A STUDY OF EASTERN BLUEBIRDS IN ARKANSAS

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THE Eastern Bluebird (*Sialia sialis sialis*) is common in summer, and fairly common in winter, in the neighborhood of my home near North Little Rock, Arkansas. The country is rocky upland, with sandstone formations close to the surface. Most of the area is thin woodland, with oaks the predominating tree. Homes are isolated or in clusters along the highway. There are many open spaces, such as lawns, gardens, fields, and Bermuda pastures, while cattle ranging on unfenced areas keep grass short and undergrowth low.

This paper deals, first, with the Bluebirds that occupied three breeding territories near my home during the years I have banded birds, 1937–1945; second, with data collected from 1931 to August 1945 on the winter flock, pair formation, territory, and social behavior. The three territories lie in a row on the ridge of the hill on which our house is located (Figure 1). The middle, or Dooryard Territory, includes the tended part of the grounds, with small shallow pools and a feeding station which is maintained all year. From the Dooryard's central box, it is 75 yards to the one box in the Gate Territory to the east, and about

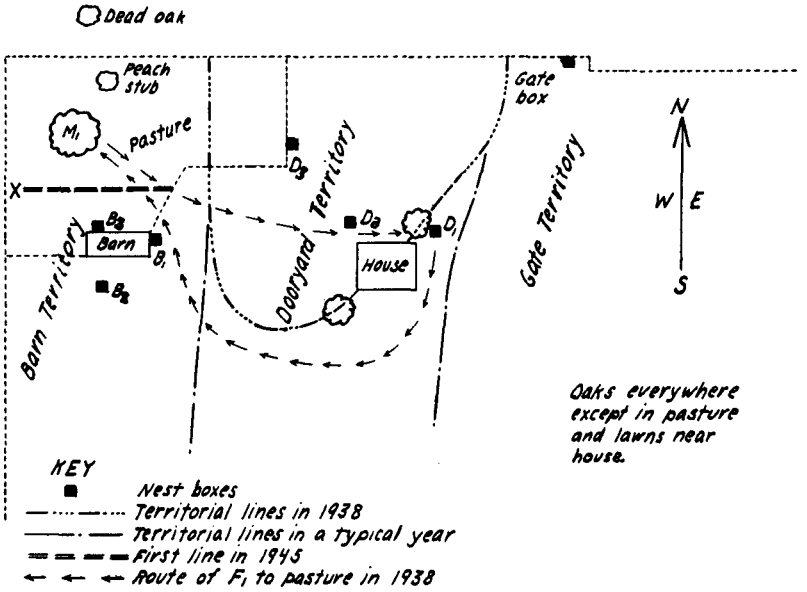

Figure 1. Map of three Bluebird territories, North Little Rock, Arkansas 1937–1945.

* I wish to express my appreciation to Mrs. Margaret M. Nice and J. Van Tyne for their assistance in preparing the text; to Prof. A. D. Moore for his careful draughting of Figure 1.

the same distance to the group of three boxes in the Barn Territory to the west. The Gate and Barn Territories are half wooded and half pasture land. Dividing lines established by the pairs, between Gate and Dooryard Territories, and between Dooryard and Barn, are perfectly clear; but the outer boundaries, i.e., the east side of the Gate Territory, west side of the Barn Territory, and north and south ends of all three territories, are not defined, since there are no near Bluebird neighbors in these directions. From the distances the pairs go for food for nestlings, I estimate that each territory comprises from two to three acres. In 1938, two pairs nested only 25 yards apart, but each territory spread away from the dividing line to the extent of two or more acres.

Technique

The Bluebirds were identified by banding and re-trapping. Many could be taken in a nest-box trap in the pre-nesting season, but since this did not indicate the ultimate owners of a territory, it was necessary to identify each pair in the course of each nesting. Females were lifted from their boxes in the latter part of incubation. This was most easily done before 6:30 a.m., when the birds were less alert than later in the day; males could usually be tempted into a trap just before or just after their young left the nest. The bait was always raw peanuts, shelled, and run through a meat chopper.

In 1937, two breeding pairs and one unmated female were banded on the left tarsus. Since their nestlings and adults of subsequent years were banded on the right tarsus, the last survivor (a female, *F*3)† of the 1937 group was recognizable at sight. In 1944 and 1945, I color-banded the breeding pairs.

Banding Data: Arrival, Residence, Returns

Table 1 summarizes the data on banding and returns. Of the nine males banded as adults and breeding in the area, the approximate date of arrival is known for seven: *M*7, October 20; *M*6, November 20; *M*9, November 22; *M*8, January 23; *M*11, February 6; *M*3, March; *M*5 (brought to the area by *F*3), May. They could have been present a week or so before they were caught. Of the 16 females banded as adults and breeding in the area, three (*F*1, *F*2, *F*3) were banded at the start of my banding in March 1937, and five (*F*4, *F*8, *F*13, *F*17, *F*18) were summer replacements for mated females that had been killed. Of the remaining eight, three (*F*5, *F*11, *F*15) were banded in April and June; five (*F*6, *F*7, *F*9, *F*10, *F*16), between November 14 and January 13. That is: at least four out of seven breeding males and five out of eight breeding females either wintered in the area in which they later held territories or came to their breeding ground in January, about two months before the start of nesting.

† Throughout this paper banded individuals that nested in the territories are designated by *F* (female) or *M* (male) followed by a number; other banded individuals are designated *F* or *M* followed by a letter indicating the color of their band (for example, *FG* = female banded green).

The seven males and seven females banded but not nesting in the study area were winter residents or January and February arrivals in search of nesting places. With some exceptions, they probably represented the number of Bluebirds above the available territories—the losers in the fights.

In addition to the four nestlings, listed in the table, that wintered at their birthplace and remained to nest, seven other young, banded as nestlings, were trapped in their first winter but were never retaken. These four breeders and seven winter residents do not represent a true percentage of the number of young remaining at the birthplace, since out of the 172 fledged in the three territories in nine breeding seasons (1937–1945) only 137 were banded. Laskey (1940:188) reported that of 521 nestlings banded in three years, 15 females were found breeding in the park in subsequent seasons, and several males, known by the band on the left tarsus to have been banded as nestlings, were seen.

Of the 10 banded breeding males (omitting from consideration *M*11, first banded in 1945), 6 (*M*1, *M*2, *M*4, *M*7, *M*8, *M*9), or 60 per cent, remained or returned to breed a second season; one (*M*2) of these for a third. Omitting from consideration the 4 banded breeding females (*F*7, *F*8, *F*10, *F*12) that were killed in their first nesting season, and *F*18, first banded in 1945, 8 out of 13 females, or 61.5 per cent, remained or returned to nest a second season; one (*F*9) of these for a third season; one (*F*3) for a third and fourth.

Four pairs (*M*1/*F*1, 1937–38; *M*2/*F*2, 1937–38; *M*7/*F*9, 1941–42; *M*8/*F*13, 1942–43) were mated in two successive seasons.

TABLE 1

BLUEBIRD BANDING DATA 1937–1945 NORTH LITTLE ROCK, ARKANSAS

Banded Oct.—Nov.	Banded Jan.—Feb.	Banded March	Banded Apr.—June
Breeders in study area banded as adults (9 ♂♂, 16 ♀♀)			
M6 '40 [41]	M8 '42 [42,43]	M1 '37 [37, 38]	M5 '40 [40]
M7 '40 [41, 42]	M11 '45 [45]	M2 '37 [37, 38, 39]	
M9 '42 [43,44]		M3 '38 [38]	
F7 '38 [39K]	F6 '39 [39]	F1 '37 [37, 38]	F4 '38 [38]
F9 '39 [40, 41, 42]	F16 '43 [44,45]	F2 '37 [37, 38K]	F5 '39 [39, 40]
F10 '40 [41K]		F3 '37 [37, 38, 39, 40]	F8 '39 [39K]
			F11 '42 [42]
			F13 '42 [42, 43]
			F15 '44 [44]
			F17 '44 [44, 45K]
			F18 '45 [45]
Breeders in study area banded as nestlings (2 ♂♂, 2 ♀♀)			
M4 '38 [39, 40]			
M10 '43 [44]			
			F12 '41 [42K]
			F14 '42 [43]
Non-breeders banded as adults (Nov.—Feb.): 7 ♂♂, 7 ♀♀; as nestlings: 133			

Total banded, March 1937—June 1945: 16 ad. ♂♂; 23 ad. ♀♀; 137 nestlings

M before a numeral designates a male; *F* a female.

Following each individual's number is the year of banding and (in square brackets) the year or years of nesting.

K following a year indicates that the bird disappeared or was killed in that nesting season.

Migratory Status

Most of the nesting pairs were permanent residents, while a few were known to migrate. This was easily observed in the first years, when the total number banded was small and the five individuals of 1937 were banded on the left tarsus and all others on the right. For the later years, data are incomplete. In order to establish a pair's permanent residence, they had to be trapped several times in November and December; failure to trap did not, of course, prove the pair had migrated.

After November 10, 1937, only one (*M1/F1*) of the pairs banded that year was seen; they were caught in every month up to March. The other pair (*M2/F2*) apparently migrated; they returned to their former territory in February 1938. The third left-banded female (*F3*) regularly migrated. The date of her return in 1938 was not noted; in 1939, it was March 1, and in 1940, February 28.

Migrating Bluebirds that stop over here (usually in groups of 6 to 12) may stimulate local birds to leave. For example, November 18, 1938, a flock estimated at 50—the only flock of that size I have ever seen—arrived on our hill and stayed for three days. On the fourth day, the transients, as well as the left-banded Bluebirds (including the pair, *M1/F1*, that had not migrated the winter before) were gone. *M1* and *F1* never returned; the other male, *M2*, was back on February 10, 1939.

Weather may also be a determining factor in migration. November and December in this latitude are very variable months. Some years there are a few cold spells with intervals of balmy days. Other years there is almost continuous cold from mid-November through December, with very heavy rainfall. The warmer weather may inhibit, and the colder release, the latent migratory impulse. Nice (1943:76) suggests this theory for the Song Sparrow (*Melospiza melodia*) of central Ohio.

Importance of Nest

In considering the life history of Bluebirds, one fact is outstanding: the individual's life is oriented to the nest site, a hole. As single birds, as pairs, or as flocks, they are drawn throughout the year, excepting only the period of the molt, to the vicinity of nesting places. The Bluebird's need is far more specialized than that of open nesters, even more than that of many hole-nesters. The Bluebird cannot make its own cavity, and it does not, as some wrens do, accept just any odd corner or cranny for a nest hole. The Bluebird requires a nest environment with open grassy places, spacious lawns, meadows, abandoned fields, pasture or fallow lands, or the margins of thin woods. Bluebirds can live neither in dense woods, nor in closely built residential sections of towns.

Several other species of hole-nesters are, to some degree, concerned with nest sites outside the breeding season. House Wrens (*Troglodytes aedon*) and Starlings (*Sturnus vulgaris*) occasionally visit boxes in

autumn, and the latter even throw out old nest material (Nice, letter). At my home, Bewick's Wrens (*Thryomanes bewickii*) remain mated or form new pairs in autumn, and the male defends a territory through the winter. They often roost in boxes, and "scold" when other hole nesters look at the boxes. Carolina Wrens (*Thryothorus ludovicianus*), which also remain paired through the winter, show less interest in nest sites, but look at boxes and explore sheds and farm buildings. Odum (1941–42) does not mention the Black-capped Chickadees (*Parus atricapillus*) as interested in nest sites until pair separation from the flock, but in this region a Carolina Chickadee (*Parus carolinensis*) will protest in mid-winter if, for example, a Downy Woodpecker (*Dryobates pubescens*) goes to the cavity or box that the Chickadee is using as a roost, and there is some casual examination by the Chickadees of holes in trees. Tufted Titmice (*Parus bicolor*) behave in general like the Chickadees.

In central Arkansas sexual activities among the hole-nesters appear so early in the year that no sharp line can be drawn between winter behavior and mating behavior. Bluebirds differ from the species mentioned above in this respect: the interest in nest sites is competitive between pairs within the flock, and is accompanied by "breeding" behavior, such as courtship and singing, and occasionally by fighting, throughout the non-breeding season.

Pairing and Courtship

Pairs form at any time between completion of the post-nuptial and post-juvenal molts (average September 15–October 1) and the start of nesting, but banding records indicate that most pairs are formed between November and the last of January.

