonexploitation of available nest boxes resulted in a distinctly different set

of median dates for progressive stages of nesting for those pairs that nested only after a previously occupied nest box was vacated (table 6). In these median dates it is possible to define "early" and "late" first broods in the manner of Lack (1948). Since late first broods and second broods both had five eggs per clutch, while early first broods usually had six, it is possible that this nonexploitation of available nesting sites within the Upper Sonoran Life Zone reduces the productivity per late-nesting pair both by eliminating the possibility of a second brood and by a reduced fecundity in the one nest attempted.

The various possible causes of the alleged Mountain Bluebird population decline discussed herein are largely unsupported by direct evidence. Thus it is impossible to draw any definite conclusions concerning the causes of decline. However, the most likely hypothesis is that highly specialized nesting requirements have produced a relatively unadaptable species, whose population has declined as a result of environmental changes of recent decades.

SUMMARY

The life history of the Mountain Bluebird (*Sialia currucoides*) was studied at Calvert, southern Cascade County, Montana, between May 1961 and June 1963. A total of 29 nest boxes were erected in 1960–1963, 126 bluebirds were banded, and 27 pairs and 21 nests were studied.

The median spring arrival date for males was 18 April, for females, 25 April. Six vocalizations were heard: *advertising song* (which served the dual purpose of mate attraction and territorial defense), *alarm*, *signal song*, *flight call*, *mechanical alarm*, and *nestling food call*. *Advertising song* was heard throughout the entire nesting cycle except in the later stages of the nestling periods.

Three types of territorial defense were observed, occurring in the following order: *advertising song*, male's conspicuous presence on his defended area, and fighting behavior. This last could be subdivided into "flying-in-pursuit," "hovering display," and "striking."

Pair formation occurred quickly, after females arrived and joined territorial males. Median date of pair formation was 25 April. Early coition attempts by males were repulsed. In precopulatory display, females on an elevated perch held their bodies horizontal with heads raised, wings slightly lowered, and tails raised. Pair bonds were broken through death or desertion of the mate.

Females made the final choice of nest sites. Nest building was done only by females and required between four and six days. The median nest-completion date was 2 May. Symbolic nest building was observed in the male. All nesting activities of a pair, such as courtship, copulation, nesting, and food seeking, occurred within the territory. Although few banded young returned, six of 19 banded adults returned, all nesting at or very close to their former nesting territories.

All normally pigmented eggs were fertile. Nine nearly albino eggs (8.3 per cent of the total) were laid, only one of which was fertile. One egg was laid each day until a clutch was completed. Early clutches usually consisted of six eggs each, and the median completion date was 16 May. Late first broods and second broods consisted of five eggs, with respective medians of 21 and 27 June. Incubation, by the female only, began the day the last egg was laid except on two occasions, and lasted 13 days. The median hatching date for early first broods in 1962 was 29 May, for late first broods, 9 July, and for second broods, 8 July.

Brooding was by the female only and lasted about six days. Feeding and feces

removal was done by both sexes. The size of food items depended on the age of nestlings. Regurgitative feeding may possibly occur when the nestlings are between one and five days old. Feces were sometimes eaten or dropped but usually deposited on fence posts or tree limbs.

Young normally fledged between 22 and 23 days of age. The median date for early first broods was 21 June, for late first broods, 28 July, and for second broods, 31 July. The greatest mortality rate occurred during the fledgling period. Fledglings began feeding themselves at about 33–34 days of age, approximately 11 days after leaving the nest.

Fledglings became completely food-independent at 22–28 days after leaving the nest (44–51 days of age). No first-brood young were seen feeding second-brood young.

Fifty per cent of all pairs successfully raising first broods had second broods. Old nests seemed to be preferred for second broods.

Nesting success (68.7 per cent) compared favorably with other hole-nesting species.

Fall flocks were formed in early August of the study years and consisted of from five to 43 juveniles and a few females. Most adults disappeared at this time for a few weeks, reappearing in late August, the period of absence corresponding to the period of postnuptial molt. By late August flocks were composed of birds of all ages and sexes.

No free water was observed being drunk at Calvert, and animal juices and green plant food probably satisfied the water need. Three distinct types of foraging behavior were seen: "perch-feeding," "hovering," and "flycatching." Sun bathing and water bathing were seen once.

The only probable predators observed were a Marsh Hawk, a Sparrow Hawk, and a group of Common Crows. Nest-site competitors were Tree Swallows, House Wrens, Mountain Chickadees, Red-shafted Flickers, and two rodents, probably a Bushy-tailed Woodrat and a Deer Mouse.

While no definite conclusions as to the cause of the alleged bluebird population decline have been reached, a number have been explored, and the possibility of too specialized nesting requirements is considered to have merit.

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LITERATURE CITED

AMADON, D. 1966. Birds around the world. Nat. Hist. Press, Garden City, N.Y.

BENT, A. C. 1949. Life histories of North American thrushes, kinglets, and their allies. U.S. Natl. Mus. Bull. 196.

BERGER, A. J. 1961. Bird study. John Wiley and Sons, London.

CRIDDLE, N. 1927. Habits of the Mountain Bluebird in Manitoba. Canadian Field-Naturalist, 41:40–44.

DAWSON, W. L., and J. H. BOWLES. 1909. The Birds of Washington I. Occidental Publishing Co., Seattle.
HEADSTROM, R. 1951. Birds' nests of the West: A field guide. Ives Washburn, New York.
LACK, D. 1946. The life of the Robin. H. F. and G. Witherby, London.
LACK, D. 1948. Natural selection and family size in the Robin. Evolution, 2:95–110.
LASKEY, A. R. 1939. A study of nesting Eastern Bluebirds. Bird-Banding, 10:23–32.
MILLS, E. A. 1931. Bird memories of the Rockies. Houghton Mifflin, Boston and New York.
RIDGWAY, R. 1907. The birds of North and Middle America. U.S. Natl. Mus. Bull. 50: pt. 4.
SAUNDERS, A. A. 1921. A distributional list of the birds of Montana. Pacific Coast Avifauna no. 14.
VAN TYNE, J., and A. J. BERGER. 1959. Fundamentals of ornithology. John Wiley and Sons, New York.
WEYDEMEYER, W. 1934. The song of the Mountain Bluebird. Condor, 36–164.
WHEELOCK, I. G. 1904. Birds of California. A. C. McClurg and Co., Chicago.

Department of Zoology, University of Montana, Missoula, Montana, 26 March 1965.