Courtship is inseparable from pair formation. It functions as mutual stimulation and—in weeks immediately preceding nest construction—as advertisement of ownership of a box and territory. It always takes the form of visiting a nest box but varies in intensity according to the time of year and the number of pairs present. In the fall, in the case of a lone pair, it may be no more than male and female looking into the box together and even in spring a lone pair is rather quiet, although making daily visits to their box. But if in spring a pair has close neighbors (for example, if all three territories at my home are claimed by as many pairs early in the season), the courtship is a frenzy of warbling by both sexes, of flying and fluttering around the box with continual wing-lifting and twitching. The two keep up the warbling and wing movements in trees near the box. The male often flies at the female and takes her perch as she moves away, but this is the only expression of dominance within the pair; when she flies off and he follows, there is no hint of a chase. Either at the first meeting of male and female at the box in the pre-nesting season, or in the few days just before the female begins to gather nest material, the male may hold a

wisp of dry grass in his beak as he perches on the box or looks into it. He does not feed his mate in the courtship period, and I have never seen a female beg at this time, but in January 1945, I twice saw a female fly after a male as if she wanted the grub he had (see below).

For a pair's second and third nestings in a season, the courtship is usually limited to looking into the box, with slight wing lifting.

Examples of Pair Formation

In fall. In 1944, a green-banded daughter (*FG*) of the second 1944 brood of *M*10 and *F*16 was paired with a banded but unidentified juvenile male by September 18. At this time, other juveniles had disappeared, and the newly-formed pair, with *FG*'s parents, constituted a flock. The two pairs frequently visited nest boxes together. There was very little warbling or wing lifting, and no fighting except for the mild dominance of the old male over the juvenile; *M*10 would occasionally fly at the young male, forcing him to quit his perch on top of the box.

In 1938 for two days (November 12 and 13), one of the old left-banded pairs defended the central Dooryard box (D3, Figure 1) from a pair apparently newly-formed. The attacking male was right-banded; his mate, an obviously young bird, unbanded, fluttered back and forth but took no part in the fighting. The courtship excitement was up to the pitch usual in March. On the third morning, the old pair did not appear; the right-banded male and his timid mate were in possession. The female made three or four trips to the box with grass in an uncertain manner, and at that time was trapped and banded *F*7. The male evaded my attempts to capture him, which I especially regretted when on February 19, 1939, I found the male owning this box to be *M*4, a fledgling from the summer before. He then had an unbanded mate; *F*7 was found the next month paired with an unbanded male in the Gate Territory.

Within the winter flock. On December 3, 1944, the unidentified male, mate of *FG,* disappeared. At this time, the yellow-banded pair (*M*9/*F*17) had joined the flock, so that it then consisted of two pairs and *FG*. On December 13, a new male, promptly banded green (*MG*), joined the flock and paired with *FG*. There was some flock visiting of the boxes, but at times only the new male and *FG* looked at a box, and their courtship continued up to his disappearance on December 23. There was almost no excitement.

Rivalry between females. Through the disappearance of one individual after another, the winter flock had been reduced by December 27, 1944, to the two old females, *F*16 and *F*17. On January 11, 1945, a new male arrived and was banded red (*MR*). There was all-day visiting of boxes, with little excitement early in the morning, but more in the afternoon on the part of the females. It seemed to be an example of rivalry between females before full gonadal development, as well as an example of the courtship's stimulating effect.

8:30 a.m. 33° F., sunny: *MR* on fence beside box in Barn Territory. *F*16 and *F*17 in trees between barn and house. *F*16 flies at *MR*, displacing him. He gives a low warble and looks into box; *F*16 perches on top of box. *F*17, still in tree 40 yards to east, calls *tu-a-wee*. *F*16 does not answer.

8:40: *MR* and *F*16 fly to Dooryard box, with *F*17 following; all are chased by a Mockingbird (*Mimus polyglottos*). They fly to Gate Territory box. *MR* looks in, *F*16 looks and goes inside, *MR* perches on top. No warbling or wing lifting. *F*17 stays 10 yards off. All fly out of sight.

10:30: All three at Barn box, then to Gate box, *MR* now warbling almost continuously in low voice, and lifting wings. *F*16 stays close to him, and after he has clung to box and looked in, she looks in. If *MR* stays in trees for several minutes, *F*16 takes initiative, flying to the box, warbling softly, lifting wings; *MR* then flies to box. *F*17 approaches within two yards, *F*16 several times flies at her, snapping her bill. *F*17 retreats, perches with fluffed feathers.

11:40: All three in trees east of our house. Only *F*16 comes down to feeding table; *F*17 perches with fluffed feathers. *F*17 is first to fly back to Dooryard box; then *F*16, *MR* following. At 1:25, this program is repeated, *F*17 leading the way to the box after a visit to the feeding table.

1:50 p.m.: *MR* and *F*17 (who is now more confident) visit Dooryard box, with *F*16 perched in vegetable garden 10 yards off. *MR* goes to compost heap, finds large grub, flies with it to a tree, *F*16 following just one foot behind him like a nearly grown fledgling after a parent, as if about to beg, but they go out of my sight.

3:00 to 3:40: All three near Dooryard box. *MR* now indifferent most of the time, going often to ground to feed. Females not feeding at all, continually fluttering about box, rushing at each other, occasionally falling to ground but separating immediately. When *MR* perches on box, females' excitement increases; they give a low chatter, almost a warble. Again *MR* finds a large grub, and both females fly after him as if to beg. He flies to another tree to escape them, and eats the grub.

4 p.m.: *MR* on fence beside box with a short piece of grass in his beak, which he "works," then drops. Females are near by, still flying at one another. As I go by, all three are frightened off.

On January 12, as I left home at 7:30 a.m., all three Bluebirds were in the vegetable garden near the Dooryard box, the females flying at each other as on the evening before. On my return at noon, all excitement had subsided, there was no visiting of the boxes, and the three birds moved together as a flock. From later actions of the three, it appeared that *F*16 and *F*17 had come to an "understanding" on January 12 that *F*16 was paired with *MR*. At the same time, *dominance shifted* from *F*16 to *F*17. Up to that date, *F*16 had consistently pecked *F*17 at the feeding table. From then on, *F*17 became a despot, driving *F*16 from all feeding shelves.

On January 13, *MR* was caught in a nest-box trap, which indicated his interest in nest sites, yet there was no demonstration, such as warbling and fluttering, at any of the boxes. Several times that day, *MR* and *F*16 were seen together, *F*17 not present; the latter, in the course of the afternoon, came five times to the feeding table, each time alone. From January 14 to 19, the three were always together when I

observed them; on January 19, at 8 a.m., *MR* and *F*16 were alone at a Barn box, first one and then the other going into it, and this removed all doubt that they were the pair.

In late winter. After the pairing of *MR* and *F*16 on January 11, 1945, no other male appeared in the study area until February 6. At 9 a.m., a new male (later banded *M*11) and *F*17 were observed visiting the Dooryard box in a courtship of highest intensity. They were apparently paired from the first meeting at the box.

Replacing a Lost Mate

When a male's mate is killed in the nesting season, he may go off for a time and return with a new mate, or remain in the territory until a female arrives.

*M*2 lost his mate about March 21, 1938, while she was incubating, and was not seen until March 25, when he appeared with a new mate. (Since the Barn Territory is the least observed, he may well have come back to his box at times without being seen.) The courtship with the second mate lasted only a day; on the next day she started building.

*M*9 (yellow-banded) lost his mate and young about May 1, 1944. He was seen every day thereafter, looking into the box and warbling softly, but may also have ranged beyond the territory. On May 26, at noon, he was still alone. At 9:30 a.m. the next day, a female was carrying grass into the box.

In 1936, the male of the Dooryard Territory lost mate and eggs on June 1, and remained in the territory. For the first two days, he warbled and looked into boxes. On the third, he carried grass to one box, but continued to visit other boxes. The warbling and visiting of boxes, with intermittent grass-carrying, continued for 10 days, when a female arrived and typical courtship began.

A fourth male, *M*8 of the Dooryard, lost his mate on April 24, 1942 (three days before the young left the nest). He warbled some, while continuing to feed the nestlings. On April 26 a female appeared and fluttered at Dooryard box 3 that held the young. Later, she and the male together looked at Dooryard box 2. This was the courtship. The next morning, the fledglings left the nest, and in the afternoon the new mate carried fresh grass lining into Dooryard box 3.

In 1945, *M*11's mate, *F*17, disappeared between June 10 and 24, while I was away. On my return, *M*11 and a new mate (*F*18) were in courtship at a Dooryard box, this territory having been previously unoccupied that season; *M*11 and *F*17 had had two successful nestings in the Gate box.

In every case where the female was known to have disappeared—presumably killed—the male has obtained a new mate. However, there have been four instances of a *pair* disappearing after a nest disaster, and this may indicate that the female was killed, and the male left in search of a new mate, which he failed to find. For example,

when *M2* and *F4* had their young killed in the nest about April 28, 1938, and the pair disappeared, *F4* may have been killed. *M2* returned the following year with a new mate.

I have no record of a male being killed while the female had eggs or nestlings, but I judge, from the arrival of unmated females here in the nesting season, that a widow wanders off in search of a new mate. In the winter of 1944–45, the two old females, *F16* and *F17*, whose mates disappeared in late December, stayed in their home territories for a large part of each day, but at times, on a walk over 10 acres, I could not find these females. On January 9, 1945, at 3:45 p.m., I saw *F16* start from the Barn territory to the north, flying above the trees until she was a vanishing speck in the sky; she was back at the feeding table early the next morning. It seems probable that they ranged a considerable distance each day. As noted above, males (*MR* and *M11*) came to these females' home territories on January 11 and February 6.

Fighting to Obtain a Mate

The male that has lost a mate after the start of nesting does not at any time invade the territory of a mated pair to fight the male for his box and mate. All the widower males cited in the preceding section had near neighbors, yet they were not seen even to trespass. But an unmated female will invade a mated pair's territory, either just before the first nesting or in the interval between nestings, and fight the female. The mated pair's courtship at the start of the cycle appears to stimulate the unmated female, whereas the quiet behavior between nest-making and fledging of the young inhibits attack.

Many fights between females have been observed in the pre-nesting season when identities could not be ascertained. Where the birds were known, the best example is that of *F3*'s defeat of *F6*. *M4* and *F6* were established in the Dooryard Territory by late February of 1939. On March 1, *F3*, the female who had nested in the Dooryard the year before and had migrated, returned. At first, *F6* chased *F3*, with *M4* following. Presently the two females fought, repeatedly meeting in the air and falling to the ground. The male was greatly excited, flying back and forth, hovering above the combatants, warbling continuously and lifting his wings. In the last struggle on the ground, one female cried like a captured fledgling. They separated, and one flew up to a tree; the other lay for a moment as if exhausted, and then flew slowly away to the woods. *F3*, the victorious female, perched on top of the box; she and *M4* then went through the courtship ceremony; he remained in the territory with her as mate.

Another example occurred in 1935, when the Dooryard Territory was occupied by an old pair that were unbanded but had recognizable individual characteristics. On the morning of March 10 the old female was carrying grass to her box, and I saw another female take grass to a box just 10 yards off. She appeared awkward and uncertain at her

work. The old female deposited her own load of grass and then drove the new female off. That afternoon there was a fierce battle in the Dooryard between two females, probably the old female and the visitor of the morning; afterwards one chased the other down hill. The old female remained in undisputed possession of the territory.

Pettingill (1936:86) reports a battle between two females soon after the start of nest-making, the attacker driving off the first mate. Nice (1931:144) mentions a fierce fight between two females on the day before the second nest of one of them was begun.

Pair Formation Among Returned Migrants

There is some indication that Bluebirds that migrate may find a mate in the wintering grounds. *M*2 on his return to his old territory in 1939 had a new mate that had not been banded as a member of the local winter flock, and *F*3 on returning in 1938 had an unbanded mate; they could, however, have found these mates in the roaming population of the pre-nesting season in this neighborhood. *F*3 came back without a mate in 1939, drove *F*6 away, and thus obtained *M*4. She was again alone when she returned February 28, 1940; within the next week she left the neighborhood, coming back on May 9 with a mate (*M*5) and fought the pair *M*4/*F*9 for the territory. Without the use of colored bands, it was not possible to determine whether mates return together from the south.

Mating Behavior During Migration

On September 16, 1944, two pairs of Bluebirds, unbanded and presumed to be migrants, spent the afternoon in the Dooryard Territory, and for the 20 minutes that I watched, performed a series of acts that seemed to be a form of courtship, nest-making, and boundary settlement.

The males flew at the females, forcing them to quit their perches, and alighted in the places the females had left. Moving through the trees, continually displacing the females, the males kept up a courtship chatter that sometimes became a low warbling. Once a male flew to the ground and pulled at grass, and then the females, about two feet apart, picked at grass. Another time, the males were on the ground within a few feet of each other, teasing at grass. They came face to face, and there was a brief encounter, the two jumping like little cocks; then they hopped in opposite directions and pecked at the ground; they several times picked up and tossed away dead leaves. During this time, a female came down near them and gathered grass, dropping it before she returned to a tree. In the time that I watched, the migrants did not go to the Dooryard box, which was about 25 yards from the area of their activities.

The pecking at the ground and tossing of leaves was apparently substitute behavior for fighting at a boundary line, as I realized when on October 22, 1944, the red- and yellow-banded pairs (*M*10/*F*16 and

*M*9/*F*17) went through a similar performance on the line that had divided their breeding territories.

The Bond Between Mates

Courtship repeated in varying degrees through the winter seems to maintain the bond between mates wintering in the study area. Nevertheless, the bond between the mates of fall- and winter-formed pairs is probably very slight. Indeed, there is doubt whether every association of male and female is a pair, and the flutterings at a box may sometimes be flock behavior rather than pair behavior.

Between old mates, however, there appears to be a real bond the year around. This is not apparent from their behavior toward each other when the pair is in the flock, but is indicated by their occasional withdrawal from the flock, or even their continuous segregation, as when only one pair was present during the years when there was only one box in the area (1931–1934). It is also suggested by the dominance of one male and one female over others in the flock; in the fall of 1944, the red-banded pair (*M*10/*F*16) dominated the two other pairs, *M*10 pecking the males, and *F*16 the females.

The old unbanded pair referred to above gave a specific illustration of the bond. From some time in November 1934 up to nest-making in March 1935, the female roosted on a small shelf-like space at the top of a corner porch-column. The male never slept there. He appeared at the feeding table early each morning, and the female joined him there. Early on the morning of February 17, he attracted my attention by warbling and flying back and forth on the porch, hovering several times before the empty shelf. Apparently the female had not met him at the feeding table, and he was disturbed at not finding her either there or at her roosting place. A little later, the pair were together, and that night the female was on her roost as usual.

Colquhoun (1942:127) in his study of color-banded Blue Tits (*Parus caeruleus*) in England, found that the bond between mates was not evident while they were in the flock but was very plain at roosting time. The mates chased one another, with the male singing; the male visited his mate's roosting site, then roosted nearby.

In 1944, the Bluebird mates, *M*10 and *F*16 (red-banded), were together continuously, even during the molt, until the male's disappearance on December 25. During the fall, they often visited the box in which their last brood had been fledged. On October 13, the female was seen to gather grass and carry it to a fence post where she worried it and dropped most of it; she finally took a small amount to the box. She gathered a second load, and after some dawdling she took a little in. The box was found to contain half an inch of grass. On October 17, the male perched beside the box with grass in his beak, which he let fall; then the female gathered grass and clung to the entrance hole but did not take the grass in.

The yellow-banded mates, *M*9 and *F*17, also remained together until the male's disappearance on December 23, and on several dates in October were seen in similar grass-gathering performances. They were somewhat more excited than the other pair, the male squealing as in the mating period.

Mates remain together through the nesting season unless separated by an attacking female. Pontius (1928:75) gives an instance observed by Thomas in Ohio of a male that changed mates for the second nesting but had his first mate back for the third nesting. He gives no explanatory circumstances.

The Nesting Cycle

Tables 2 to 4 summarize the nesting data for the nine seasons of banding.

The season. My earliest record for nest-making is February 16 (1944). The average date is between March 7 and 10. Weather influences the start. Interference by another pair or by an unmated female may cause a delay. In 1937, *F*3 fought *F*1 throughout March delaying the latter's nesting until April 1. Young of the last brood are usually fledged by the middle of July, occasionally in the first week of August, rarely later.

Selection of the box. Young pairs probably find the nest site together. They have looked at boxes in the area of the winter flock, and as they ranged, watched for holes in posts and trees. When an old male or female takes a new mate, either may lead the other to a box. The males whose mates have died or disappeared have all had new mates in their old territories. The females *F*5, *F*9, *F*16, and *F*17 kept their old boxes with new mates. *F*3 brought two males, and possibly three, to her box. (It is not known whether *M*3, her mate in 1938, had been her unbanded mate of 1937).

Nest-making. Under natural conditions it is doubtful if a female ever builds more than one nest at a time. When two or three boxes are offered in a territory, the male visits them all, his mate following him, and she may build as many nests as there are boxes. Apparently she makes the final choice when ready to lay. An occasional male takes grass to the box at the start of construction, but as a rule the female does all of the building. She finds her material, always dry grass, with sometimes a few chicken feathers or a little hair, within 30 or 40 yards of the box. She works rapidly, rarely taking more than four days to construct a nest. The male does not accompany the female to and fro but frequently flies to the box as she returns to it, perching there and lifting his wings. The male with a new mate shows more excitement at this time than one long-mated; also a male's excitement when a later nest is started is greater after a loss of eggs or young than after a successful nesting.

Laying. In the first cycle, started in late February or early March, there may be a lapse of a week or more between nest completion and the laying of the first egg. With later nestings, most females have laid five days after they began the nest. Eggs are usually laid on successive

TABLE 2

DOORYARD TERRITORY

Year	Pairs	Nesting	Laid	Hatched	Fledged	
1937	M1/F1	1(4–1)	6	6	4(5–11)	2 died in nest at 12 days. 1 fledgling disappeared.
		2(5–24)	4	0	0	Eggs taken by predator.
		3(6–27)	2	2	0	Yg. killed at 10 days. Different box used for each nesting. TOTAL SUCCESSFULLY FLEDGED: 3
1938	M3/F3	1(3–8)	5(3–20)	5	2(4–21)	3 died in nest at 10 days. 1 fledgling died in rainstorm 4-22.
		2[4–28]	4	4	4(6–8)	Different box used.
		3[6–20]	3	3	3(7–30)	TOTAL SUCCESSFULLY FLEDGED: 8
1939	M4/F3	1(3–6)	5(3–26)	5	5(5–2)	F3 drove away F6, first mate of M4.
		2(5–30)	4(6–3)	4	4(7–7)	1 yg. left nest at 13 days; killed by dog. TOTAL SUCCESSFULLY FLEDGED: 8
1940	M4/F9	1(3–8)	5(3–24)	5	5(4–28)	Pair driven away by M5/F3. (Had 2nd nesting in Gate Territory.)
	M5/F3	1(5–12)	5(5–17)	5	5(6–20)	
		2(7–11)	4(7–15)	0	0	F3 incubated until 8–18. M5 had deserted by 8–10. TOTAL SUCCESSFULLY FLEDGED (from 2 pairs): 10
1941	M6/F10	1(3–5)	5(3–21)	5	5(4–24)	
		2(5–9)	4(5–18)	3	3(6–20)	1 egg infertile.
		3(6–28)	4(7–3)	1	0	3 yg. died in shell; 1 a few hrs. after hatching. M6/F10 visit nest till 8–6. TOTAL SUCCESSFULLY FLEDGED: 8
1942	M8/F12	1(3–12)	3(3–25)	3	3(4–27)	F/12 disappeared 4–23. F13 arrived 4–26.
	M8/F13	1(4–27)	5(5–2)	5	4(6–7)	1 yg. died at 14 days.
		2(6–21)	3(6–25)	2	1(7–28)	1 egg infertile. 1 yg. died at 3 days. TOTAL SUCCESSFULLY FLEDGED (from 1 ♂, 2 ♀ ♀): 8
1943	M8/F13	1(3–15)	4(3–27)	4	4(4–24)	
		2(5–5)	4(5–10)	4	4(6–11)	Yg. left prematurely.
		3(6–19)	2(6–22)	0	0	Eggs infertile. Deserted after 16 days. TOTAL SUCCESSFULLY FLEDGED: 8
1944	M10/F16	1(2–16)	5(3–2)	5	0	Yg. taken by predator at 11 days.
		2(4–3)	5(4–8)	5	5(5–13)	Different box used.
		3(5–24)	4(5–28)	4	4(6–30)	M10/F16 annex Barn Territory. TOTAL SUCCESSFULLY FLEDGED: 9
TOTALS:		23	95	80	65	TOTAL SUCCESSFULLY FLEDGED: 62 TOTAL SUCCESSFUL NESTS: 17

Dates following the number of the nesting, the number of eggs laid, and the number of young fledged represent respectively: the date of starting nest construction, the date of laying the first egg, and the date of fledging. Dates enclosed in square brackets are approximate.

mornings; I have noted only one exception—in 1945, *F*16 laid a fourth set, starting July 22; she laid the second egg July 23, skipped the next day, laid the third (and last) egg July 25. Smith (1937:26) also noted an exception; a female laid May 13, 14, and 15, skipped May 16, laid on May 17 and 18. Bluebirds lay rather late in the morning, usually around 8:30, which is about two hours after sunrise in the first week of March. On May 6, 1945, *F*17 laid the first egg of her second set at 8:55 a.m., which was nearly four hours after sunrise (5:13). I had opened the box, believing that she would have laid and left by that time; at the touch of my hand upon her back, the bird flew out to an oak tree, perching with her feathers much fluffed. In a moment she laid, the egg falling to the ground and breaking. As soon as I withdrew, she returned to the nest. She did not abandon the nest, as might have been expected, but laid four more eggs on successive days. Sets contain from three to six; a late set may contain only two. Laskey (1939:24) reported a set of seven.

Incubation and brooding. As a rule, only the female incubates and broods, but Smith (1937:26) saw a male take his mate's place on the eggs three times in three hours.

I have noted only two males that fed the female during incubation. One was the Dooryard male in 1933. In 1945, *M*11 was noticed carrying food several times a day to the box in which *F*17 was incubating; this was true during both her first and second nestings, and he also took food to his new mate, *F*18, as she incubated. Rather surprisingly, *M*11 fed *F*17 on June 1, 1945, when the young in the nest were 11 days old; he took a beakful of peanuts from the feeding table up to *F*17, who was perched in a tree, and she fluttered her wings like a begging fledgling.

Incubation starts with the laying of the last egg, or, in a set of six, with the fourth or fifth. The period is 13 to 15 days, commonly 14; Smith (1937:26) found it once extended to 16. Laskey (1940:18) reports an incubation of 21 days in the case of infertile eggs. In 1940, *F*3 in the Dooryard Territory incubated 33 days. She had started July 17, and one egg was pipped on July 31. The chick died in the shell, and the other three eggs also held dead chicks. She continued to incubate through August 18, and occasionally looked into the box until August 25. Body feathers in the nest indicated the bird had begun to molt.

The female Bluebird is not a close sitter; she usually flies out of her nest at a human's approach; apparently she can hear footsteps in grass 20 feet from her box.

Care of Young. Both parents feed the young. In the first few days after hatching, the male seems to deliver food to the brooding female. Within a week, both bring food, entering the box with it. In an intermediate stage, they perch in the entrance to the hole and lean far down to feed the young. In the last stage, the young meet the parents at the entrance.

Both parents attend to sanitation, dropping the sacs 20 to 40 yards away. In the last day or two of nestling life, this duty is somewhat neglected, and many nests become quite dirty. In extremely hot weather, parents give little attention to sanitation. For example, in 1945, the nest which the three young of *M*11 and *F*18 left on July 30 looked as if sacs had not been removed for at least a week.

TABLE 3

BARN TERRITORY

Year	Pairs	Nesting	Laid	Hatched	Fledged	
1937	M2/F2	1(3–9)	4(3–20)	0	0	Eggs taken by predator.
		2[3–26]	5	5	5(5–9)	
		3[6–7]	4	1	1(7–18)	3 eggs addled.
						Different box used for each nesting.
						TOTAL SUCCESSFULLY FLEDGED: 6
1938	M2/F2	1(3–4)	5(3–13)	0	0	F2 disappeared during incubation period.
	M2/F4	1(3–26)	4(4–3)	4	0	Different box used.
						Yg. killed in nest.
1939	M2/F5	1[3–12]	4(3–23)	4	4(4–25)	
		2[5–16]	3	3	3(6–23)	
		3[6–25]	3	3	3(8–1)	Different box used for each nesting.
						TOTAL SUCCESSFULLY FLEDGED: 10
1940	Mx/F5	1(3–13)	3	2	2(4–26)	1 egg infertile.
		2[4–29]	4	0	0	Different box used.
						F5 deserted eggs (human interference).
						Pair remained in territory 10 days.
						TOTAL SUCCESSFULLY FLEDGED: 2
1941	Mx/Fx	1(6–20)	4(6–23)	4	4(7–26)	Pair arrived about 6–15.
						TOTAL SUCCESSFULLY FLEDGED: 4
1942	Mx/F11	1(3–7)	4	4	4(4–23)	
		2[4–26]	4	4	4(6–2)	
		3[6–22]	3	3	3(8–3)	
						TOTAL SUCCESSFULLY FLEDGED: 11
1943	Mx/Fx	1(3–16)	4	4	4(4–29)	
		2[5–13]	4	4	4(6–24)	
		3[7–3]	3	0	0	1 egg infertile, 2 with dead embryos.
						TOTAL SUCCESSFULLY FLEDGED: 8
1944	Mx/F15	1(3–13)	4(3–26)	0	0	Eggs taken by predator, 4–4.
		2(4–10)	4(4–16)	0	0	Different box used.
						Eggs sucked dry by predator, 4–23.
						Territory abandoned.
1945	Mx/F16	1(3–9)	0	0	0	Nest destroyed (human agency).
		2(3–16)	5(3–22)	4	1(4–25)	Changed territorial boundaries.
						1 egg infertile.
						3 yg. dead in nest.
		3(4–23)	5(4–27)	5	5(6–1)	Different box used.
		4(6–5)	5	3	3(7–16)	2 eggs addled.
		5[7–20]	3(7–22)	0	0	Pair abandoned nest and territory.
						TOTAL SUCCESSFULLY FLEDGED: 9
TOTALS:		24	91	57	50	TOTAL SUCCESSFULLY FLEDGED: 50
						TOTAL SUCCESSFUL NESTS: 15

x, instead of a number, after *M* or *F* indicates an unbanded bird.

Dates following the number of the nesting, the number of eggs laid, and the number of young fledged represent respectively: the date of starting nest construction, the date of laying the first egg, and the date of fledging. Dates enclosed in square brackets are approximate.

When all goes well, the young are fledged at 17 or 18 days. At this age, they can fly 10 to 20 yards. Usually, all leave the box within an hour, but in some cases they leave two or three hours apart, or the youngest or least developed may remain in the nest until the next day. If the nestlings are disturbed at any time after about the thirteenth day, they are almost certain to pop out suddenly. They are unable to fly, but they scramble and flutter across the ground.

TABLE 4

GATE TERRITORY

Year	Pairs	Nesting	Laid	Hatched	Fledged	
1937	Mx/F3	1(5–29)	3(6–7)	0	0	Eggs deserted when Cowbird laid in nest. Territory abandoned 7–5.
1938	M1/F1	1(3–7)	4(3–16)	4	4(4–17)	2 fledglings killed by dog.
		2(4–20)	6(4–23)	6	6(5–30)	1 yg. very weak (counted as lost).
		3(6–14)	5(6–19)	5	5(7–24)	Annexed Barn Territory; used box there. TOTAL SUCCESSFULLY FLEDGED: 12
1939	Mx/F7	1(3–17)	4(4–2)	4	0	F7 disappeared 4–25. 6-day yg. died for lack of brooding.
	Mx/F8	1(5–6)	4(5–11)	4	0	F8 disappeared 5–30. 3-day yg. found dead in nest.
1940	M4/F9	1(5–26)	3(5–31)	3	3(7–5)	Pair's 2nd nesting of season; 1st in Dooryard. TOTAL SUCCESSFULLY FLEDGED: 3
1941	M7/F9	1(3–5)	5(3–20)	5	5(4–24)	
		2(5–12)	5(5–17)	5	5(6–22)	TOTAL SUCCESSFULLY FLEDGED: 10
1942	M7/F9	1(3–16)	4	4	4(4–27)	
		2(5–14)	5(5–18)	4	4(6–21)	1 egg infertile.
		3(6–27)	4	4	4(8–4)	TOTAL SUCCESSFULLY FLEDGED: 12
1943	M9/F14	1(3–17)	4(3–30)	4	4(5–5)	
		2[5–14]	4	4	4(6–24)	TOTAL SUCCESSFULLY FLEDGED: 8
1944	M9/Fx	1(3–7)	4(3–15)	0	0	Eggs taken by predator 3–28.
		2(4–6)	4(4–11)	4	0	Fx disappeared about 5–1. Yg. found dead in nest.
	M9/F17	1(5–27)	4(6–1)	4	4(7–5)	F17 arrived 5–27. TOTAL SUCCESSFULLY FLEDGED: 4
1945	M11/F17	1(3–9)	5(3–22)	4	4(4–26)	1 egg held dead embryo.
		2(5–4)	5(5–6)	4	4(6–8)	1 egg laid on ground (human interference). F17 last seen 6–10.
	M11/F18	1(6–23)	4(6–27)	4	3(7–30)	Used Dooryard box.
					(7–31)	1 yg. dead in nest. TOTAL SUCCESSFULLY FLEDGED (from 1 ♂, 2 ♀ ♀): 11
TOTALS:		20	86	76	63	TOTAL SUCCESSFULLY FLEDGED: 60 TOTAL SUCCESSFUL NESTS: 15

x, instead of a number, after *M* or *F* indicates an unbanded bird.

Dates following the number of the nesting, the number of eggs laid, and the number of young fledged represent respectively: the date of starting nest construction, the date of laying the first egg, and the date of fledging. Dates enclosed in square brackets are approximate.

The male feeds fledglings for 18 to 21 days, and sometimes longer. If the female re-nests at once, she is soon indifferent to the young of the previous brood, but otherwise she feeds them for some two weeks, though less frequently than the male near the end of the period. In 1944, on July 25, when the last brood of the red-banded pair (*M*10/*F*16) had been out of the nest 25 days, one young begged from its mother at the feeding shelf and then from two fledglings of the first brood (three months old) but was ignored.

Interval between nestings. In 1945, *F*16 started a new nest April 23, two days before the one surviving young of the first brood left the box. One female started a new nest two days after young were fledged; two females waited three days after the fledging. At the other extreme, two females waited 28 days after the fledging of one brood before starting another nest, and several waited from 15 to 20 days. However, most females have built a new nest in from 6 to 14 days after young were fledged. In most cases, the female has built in the same box or in another in the same territory. Three pairs have moved after one nesting to a box in another territory. Although the female will build on top of an old nest, the preference seems to be for a box from which the old nest has been removed.

Number of nestings. Pairs that start late and wait three weeks before beginning the second cycle may have only two nestings, but commonly there are three attempts. An occasional pair makes four attempts, fledging three broods. In 1935 the Dooryard pair (unbanded) had the first brood of five fledged on April 18, and a second brood of four on June 10; the third brood of five was taken by a predator when it was three days old, July 5, and the fourth brood of four was fledged August 12. In 1945, *F*16 had five successive nests, with four sets of eggs, and three broods fledged. On March 11 I found her first nest, completed or nearly so, in the cavity of a dead and rotting tree north of the Barn Territory. At my touch, a slab of bark fell away, leaving the nest exposed and unsafe, and I tore it out. There were no eggs. The following day the pair claimed the Barn Territory, but fights with *M*11 and *F*17 (see below) delayed the start of the second nest until March 16. From this nest of four young, only one was fledged, on April 25; *F*16 started her third nest April 23; five young were fledged, June 1. She started the fourth nest June 5, and three young were fledged July 16. In the next week, *F*16 added fresh grass to this old nest, and laid July 22, 23, and 25. On July 26, she was seen near the nest but then disappeared; she may have abandoned the nest because of the extreme heat at that time.

Summary of Successes

In the nine-year period of banding, 26 pairs made 67 nesting attempts, with 47 successful nests, 272 eggs, 172 fledglings. This gives an

average per pair of 2.6 attempts per season, 1.8 successful nests, 10.4 eggs, and 6.6 fledged young. The number of eggs per pair per season ranged from 3 to 18, and the number of young fledged, from 0 to 12. Only one female (*F*16 in 1945) in the period of banding (1937-1945) laid as many as 18 eggs; however, in 1935, the unbanded Dooryard female made four nesting attempts, laid 18 eggs, and fledged 13 young.

It should be emphasized that the 172 young that were actually fledged were in most cases 17 or 18 days old and able to fly; hence they had greater chances of survival than the fledged young of many open nesters—such as warblers and sparrows—that may leave as early as 8 days after hatching. The young Bluebirds that left the nest prematurely and were known to have been killed before the normal nest-leaving age are counted among the losses.

The percentage of successes to attempts by years was as follows:

1937	43%	1940	66%	1943	75%
1938	75%	1941	83%	1944	37%
1939	71%	1942	100%	1945	75%

There was a wide variation between years; 100 per cent of the attempts being successful in 1942, only 37 per cent in 1944.

Based on the number of eggs (272 in the 9 years), the percentage of young successfully fledged was 63.2. This agrees well with the results found for hole-nesting passerines both in this country and in Europe. Musselman (1935) in southern Illinois reports 60.4 per cent success for 1,223 eggs, with 739 fledged in three years. Laskey (1940:185) in Tennessee reports a success of 57.6 per cent for 460 eggs in 1938, and 50.3 per cent for 576 eggs in 1939, or a success of 53.8 per cent for the two years. Her lower rate may have been due to the disturbances that are inevitable in a public park area, and also to cats, English Sparrows and Starlings. In my study area, cats and English Sparrows are controlled as far as possible, and Starlings do not occur in the nesting season.

Summary of Losses

Of the 272 eggs laid, 59 were lost as eggs, 35 as nestlings, and 6 as young that left the nest prematurely, making a total loss of 100. Distribution of losses is shown in Table 5.

Predators accounted for about half the losses. If the indirect loss of eggs and young due to the killing of the mother (17), and the loss of eggs and young taken from the nest (25) are combined, the percentage is 42. Deaths in the boxes (17) could not be separated as to cause, i.e., predation, parasites, or inherent weakness of the young, but certainly part were due to predators, and these, added to the deaths of nestlings out prematurely and killed by dogs (3), would make the loss from predators well over 50 per cent. I have witnessed no robbing of a nest; the suspected predators are rats, mice, flying squirrels, cats, opossums,

and snakes. Loss by predators has occurred even when the supporting post was encircled with galvanized metal.

Premature departure of nestlings is usually due to disturbance by man or predator, but in late July may be chargeable to great heat. In two cases of young killed in the nest, the flies and maggots that appeared may have caused the survivors to leave before the normal time. Parents have removed dead young from the nest only if very small; at a later stage, dead young are left in the nest.

Nestlings out only a day or two before they can fly are able to get into a tree by climbing the trunk; those out earlier can only scramble across the ground. Dogs are a special danger. My own are confined whenever it is known that young of any species are on the ground, but accidents have happened. Since dogs roam almost everywhere that Bluebirds nest, they must be counted as a common predator.

Many nests are found to be heavily infested with mites, yet entire broods have been fledged from such nests. Occasionally ants get into the boxes; parents indicate trouble by peculiar actions, such as repeatedly looking into the nest or entering without food, and then I have brought pyrethrum powder to the rescue. Laskey (1940:186) tells of three broods killed by ants at the time of hatching.

TABLE 5

LOSS OF EGGS AND NESTLINGS

Eggs infertile or addled	13
Eggs with dead chicks	11
Eggs laid on ground (cause: human interference)	1
Eggs deserted (cause: parasitism by Cowbirds and human interference)	10
Eggs and nestlings lost when female killed	17
Eggs and nestlings disappeared from nest	25
Nestlings died or killed in nest	17
Nestlings prematurely out of nest (3 killed by dog, 1 in rain; 2 disappeared)	6
	100

Late spring cold snaps have not been known to affect eggs or young. An occasional fledgling is found dead after a heavy rain, but broods fledged at the normal time usually survive even violent storms. At the time of the last nesting, extreme heat may affect development of the young or even cause death. The nestlings appear not to grow as rapidly as during normal weather; they sprawl in the box as if in the greatest misery, and when older let their heads hang limply from the hole. Loss might be considerable if the boxes were not of thick lumber with ventilating holes near the top. Parents feed the young infrequently during the hours of greatest heat. In 1945, heat probably hastened the death of one of the young in the brood of *M*11 and *F*18. On July 24, when the four young were 10 days old, they showed very

uneven development, the smallest being about one third the size of the largest. That day the U.S. Weather Bureau at Little Rock recorded a maximum of 99° F., with high humidity. Three of the young kept their heads lolling from the entrance hole even through the cooler evening hours, so that the parents, on resuming feeding at the end of the afternoon, were obliged to stand on the roof of the box and reach down to the young. The smallest young, inside the nest, probably received no food. On the morning of July 25, it was dead; the other three seemed listless and did not cheep when fed, but they grew livelier by noon; the day was cooler, and the parents fed them oftener.

In 1936, the deaths of two of a brood of four that hatched August 6 could almost certainly be attributed to heat. Abnormally high temperatures prevailed through most of the month, with a maximum of 110° F., on August 10; under the tin roof of the barn, where the nest was located, the temperature was much higher. When 11 days old (August 17), two nestlings died; the nest was filthy; the parents fed infrequently and spent most of their time perched near the pool in the Dooryard Territory, which the owning pair had ceased to defend when their last brood was fledged July 20. I placed the two surviving young in a Dooryard nest partly shaded by oaks, and the parents fed the young in the new location. Both young left on August 23 at 17 days, the age at which fledglings normally can fly, yet these could only scramble across the ground. Three days later, one could fly weakly; the other remained in a woodpile where I placed it for safety, and it was not seen thereafter.

Few pairs ever attempt a nesting so late. In the 9-year period, 1937–1945, the latest dates on which young left the nest were August 1, 1938, and July 31, 1945. It may be significant that the two cases of chicks pipping the shell, but dying before hatching, occurred late in the season. *F*3 in 1940 had laid July 15–17; and *F*10 in 1941, July 3–6.

Sometimes the location of a box seems to favor disaster. The Dooryard box 2, located close to a fence and overhung by dead branches of a black jack oak, had a long history of losses and was several times infested with ants. After nestlings were killed in this box in 1938, it was moved to the open (to the pasture gatepost); it then became the preferred Dooryard box (D3, Figure 1) and was not troubled by predators until 1944.

The Bluebird as Parent

Normally, both parents feed the young, with the male taking full charge as they approach independence. I have records of two males that did all the feeding for a time, and one of a female that carried the whole burden of the brood from hatching on.

On May 31, 1934, a female with six-day-old nestlings was injured. Feathers on the ground near the box indicated that she had had a narrow escape from a predator. Every day for a week she perched in a

nearby tree, her feathers fluffed, and was rarely seen to find food for herself. She went to the nest only at night to brood. Throughout this time the male fed the young himself. Then the female began to help, and she was apparently fully recovered on the day the fledglings left, June 12. Three days later she was making another nest in the same box.

In 1942, *F*12 of the Dooryard pair disappeared on April 23, when her nestlings were 14 days old. The male continued to feed them despite the distraction of a new mate that arrived on April 26 and started her nest on the following day, just a few hours after the fledglings left the box. She was never seen to feed her "step-children." The father raised all three.

In 1938, *F*1, of the pair on the east fringe of the Dooryard Territory, fed her second brood without the assistance of her mate, *M*1. He had, however, performed his share of the duties with the first brood, which was out of the nest prematurely on April 17. The female laid the second set, six eggs, April 25 to 30, beginning incubation with the fourth egg. On the morning of May 3, *M*1 appeared at the box minus his tail. He went through a courtship sequence more extreme than any other I have ever watched. He warbled some, but more often gave the squealing call characteristic of sexual excitement. *F*1 was much disturbed. Many times she left her eggs to cling to the front of the box and look in—the female's normal courtship response before nest-making. For several days, *M*1 repeated his visits with the same behavior, but gradually calmed down. Thereafter he spent most of the time in the Barn Territory (abandoned shortly before by *M*2 and *F*4) with the two surviving fledglings of the first brood, and was still occasionally feeding them when they were 27 days out of the nest.

Meanwhile, the eggs had hatched. The female found good hunting in the pasture that was part of *M*1's new territory, and he often flew at her side as she returned to the box. (At this time, his new tail was about half grown out.) Once he looked into the nest, but did not feed the young. Near the end of the nestling period, he came with his mate more often. She would feed the young, give a short note, and fly swiftly away; he followed.

On May 29 and 30, the six fledglings left the nest, and *M*1 showed none of the usual concern of a male at that time, giving no alarm notes, for example, at the approach of a Blue Jay (*Cyanocitta cristata*). *F*1 appeared to toll the young over to the Barn Territory; a week later I found only three survivors. On June 14, *F*1 was building. She made two nests, one in the old box in the Dooryard, the other in the Barn Territory. She laid in the box at the barn. For this third nesting, in which five young were fledged, *M*1 was a normal father.

The only clue to an explanation of *M*1's failure to feed the second brood lies in the loss of his tail. This is not an uncommon accident, and tail-less birds have been known to carry on their nesting activities. But *M*1's terror when his tail was pulled out by hawk or owl may have been

equivalent to the psychological shock of having his nest destroyed. His instinct was to start a new cycle. Bigglestone (1913) has described a somewhat similar occurrence in the case of a pair of Yellow Warblers (*Dendroica aestiva*). The male abruptly stopped feeding his nestlings after an adventure with a snake that killed one of the young. This male, however, did not try to re-nest.

In the case of the two male Bluebirds that did all the feeding for a time, it should be pointed out that in one instance (1934) the female, although sick or injured, continued to brood the young at night, while in the other (1942), the young were nearly fledged at the time of their mother's disappearance and no longer in need of brooding. Twice in 1939, and once in 1944, in the Gate Territory, the female was killed, and the young, just a few days old, died in the nest. Whether the male in any of the three cases fed the young after the mother's death was not observed; even if fed they would have perished without brooding. While it is shown that the male may increase his feeding effort in response to increased stimulus, to brood is not in his normal instinctive routine, and it is improbable that he would brood in any emergency. *M*1's continued feeding of the fledglings of the first brood may be explained by the stimulus of their begging, to which male Bluebirds are, in the normal course of events, very responsive.

In 1938, when *M*1 failed to feed his young, his mate was able to fulfill all the needs of the brood because she provided both warmth and food. Whether she would have carried on her role as parent if *M*1 had been killed is doubtful. Although they were in different stages of the nesting cycle, there was still the bond of mates, and his presence, while not relieving her labors, apparently satisfied the need for a male partner. *F*1 was almost constantly subjected to opposing stimuli, first the eggs and then the young as against the male's courtship, and the nest with its contents was the stronger. *M*1's behavior soon after she started incubation was an interruption of her cycle, just as the loss of his tail was to him, but in her case the break was only temporary—as when she left her eggs to peer into the box.

Juvenile Behavior

Fledglings give the adults' location note, *tu-a-wee,* on leaving the box and sometimes for an hour or two before their departure. Out in the trees, they usually keep apart, but one may perch within a few inches of another for a short time.

The fledgling just out of the box waits quietly, except for an occasional low *tu-a-wee,* and breaks into the hunger chatter only at the arrival of a parent with food. By the end of a week, the young bird moves from one tree to another to meet the parent. At three weeks, two or three young pursue their father, with loud clamoring, when he has found a caterpillar. He is obliged to fly to one perch after another to beat the prey to an edible state.

Broods fledged in April almost invariably leave the area on attaining independence. Mid-season broods often stay in the area, or return frequently during the parents' next cycle. This is dependent on the attitude of the male parent, who may drive them or tolerate them. Weather is also a factor; the juveniles seem less inclined to roam in dry, hot spells. In two cases of parental tolerance, only one fledgling had survived (each time, a female); these may have remained because they did not have the stimulus of brothers and sisters to cause them to wander.

Parents that tolerate fledglings permit them to look into the nest and to perch on top of the box. In 1944, the May-fledged young of *M*10 and *F*16 were greatly interested in the nestlings hatched on June 14, and took turns fluttering at the doorway. The next day, they were in trees near the box, and in the following days they were occasionally near. The father was seen to fly at them only on the evening the younger brood left the box. On July 20, the hottest day of the year, with a maximum temperature of 102° F., parents and both broods spent the afternoon together at the pool and feeding table. On September 1, one of each brood was caught in a two-cell trap. A late brood usually remains in the neighborhood with the parents through September.

I have never observed juvenile helpers at the nest, but Nice (1931: 144), Laskey (1939:28) and Wetherbee (1933:199) have reported fledglings that fed a younger brood and removed excreta. Three female juvenile Bluebirds showed a precocious instinct for picking up nest material. One at 38 days old, May 10, 1934, and another at 35 days, May 7, 1935, carried pieces of grass to the top of the box in which the mother was making a new nest. Another at 83 days, July 18, 1944, gathered several pieces of dry grass and hopped to a rock where a brother was bathing in a saucer-like depression. She dropped the grass, took a drink, gathered more grass from the ground and returned to the rock; she played with the grass a few minutes and then lost interest.

Territorial Behavior

The pair establishes territory around the nest box it claims. In this region, where there appear to be more Bluebirds than suitable nest sites, box-ownership is nearly always determined by fighting between pairs. Male fights male, and female, female. Occasionally one of a pair retires for a few moments, and then the other bears the combined attack of the opposing pair.

Two combatants meet in the air, hovering, and snapping their beaks, then fall to the ground, apparently locked together, breast to breast, but whether the feet are engaged I have not been able to see. At times, one raises its head and brings the beak down in slow blows, at other times each keeps a grip on the other's throat or breast while they roll and flop. Often when thus locked, they allow an observer to approach

and all but touch them before they fly up. Each then goes to a tree, and after a brief rest, they rush together again. Victory or armistice comes when one pair flies out of the zone of fighting. Ownership may be decided in a day, but the fighting often continues for a week. I have never seen a bleeding wound or even any considerable loss of feathers.

Unmated male and territory. At the start of the season, an unmated male does not take up territory, but those males who have lost their first mates and stayed—at least, much of the time—in their territories appear to defend the territories. They sing for mates just as Song Sparrows and many other passerines do. But whether a male Bluebird without a mate could hold (or would even try to hold) his territory against a mated pair has not been conclusively shown. In no case of a widower male remaining in his territory, has a pair that apparently really wanted the box come along. In May 1945, however, in the interval between broods, the red-banded pair (*M*10/*F*16) of the Dooryard visited boxes in all three territories before taking one at the barn. On May 19, they looked at the box in the Gate Territory where the yellow-banded male (M9) was waiting for a new mate. First *M*10 and then *F*16 clung to the box. *M*9 was perched about 10 yards away, watching them, and he did not move.

Boundary settlement. Pairs claiming boxes in adjoining territories very early in the season may establish a dividing line by meeting at the line and flying at and chasing one another, with little or no fighting on the ground. (The savage fighting seen in the winter is between pairs for a box, and not for settlement of boundary.) When, however, one pair has been in its territory for some weeks, and a new pair comes to the adjacent area, fighting starts at once, the first settlers being the aggressors, and is both spectacular and long-continued. The females fight as fiercely as the males. As with other species in which a male is unable to hold the entire area that he originally claimed, the established Bluebird pair does not actually drive the newcomers off, but a boundary is established between the territories.

In 1937, there was a typical case of first settlers fighting later settlers. *M*1 and *F*1, established in the Dooryard since March 1, fought *F*3 and her unbanded mate, who came to the Gate Territory on May 26. The battle lasted three days, after which *F*3 and her mate were accepted as neighbors. In 1945, the territorial disputes of an unbanded male and *F*16 with the pair *M*11/*F*17 were much more involved and longer drawn out. The history follows:

Jan. 11. *MR* paired with *F*16 (see above under "Pairing and Courtship").

Jan. 14. *MR*/*F*16 visit hole in dead oak tree 15 yards north of the peach tree stub in the Barn territory.

Feb. 6. 9:00 a.m. New male (later banded *M*11) arrives and pairs with *F*17, the courtship taking place at Dooryard box 3. They then join another pair and an extra male in the pasture (Barn territory), and much chasing back and forth ensues.

1:00 p.m. *F*16 (red-banded) and *F*17 (yellow-banded), each accompanied by a

male (unidentified), are in the pasture. The pairs are plainly establishing a dividing line (about 10 yards north of Barn box 3) where none has ever been before. *F*16 and her mate repeatedly fly north across the pasture to a peach tree stub in which there is a cavity made by chickadees; *F*17 and her mate fly to Barn box 2; then the two pairs return to the dividing line (*X* in Figure 1). Each male continues his courtship—warbling, flying at his mate and displacing her—but the birds clash as pairs, male flying at male, and female at female. A few times two opponents clash and fall together to the ground, but they quickly separate, and there is no serious fighting. In the 30 minutes of observation the two pairs many times repeat the visits to their respective nest sites and the meetings on the line.

Feb. 8. An extra male (unbanded) is still present. *MR* is last seen on this date (found dead Feb. 21 in Gate box).

Feb. 11. *F*16 is accompanied to the feeding table by an unbanded male.

Feb. 11–March 9. *F*16 and unbanded male rarely seen. (*F*16 seen at Dooryard feeding table on only 8 days.) Apparently spend most of their time in the territory established Feb. 6 around peach stub. *M*11/*F*17 claim both Gate and Dooryard and most of Barn territory. (From occasional meetings of the two pairs at the dividing line established on Feb. 6, it is plain that this remains the boundary.)

March 9. *F*17 starts nest in Gate box (where she had raised a brood in 1944). She continues to visit Barn box 2 with her mate, *M*11.

March 11. *F*16's nest (in the dead oak tree she visited with *MR* on Jan. 14) is almost completed. This nest destroyed (see above under "Number of nestings").

March 12. At 12:30 p.m., *F*16 and *F*17 are in a fierce fight near (and apparently for possession of) Barn box 2. *M*11 hovers over them and flies about in great excitement. An unbanded male keeps to the trees 20 yards distant. (Presumably *F*16's mate, perhaps already defeated by *M*11, perhaps timid and backward.) The females fight for 10 minutes. After a last flopping on the ground one (*F*17) lies motionless for a moment, then flies east to the Dooryard territory; *F*16, the winner, perches on top of the box, lifting and fluttering her wings. *M*11 stays at the scene for about five minutes. He flies at *F*16 several times and clings to the box, warbling and lifting his wings, but finally joins *F*17 in the dooryard.

March 13. In spite of *F*16's victory on March 12, *M*11/*F*17 remain in possession of the three territories, visiting both the disputed Barn box 2 and the Gate box, in which *F*17 started a nest on March 9. She does not work on the nest, however.

March 14. *F*16 claims Barn box 3. At 9:00 a.m. she is fluttering at the box, while her mate (unbanded) fights with *M*11 on the ground below. Several times *F*16 goes close to the fighting males and once pecks one of them. *F*17 keeps well out of the fighting area. After about 10 minutes, the males separate, the unbanded male the winner. *M*11 flies away to the Dooryard. At 10:00 a.m. the unbanded male and *F*16 are at Barn box 3, *M*11 and *F*17 at Barn box 2. The two pairs fly at each other at a point about half-way between the two boxes as if establishing a new line. Gradually *M*11/*F*17 grow more aggressive. Between 11:00 and 12:00 both pairs remain on the roof of the barn above Box 3. The unbanded male and *F*16 hold the position nearer the box, with *M*11/*F*17 about three feet away. All four birds keep hopping back and forth. *F*17 frequently stands very tall and erect, pointing her beak upwards (probably substitute behavior for fighting).

March 15. *F*16 and her mate only once seen at Barn box 3—early in the morning. *M*11/*F*17 visit Barn box 2, as well as the Dooryard and Gate boxes. *F*17 occasionally carries grass to the Gate box.

March 16. At 7:30 a.m., *M*11/*F*17 are at Barn box 3, keeping *F*16 and her mate away. They apparently try to keep the boundary line 20 yards north of the box. The pairs meet at this point, perching on dead weed stalks—mates within a foot or so of each other, the pairs a yard or two apart. At 8:00 a.m. they are

darting at one another, *M*11/*F*17 then flying back to Box 3, *F*16 and her mate retreating to the tree in the middle of the pasture. Occasionally *M*11/*F*17 fly to Barn box 2, whereupon *F*16 and her mate fly to Barn box 3, but *M*11/*F*17 immediately return to Box 3 and drive the other pair back to their tree. *M*11/*F*17 are plainly the dominant, more aggressive pair. The performance continues until 8:45. Just then a Bluebird calls *tu-a-wee* from near the Gate box. *M*11/*F*17 fly over in great excitement, apparently to drive out the trespasser. *F*16 and her mate take possession of Barn box 3 and the whole Barn Territory. *M*11/*F*17 seem to have given up the dispute. At 9:05, *F*16 and her mate are at Barn box 3, *M*11/*F*17 fluttering at the Dooryard box. *F*16 and her mate also visit Barn boxes 1 and 2. By 10:30 everything seems settled. *F*16 and her mate come halfway to the house while *M*11/*F*17 remain around the Dooryard box. Through the afternoon both females carry grass, *F*16 to Barn box 2, *F*17 to the nest she began earlier in the Gate box. At 3:30 both nests appear to be completed.

No more fighting occurred between these pairs during the summer.

Boundary ceremony. I have seen one instance of what may have been ceremonial settlement of boundary, probably a sequel to fighting, and comparable to the territorial display of Eastern Mockingbirds and Brown Thrashers (*Toxostoma rufum*). On March 1, 1944, the Barn and Dooryard pairs flew down to the ground at about the half-way point between their boxes. First one pair, then the other, hopped forward a foot or more, the "attacked" pair moving sideways or retreating. Once the Barn pair fell back three or four feet, the Dooryard pair pressing their gain. Then the Barn pair turned and recovered the lost ground, the Dooryard pair yielding. The action ended abruptly with the pairs flying back to their respective territories.

Defense of territory. Little defense between neighbors is necessary, since both males and females respect the dividing lines. I have only a few times seen a male fly across the line and down to his neighbor's land to pick up an insect; each time the owner flew at the trespasser, who returned to his own territory without giving fight. In 1938, *F*1 showed a scrupulous regard for boundary. The year before, *M*1/*F*1 had held the Dooryard, but in 1938 they had all of the Gate Territory, as well as the east side yard, which usually belonged to the Dooryard Territory (Figure 1). Their box, D1, was a little northeast of the house, while *M*3/*F*3 had box D2, just 25 yards off. The dividing line ran through a tree close to box D1. While *F*1 was feeding the six nestlings of her second brood without any help from her mate (see above), she apparently found abundant food in the close-grazed Bermuda pasture that was part of the territory *M*1 had taken up, and she went there dozens of times a day. She could have gone directly from her box across the Dooryard Territory. Instead, she flew south on her own land about 30 yards, then cut west for 50 yards and turned north to the pasture. After about a week, she tried the short way home, and *M*3 and *F*3, with fledged young at the north end of their territory, did not bother her. Thereafter, *F*1 came home across their land, but continued to go by the roundabout route, which by that time had probably become habit.

When her young were fledged, she led them the long way, on her own territory, over to the pasture in the Barn Territory.

Homeless wandering pairs rarely trespass on a settled pair's territory in the course of a nesting, but if they do they are promptly chased out, and they do not give fight. The situation between nestings is quite different, and will be discussed in the following section.

Length of ownership. Some Dooryard pairs have seemed to hold territory continuously, from the first nesting to the last fledging. This is likely to be the case when there are only a few days between the fledging of one brood and the start of the next nest, but it has also been true when the interval was about two weeks.

Other pairs have led the fledglings to the fringe of the territory a hundred yards or more from the box. Formerly there were telephone wires (running east and west) about 75 yards north of our north boundary fence, and these wires were favorite perches for Dooryard and Barn pairs with fledged young. There are still wires above the highway about 80 yards to the east, and a Gate pair with fledged young can nearly always be found in that area. At Mrs. Nice's home (1931:144) in Oklahoma, the pairs and their young disappeared between broods, returning in from 9 to 16 days.

There is a doubt that the pairs that stay in the territory between cycles are actually holding territory. Nice (1941:441) wrote: "the owner of a territory is nearly invincible in his territory," and Tinbergen (1939:57) goes further, stating that "a male on its own territory is undefeatable." I have found that Bluebirds are invincible in their territories only in the course of a nesting, not after their young are fledged.

In 1940, *M*4 and *F*9 of the Dooryard had fledged a brood on April 29. On May 9, an unbanded male and *F*3 appeared, and in one day fought and drove out the owners. The new male (later *M*5) and *F*3 had a brood fledged June 20, and on June 23 they in their turn were attacked by an invading pair, but in this fight owners were winners. I have observed many fights between pairs in the interval between broods, but the identities were not known.

A homeless pair attacks when a box *is not in use.* In one case, the fighting took place 10 days after the young were fledged, and in the other only three days after. This suggests that use of the box and the holding of territory are inseparable, and that the pair with fledged young are in the position of all pairs at the start of the nesting season.

Even with the pair that stays near its box, there may be a temporary abandonment of the land, and then a repossession when the next nesting is started. Certainly the pairs that wander off to the extreme limits of a territory cannot consistently defend the other boundaries, or the box, from neighbors' trespassing. But from a very considerable distance, they may become aware of another pair's courtship at their box, and hurry back to fight for it.

Nice (1935:110) expressed the belief that "the purpose of territory is primarily to prevent interference in family life." The Bluebirds' territory prevents interference from the time of nest-making to the fledging of the young. When they have not been frightened out prematurely, the young fly fairly well on leaving the box, and within a few days are able to follow parents over an extensive area.

In this region, factors not associated with defense of territory may keep many pairs in or near their territories. Lawn, garden, and pasture may offer better feeding than the edge of the woods or the roadside. Our pools are their usual watering places, and in years of drouth may be the only available water in the neighborhood.

Extending territory. When a territory becomes vacant, the pair in the next territory extend their hunting and may move into the acquired land for their next cycle, yet retain their original area. This happened in 1938, when *M*1 and *F*1 had the first and second broods on the east fringe of the Dooryard and the third at the Barn; in 1944, when the red-banded pair (*M*10/*F*16) owned both Dooryard and Barn Territories; and again in 1945, when *M*11/*F*17—and *M*11 with his second mate, *F*18—owned both Gate and Dooryard Territories.

Desertion of territory. I have five records of territorial desertion during the season. In 1937, *F*3 and her unbanded mate deserted their first set of eggs in the Gate Territory because of parasitism by a Cowbird (*Molothrus ater*); there was then a three-day battle (June 28–30) with *M*1/*F*1 of the Dooryard, by which *F*3 and her mate appeared to win an extension of their land, but within the next week they left the area without having started a new nest. In 1938, *F*2 and his second mate, *F*4, disappeared after the young were killed in the nest. In 1939, an unbanded male deserted the Gate Territory after losing two mates and two broods. In 1940, *F*5 and her mate remained in the Barn Territory for about 10 days after *F*5 deserted her eggs (apparently because disturbed when lifted from the nest for identification); they then disappeared. In 1944, *F*15 and her mate abandoned the Barn Territory after two sets of eggs had been taken by predators. In each case, except the first, the desertion occurred in late April or May, when there was still time for another nesting. Some pairs may be inhibited from occupying a territory in which they have had a failure, and this may account, at least in part, for the homeless pairs that appear between cycles to fight established pairs for box and territory.

Post-nesting abandonment of territory. A few days after the fledging of the last brood, a pair becomes indifferent to the presence on its territory of neighbors, strangers, or flocks of juveniles.

Flocking

Early social bonds. Nice (1943:53) points out that nestlings of some passerines lose the first bond to one another when they leave the nest and seek separate perches. On two occasions I found fledgling

Bluebirds roosting together the first night out of the box: on April 20, 1934, the weather turned unseasonably cold, and five fledglings of a brood that had left the box that morning roosted in a row, close against each other, on a limb of an oak; on April 21, 1938, the two surviving fledglings of the brood of *M*3 and *F*3 roosted side by side their first night out of the box.

While early broods nearly always vanish soon after attaining independence, the June- and July-fledged young frequently have remained into September and later. In August, 10 to 15 juveniles, some banded and some not, form a loose flock, and come together to bathe. Three or four enter the water at once. These groups show great liveliness as compared with the apathy of the molting adults, and many chases occur. For the only time in their lives, the Bluebirds are rather noisy, breaking into frequent alarm chatters for no apparent reason. Often my walking into the garden is enough to start the flock "scolding." The juvenile flock gradually decreases in number, or all disappear at once in a spell of autumn weather. Some old pairs remain, with, occasionally, a fledgling, and are the focus of the winter flock, which is formed by mid-November. New Bluebirds arrive about the middle of January, and summer residents sometimes arrive that early.

Composition of the flock. The number of nest sites in a locality and the Bluebird population of the surrounding country determine the size of a winter flock. From 1931 to 1934, there was but one box (in the Dooryard Territory) in about 50 acres of woodland. During this period, only one pair was regularly seen in winter. Since the erection of boxes at the barn and the driveway gate, two, three, and sometimes five pairs have been present from mid-October to the taking of boxes in February. While two resident pairs may comprise the flock, they are usually joined by new arrivals in November. My wintering flock has never exceeded 12 individuals. A similar flock may be observed in any piece of roadside country that offers suitable nesting sites such as old chickadee and woodpecker holes in trees, fence posts, or poles.

It is a striking fact that the sexes in the flocks of my neighborhood are nearly always equally divided. A typical flock is composed of three males and three females. In November 1944, the first year of color-banding, the flock consisted of the red-banded (*M*10/*F*16) and yellow-banded (*M*9/*F*17) pairs that had nested in the Dooryard and Gate Territories; the first pair's fledgling daughter, *FG*, banded green; and a banded but unidentified male.

The history of the flock is as follows:

December 3, the banded, unidentified male disappeared.

December 13, a new male arrived, to be banded green (*MG*); he paired with *FG*.

December 23, *MG* and *M*9 disappeared.

December 25, *M*10 disappeared.

December 26, a new male arrived about noon.

December 27, the new male and *FG* disappeared.

December 27, 1944–January 8, 1945, the two old females were alone except for December 8, when a new male appeared and stayed for a few hours.

January 11, a new male arrived, and was banded red on the right tarsus, *MR*. He paired with *F*16.

February 6, two new males arrived; one paired with *F*17.

February 6–11, *MR* disappeared (later found dead), and the other new arrival paired with *F*16.

Losses from this flock were abnormally heavy. The first male to disappear, the new male, *MG*, and the two old males (*M*10 and *M*9) may have been killed by the Screech Owls (*Otus asio*) then known to live on the place. *FG* and the male that was here for only one afternoon may have left together to go to the male's own flock and breeding grounds. While in former years it was not possible to keep a day by day check on the individuals of the winter flock, it was apparent that fluctuations took place, and the appearance and disappearance of single birds suggested roaming and shifting from flock to flock to find mates.

The 1944–45 season was also unusual for the late arrival of the male replacements and for the fact that no new females or pairs came in January, February, or March.

Flock behavior. Throughout the winter, the flock visits the nest boxes, at times with little display of courtship or competition, at others with much flying and snapping at each other. In general, warm weather seems to stimulate the activities about the boxes, and cold to inhibit. However, when the flock is composed of an old pair and new pairs that arrived in the fall, or wholly of new pairs, there may be much singing and fighting around the boxes even at freezing temperatures, if it is not raining, snowing, or blowing hard. In the fall of 1944, when the two old pairs with a fledgling female and a third male made up the flock, there was no fighting at the boxes; this was probably due to the dominance of *M*10 and *F*16 over the others, as well as to the fact that two pairs were residents with a previously established relationship as holders of adjoining territories.

Members of the flock often separate, perching or flying 100 yards apart, but keep in contact by means of the location note, *tu-a-wee*. In long flights above the trees, the formation is open, with two or three in the lead, one or two 50 yards behind, and a last still farther to the rear. The location note is always heard as a flock goes over.

In winter, much more than in summer, the Bluebirds perch at the very tops of trees, which keeps them in sight of one another, and may account for the lack of any flock notes other than the *tu-a-wee*. The Chickadees and Tufted Titmice that almost continually utter notes of a wide variety are usually moving through the lower and middle branches of trees much of the time, and are perhaps therefore more dependent on sound for contact.

Occasionally, the Bluebirds are in a close group, as in a berried shrub or at a feeding table. Here they give an example of the social bond. When one is trapped and utters notes of fright and alarm, others in the flock break into the alarm chatter and fly about in great excitement, and may, when the trapped bird is being removed, swoop down at the bander's head.

Dominance. A peck order apparently exists. When flocks of 6 to 10 Bluebirds visit the feeding table, there is much flying back and forth, an individual or pair leaving the table as others come down to feed. Rarely, and only in the worst weather, have two pairs eaten side by side. With the color-banded flock of 1944–45, it was possible to observe the relationships of individuals. The red-banded *M*10 and *F*16 dominated all others, which suggests that dominance goes by pairs. At the feeding table this pair pecked their daughter, *FG,* but the mother pecked more often than the father. The daughter's mate (unidentified) usually waited until the others had eaten before coming down. The yellow-banded pair (*F*9/*M*17) also waited, or promptly yielded their places to the dominant pair. Males were not despotic over their mates; a male only occasionally pecked his mate when they met at the table. In the interval between December 27 and January 11, when only the two old females were present, *F*16 was noticeably dominant, but not tyrannical, over *F*17. After *F*16's pairing with *MR,* the order was suddenly reversed, and *F*17 became the tyrant, driving *F*16 from all feeding places. Nice (1943:91) reports reversals of dominance in the case of hand-raised Song Sparrows.

Inter-flock relations. Winter flocks rarely mingle in the area of their nest sites; in bitter weather, my flock has been joined by one pair or two pairs, probably attracted by the general gathering of birds at the feeding table, but with the return of mild weather the newcomers either leave of their own accord or are driven off by the resident Bluebirds. In October, November, or January, my flock may be joined by small migrating or wandering flocks for a few days; at such times there is always great excitement during the visiting of boxes.

The flock's range. Leaving the home place, the Bluebirds fly out of sight. Some flocks, in the coldest weather, have come to the feeding table only in the morning, then left, not to return to the area until afternoon. It is presumed they seek feeding places more sheltered than our wind-swept hill.

Flock roosting. As a rule, the Bluebirds roost in trees near their nest boxes. Three or four snuggle within a terminal cluster of dead leaves. Two post oaks with low hanging limbs that hold their leaves late are favorite roosting trees from year to year. Migrating flocks roost in the same way. I have found them most often in trees at the foot of the hill, 150 yards from the boxes. The flock of 50 referred to

under "Migratory Status" were distributed among five or six trees. As I walked among these trees, small groups that had settled for the night would fly out with startling suddenness; from a distance I watched them returning.

In the winter of 1944–45, I did not discover the roosting place of the home flock, and from several incidents, believed they left to roost some distance away. Their choice of a roost, perhaps more exposed to predators than the two post oaks which our Bluebirds preferred for many years, may have accounted in part for the heavy losses in the flock. Probably *MR*, from the time of his arrival and pairing with *F*16 on January 11, roosted in the breeding area. On January 13, at 7 a.m., warbling was heard from the Barn Territory; there were no answering voices, and the two females did not appear until 7:40. On the evening of February 6, I found *MR* gone to roost in a rotting stump below the Barn Territory.

Only in the coldest weather have the Bluebirds slept in boxes. In January, 1940, during a week of snow with a minimum temperature of 5° F., two pairs slept in the same box, notwithstanding that on the first day of the snow they had fought each other for the box.

Relations With Other Species

With two exceptions in 15 years, Bluebirds have not interfered with other hole-nesting species. The rule is to show great curiosity. On seeing a pair of another species start to build, both male and female Bluebirds fly to the box and look in, give the squealing notes, and perhaps dart at the new tenants, but in a day or two they ignore the neighbors.

Here they have nested year after year within a few yards of Carolina Chickadees, Tufted Titmice, Bewick's and Carolina Wrens, Crested Flycatchers (*Myiarchus crinitus*), and Flickers (*Colaptes auratus*). Much cause for conflict is avoided by careful placing of the boxes. Those for Bluebirds and those for flycatchers are in the open, those for Tufted Titmice on trees. Chickadee boxes are very small, on low posts under oak trees. Wren boxes are shallow and are placed under the eaves of low buildings, inside shed or barn, or on a porch. The Flicker boxes are too deep for Bluebirds.

Both exceptions occurred in the history of a male Bluebird who was a permanent resident from 1933 through 1935. In 1934, from about February 1 he chased a pair of White-breasted Nuthatches (*Sitta carolinensis*) every time they visited a box until March 15, when they left the neighborhood. (It is, of course, not certain that they would have stayed if the Bluebird had let them alone.)

In 1935, the same male Bluebird twice threw out the nest material from a box chosen by Crested Flycatchers. There was doubt here also that the routed birds would have nested. The first time the Bluebird interfered was on May 29, when the female Flycatcher had just

started to build. She waited a week, started again. Yet the nest was still incomplete two weeks later when the Bluebird's brood was fledged and he set to throwing out the Flycatcher's grass and weeds.

This particular Bluebird showed antipathy to all hole-nesting species. He carried on a perpetual feud with Downy Woodpeckers (*Dryobates pubescens*) that used our boxes as sleeping places in winter. Two years, in December, he threw out chips that a woodpecker had torn from the box walls, and then he carried in grass, warbling as in spring. On finding the Downy gone to roost early in the afternoon, he would flutter at the hole and keep up an alarm chatter for many minutes.

In this section, Bluebirds have no competition from House Wrens or Starlings, and they can usually compete successfully with English Sparrows (*Passer domesticus*). Both male and female Bluebirds fly at any bird that perches on or near their box, but do not drive other species from the territory.

Adults are not as a rule quarrelsome at feeding tables, although some fledglings go through a stage of being "bossy" to adults of other species. Bluebirds follow Chickadees and Titmice to the table, but never seem a part of the group.

Yet the Bluebirds' response to the distress of other species is strikingly like their responses within their own winter flock. A male Bluebird will hover over an English Sparrow fallen to my rifle, when no other bird takes any notice. He will join a Robin (*Turdus migratorius*) in attacking a Blue Jay near the Robin's fledgling. Many species gather at a disturbance, but usually exhibit more curiosity than flock alarm.

Mockingbirds guarding winter feeding shelves often show a marked antipathy to Bluebirds. In fall, Myrtle Warblers (*Dendroica coronata*) pursue and even nip them, and Wood Pewees (*Myiochanes virens*), Eastern Phoebes (*Sayornis phoebe*), and Summer Tanagers (*Piranga rubra*) fly into the juvenile flocks, snapping first at one and then another.

Enemy Recognition

Bluebirds' alarm signal is a short whistled note or a series of chattered notes. They sometimes initiate an alarm when the specific cause cannot be observed and keep up the chattering for several minutes or longer. Other species respond to the Bluebirds' alarms by taking flight at the whistled note and by gathering, as in curiosity, at the scene of continuous chattering. On July 30, 1945, *M*11 gave the whistled note as his young were leaving the Dooryard box, and three juvenile Bewick's Wrens that were foraging on the lawn 30 yards distant flew up with explosive suddenness. One wren flew into the screen of the window from which I was watching and clung there a moment, "frozen." When the Bluebird did not repeat the alarm, the wrens resumed their feeding.

Bluebirds ignored the Sparrow Hawks (*Falco sparverius*) that three summers nested within the territories. Occasionally, in winter, the

Bluebirds flutter at a box where a Screech Owl is known to be, and chatter, but their interest is never so sustained as is that of Carolina Chickadees and Tufted Titmice.

They recognized the following as enemies to eggs or young: Blue Jays, Red-bellied Woodpeckers (*Centurus carolinus*), dogs, squirrels, and snakes. The only cat that has appeared in the daytime near a nest box was discovered by Carolina Chickadees, and the Bluebirds were just joining in the alarm when I went out, and the cat fled. Rather unexpectedly, they have "chattered" and flown at cows that sometimes stand beside the box on the pasture gatepost. They ignore rabbits.

The male Bluebird, as guardian of his nest, objects to the Blue Jay's near presence at any time. Hostility increases as the day of fledging approaches; as the young are leaving, both male and female will attack like furies, even pulling feathers. For a week after fledging, they give the alarm chatter at a Jay's appearance.

Hostility to the Red-bellied Woodpecker is usually confined to the periods just before and just after the young are fledged. This woodpecker nests in the neighborhood, coming regularly for suet, and I have not known it to take eggs or young. The only other birds seen to drive the Red-bellied Woodpecker are Tufted Titmice, and they attack also the Red-headed Woodpecker (*Melanerpes erythrocephalus*) a spring straggler in this locality, and known to destroy eggs and young.

Both parents give the alarm chatter if a dog goes near a box as young are leaving. They fly back and forth, hovering for a few seconds above the animal, chattering and snapping their beaks. Excitement rises to a frenzy if the dog goes near a fledgling on the ground. During the next week, the pair chatter and fly back and forth if a dog wanders beneath the trees where the young are perched. But parents with fledglings 30 to 50 yards from the house return to the feeding table and ignore the dogs near it.

On June 18, 1944, the red-banded male (*M*10), with four-day young in the nest, chattered and flew at a red squirrel in a tree 20 yards from the box. He flew into the tree repeatedly, snapping as he passed within a foot of the squirrel, and kept up the charge until the squirrel ran from the tree.

Bluebirds have given innumerable alarms at the sight of snakes anywhere in their territories, and as a result I kill from 6 to 12 snakes a year. They have included copperheads, coachwhips, black chicken snakes, milk snakes, and king snakes. The smallest were the copperheads, about two feet long, while many of the black snakes were between four and five feet in length. On finding a large snake in the outer branches of a tree, both male and female Bluebirds chatter and fly in wide arcs, back and forth, snapping as they pass close to the snake's head, or hover near it for a few seconds. Males are usually much bolder than females. Juvenile Bluebirds still with their parents join in the

general alarm, chattering and flying through the tree. When a snake is on the trunk of a tree or on the ground, the Bluebirds hover near it or above it, returning again and again, and keeping up the chatter.

On July 3, 1939, at 1 p.m., the pair with 13-day-old young in Door-yard box 3 gave the chattered alarm. Both male and female flew back and forth in front of the box, hovering to look into the entrance hole, while Field Sparrows (*Spizella pusilla*), Bewick's Wrens, Orchard Orioles (*Icterus spurius*), and Brown Thrashers, had come to the fence and near-by bushes to peer down into the tall grass. They scattered when I approached. Not finding a snake, I withdrew to watch, and in about two minutes one nestling Bluebird tumbled out of the box and scrambled off, the parents still chattering. At 3 p.m., the birds again gave the alarm and hovered above some sparse weeds 30 yards from the nest. I found a black chicken snake at the spot and killed it. The other nestlings had stayed in the box.

On June 24, 1944, just before dark, the red-banded pair (*M*10/*F*16) and their five fledglings, then 59 days old, began a loud alarm in a tree about 10 yards from the box where the 10-day-old nestlings were. I kept at a little distance until the birds could "show" me the snake, but the male did not fly at it as he had swept at the squirrel just a week before. There was excited flying through the branches of the tree, and the Bluebirds would leave, only to rush back at once. Finally a Mockingbird hovered close to the trunk, and thus gave me the clue. A huge chicken snake lay at full length through a low fork, and was easily killed.

On June 20, 1944, these fledglings, then 55 days old, and unaccompanied by their parents, had found a snake on the lawn close to the house. They gave only a few alarm notes, and it was by chance that I saw them as they hovered above the grass. They perched on the fence for a moment, looking down, and then flew away. In a moment, two fledglings were back, hovering above a spot about six feet from the place where they had first hovered. I found a long milk snake there.

The Bluebird's reaction to snakes is markedly different from that observed in Song Sparrows by Nice (1943:257). One male Song Sparrow displayed only curiosity on finding a garter snake coiled beneath his nest with young, although his mate of the next year attacked small snakes near the nest.

Since the juvenile Bluebirds that found the snake on the lawn on June 20 were then 55 days old, it is unlikely that this was the first snake they had seen, and their response may already have been conditioned by the parents' behavior. Nevertheless, the almost silent hovering above the snake may have been innate behavior corresponding to young Curve-billed Thrashers' (*Toxostoma curvirostre*) stereotyped snake display (Rand, 1941:232–235). Just four days later, with their parents, the young Bluebirds flew and chattered in excitement as described above.

Rand's observation (1941:241) that a snake of large size in motion produced the Thrasher's display in its greatest intensity offers a possible explanation for the varying types of reaction to snakes seen in adult Bluebirds. The boldest charge by the Bluebird is made upon the snake that has made its way to the smaller, outer branches of a tree and lies there in *S* loops; even if the snake is at rest, its weight and the light breezes that stir the branches are apt to create the impression of coils in motion. There is almost equal excitement, but less directed flying, at a large snake lying quietly against the trunk of a tree; there is much less excitement over a snake that is partly concealed in tall grass. Frequently, a snake killed in the morning has been left on the open lawn until evening. On a few such occasions, a Bluebird has hovered momentarily above the dead snake, but then ignored it for the rest of the day. Although Bluebirds have given the alarm chatter at finding snakes at any time in the summer, they are most excited, and boldest in the attacks, when they have young, either nestlings or dependent fledglings.

Voice

The song. The familiar warble, given by both sexes, is heard occasionally even in winter, especially when several pairs visit a box together. From about February 1 until egg-laying, the male sings regularly at the start of morning twilight. Males vary in the amount of singing they do during the day; in general, the more pairs present, the more warbling there is. The singing ceases at about the time the female begins incubation, although some males continue the early morning warbles for a few days longer. At the start of a new cycle, the male again sings in the morning twilight. When this cycle follows a successful nesting, there is apt to be little or no warbling during the day. However, any break in the normal sequence of events, such as the loss of eggs or young, the death of the female and her replacement, or fights with encroaching neighbor-pairs, stimulates singing comparable with that of the first cycle. The female's warbling is usually limited to the time she is fluttering around the box, especially in the early spring. On January 24, 1945, I heard a solitary Bluebird warbling in the Dooryard and found it to be the red-banded female, *F*16. At first the notes were given in one pitch, but gradually they assumed the typical expressive inflections. A few minutes later, *MR* came flying in from the west. Apparently the song may sometimes have the same function as the location note, and females may sing more often in the pre-nesting season than has been observed. The voices of the sexes are indistinguishable.

Courtship chatter. A low, continuous *chee-chee-chee* that often merges into a soft warbling. It is most often noticed in the pre-nesting season when two or more pairs are visiting a box.

Whining. A long whining, or squealing, cry, expressing sexual excitement, sometimes frustration or distress, accompanied by repeated wing lifting. Some Bluebirds are not heard to give the whining note. This is apt to be the case when affairs have gone evenly, and nest making has started early. Others whine in the courtship performance even in January and February, especially if several pairs take part in the visiting of boxes. After all-day fights, a victorious male sings and whines and flies after his mate in the greatest excitement. At other times, as in the mating period, there is no interference to account for the whining. Some females utter a similar crying, very low, which is often, but not always, a preliminary to coition.

The whining may be heard again when a nest of eggs or young is lost to a predator. When *M*1 lost his tail and was thrown back to the start of the cycle, he "squealed" more than he warbled.

Alarm notes. 1. A sharp, rising whistle. It implies danger to the adult rather than to the nest and is a signal for flight to safety. It also suggests that the bird giving it has been startled. I have seldom been able to discover the specific cause for this alarm note. In many instances it is perhaps the alarm for a passing hawk.

2. A loud, emphatic, long continued chatter, given for an enemy of the nest or young, or when a mate or one of the winter flock is trapped. While the whistle is for escape, the chatter is for attack on the enemy or for any general disturbance, and it is accompanied by excited flying in and out of trees.

3. A short *upp,* the mildest alarm, uttered as a Blue Jay comes near, even in winter, and usually as the Bluebird leaves its perch.

Location note. The note *tu-a-wee,* with the tone quality of the song, is used throughout the year, in the flock, and between mates and fledglings.

Food and Feeding

Forbush (1929:422) sums up the Bluebirds' food as seven-tenths from the animal kingdom (chiefly insects) and the rest from the vegetable (mainly wild fruit).

The birds procure most of the insect fare from the ground. The rule is to perch in an exposed place, and fly down on seeing prey. If it is small, it is eaten then. A caterpillar or moth of any size is carried up to a perch, worked in the mandibles and "whacked" several times before it is eaten. In early spring and on many summer evenings, Bluebirds take to fly-catching. They do not pick up the insect in passing, but hover to take the victim, and then return directly to their perch on tree or wire.

Temperament

There is much individual variation in temperament, due in part to conditioning. Some Dooryard pairs and their fledglings have become as tame as Robins or Mockingbirds. Some pairs in the Barn Territory

have remained "wild" and difficult to observe, while the Gate pairs are usually between the two extremes.

As a rule, pairs that have wintered here, regularly visiting the feeding table, are more tame than spring arrivals, although some newcomers that are exceedingly shy and nervous at the start of the season grow accustomed by the middle of the summer to people, dogs, and their outdoor activities. In a summer of long drouth, the Bluebirds stay more at home in the intervals between cycles and at the close of the nesting season, and thus become tame; in a rainy season they wander away.

In the late winter and early spring of 1945, *M*11 and the unbanded male that was mate to *F*16 were interesting contrasts. *M*11 was tame from the first, eating peanuts with his mate, *F*17, from the second day of his arrival; in his first 10 days here he was trapped six times. The other male would follow his mate to the trees above the table but never came down with her. Efforts to capture him in the Barn Territory during the nesting season failed. This male seems to have influenced, or perhaps dominated, *F*16, first in the choice of the dead tree north of the Barn Territory for their earliest nesting attempt, and then in keeping her away from the Dooryard. In the previous summer, *F*16 and her mate *M*10 had had their third nesting at the barn, yet had continued to come to the Dooryard.

Males vary in aggressiveness. Some resent any tampering with the box at any time, and swoop down with the alarm chatter, barely missing the offender's head. Others watch quietly while nestlings are banded, and are stimulated to attack only if the young make a sound.

Summary

Banded Eastern Bluebirds (*Sialia sialis sialis*) of three nesting territories in central Arkansas were observed from 1937 to 1945, unbanded Bluebirds from 1931.

Most of the breeding Bluebirds had either wintered in the area in which they were nesting or had come in January.

Of the males, 60 per cent nested in the area for two (or more) successive seasons; of the females, 61.5 per cent. One female returned for four successive seasons. Four pairs were mated in two successive seasons. Four fledglings (two males, two females) remained for the winter and held territories in the area their first nesting season.

Most of the nesting pairs are permanent residents, but some individuals, of both sexes, migrate. One pair was resident one year but migrated the following year.

Bluebirds are attracted to nest sites the year around.

Resident Bluebirds pair at any time between early fall and the nesting season. Migrating Bluebirds may pair on the wintering grounds. Two pairs of migrants were observed in mating behavior in September.

Both male and female take part in the courtship, singing and fluttering at a nest box.

A male whose mate has been killed during a nesting may leave the territory for a time or remain in it until a new mate comes. An unmated female may invade the territory of a mated pair at the start of nesting, or between nestings, and fight the female.

The bond between mates in winter-formed pairs is apparently slight, but is strong between mates that have had one nesting season.

Nesting begins generally in the first or second week of March. The last brood is fledged usually in the last half of July, occasionally in August.

Either member of the pair, or the pair together, may select the nest site.

The female builds the nest, incubates, and broods.

From 3 to 6 eggs are laid, rarely only 2.

The incubation period is 13 to 15 days. One female incubated eggs (addled or infertile) 33 days.

Both parents feed the young and attend to nest sanitation.

Young are fledged at 17 or 18 days, and then are fed by the male parent for two or three weeks, by the female for a shorter period.

The interval between nestings varies from 2 to 28 days, averaging 12 to 14 days.

If there is no interference mates remain together and in the same territory throughout the season.

There are commonly three nesting attempts, occasionally four.

In the 9 years of study, 26 pairs averaged 2.6 nesting attempts, 1.8 successful nests, 10.4 eggs, and 6.6 young successfully fledged, per pair per season. From 272 eggs, 172 (63.2 per cent) young were successfully fledged. Of the 100 unsuccessful eggs, 59 were lost as eggs, 35 as nestlings, and 6 as young that left the nest prematurely.

Predators, taking eggs and young in some nests, killing the mother from others, accounted for at least 42 per cent of the losses.

Extremely hot weather may kill nestlings, or retard their growth, and may affect the hatching of late sets of eggs.

Two males took entire care of feeding the young for part of the cycle. One female raised a brood entirely without help from the male.

Early broods usually leave the area on attaining independence. Some mid-season broods remain through the next nesting cycle.

A pair establishes territory (usually by March 1) around the nest box. An unmated male does not hold territory at the beginning of the season, though a male that loses a mate during the season may retain the territory.

Box ownership is usually determined by fighting between pairs, beginning in early January. Pairs in adjoining territories fix the dividing line by fighting. One incident that appeared to be ceremonial settlement of boundary was observed. Both male and female respect territorial boundaries. Wandering pairs or single birds do not interfere with an established pair during a nesting.

Some pairs appear to hold territory throughout the season, but territorial attachment is not strong between nestings. A pair annexes adjoining territories if they become vacant. Territorial defense ceases with the fledging of the last brood. Nest disasters may cause a pair to desert a territory even early in the season.

Juveniles form loose flocks in late summer.

From two to six pairs in October or November form a winter flock (with local birds as a nucleus) near nest sites; they visit the nest holes throughout the winter, often with courtship behavior and fighting between pairs.

A mild dominance sometimes occurs between members of a pair, between pairs, and between individuals of the same sex.

Several flocks may occur in a given locality, but they do not mingle in the neighborhood of their chosen nest sites.

The winter flock ranges a considerable distance but usually returns to roost in trees near the boxes.

Bluebirds rarely interfere with other hole-nesting species. One male showed antipathy, however, to all hole-nesters.

Bluebirds recognize as enemies of their young: Blue Jays, Red-bellied Woodpeckers, dogs, squirrels, and snakes. Their reaction to snakes may be innate behavior.

The chief vocal expressions are a warbled song, a courtship chatter, a whining of sexual excitement or distress, alarm notes, and the location notes.

Bluebirds procure most of their insect food from the ground but at times capture flying insects.

Individuals vary widely in temperament.

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BOX 19, ROUTE 3, NORTH LITTLE ROCK, ARKANSAS.