THE ESTABLISHMENT AND MAINTENANCE OF A BLUEBIRD NEST-BOX PROJECT

A REVIEW AND COMMENTARY

By Lewis F. Kibler

Over the past fifty years there have appeared in the literature a number of reports of experiences with Eastern Bluebird (*Sialia sialis*) nest-box projects. This paper is an attempt to organize this data and coordinate it with that of the author to provide an intelligent basis for future similar projects. Such information would seem to be appropriate at this time. The people of the United States are becoming aware of the necessity of guarding our natural resources. Growing awareness is reflected in the increasing number of nest-box projects aimed at improving the status of the bluebird. Some projects include as many as 1500 boxes.

A secondary aim has been to encourage additional study. Therefore this paper has been copiously documented with references that cover the major sources on the subject.

CONSTRUCTION OF THE NEST-BOX

In establishing such a project the first consideration is the nest-box itself. The bluebird is not particular about what it selects. Under natural conditions it may select anything from the split end of a fence post to a rural newspaper mail tube (Laskey, 1939, 1943). A sensible compromise is a unit which is simple to construct and at the same time provides adequate protection for the birds.

The material of choice is three-quarter-inch-thick exterior plywood. Thinner wood does not offer sufficient insulation against the cold snaps of late spring or the heat of midsummer. Exterior plywood is preferred because it will not split or warp when exposed to the weather. If left unpainted the new box will weather to a barn-grey color and become relatively inconspicuous. Brightly colored boxes attract people if nothing else and so are not recommended. It is possible that a box with a light-colored front, by making the dark entrance hole more conspicuous, may be discovered by bluebirds more readily. Much of their courting behavior centers about holes and crevices. This is also true of some of their autumn activity when as late as October they may be observed to flock about various openings in trees and bird house entrances. A study to determine the relative attractiveness of different colors would make an interesting project. Zeleny (1968) feels that dark colors result in excessive heat and that white is too conspicuous and so recommends light green, tan or grey. I stain my new boxes drab walnut brown, the only purpose being to make them less noticeable to curious people. In hot climates a light-colored box is probably preferred because of its increased heat reflectance. Bell (1968) quotes studies by Zeleny showing that a plywood box painted all white is cooler than boxes with natural finish, dark colors, or white roof only. Both authors

agree that bluebirds are not attracted to white boxes as much as darker boxes but Bell feels that where the heat is a problem white paint may be justified.

There are two schools of thought in the literature on what should constitute the proper floor area. Musselman of Quincy, Illinois, generally credited with the origination of the "bluebird trail" concept, described his experiments with various nest-boxes in *Bird-Lore* (1934). He concluded that a box 4 x 4 inches inside measurement was ideal, noting that the usual complement of eggs in a box this size was four to six, whereas the nests in natural cavities, usually of smaller dimensions, averaged under four eggs. He stated that using this box he found little competion from House Sparrows (*Passer domesticus*) except when placed close to farm buildings. He attributed part of the success of this nest-box to their placement three feet from the ground on fence posts in open fields away from woodlands. Subsequently he distributed plans for a 3 1/4 x 3 1/4 inch box. Krug (1941: 23) changed from 5 x 5 inch boxes to 3 1/4 x 3 1/4 inch boxes because the 5 x 5 inch, ". . . is larger than necessary" and because the smaller box is less conspicuous and therefore less likely to be stolen. Also it was less likely to be broken down by cattle rubbing against it. Varner (1964) recommends 3½ x 3½ inches as being ideal for discouraging House Sparrows which prefer a larger box in which to construct their bulky nest. The Audubon Naturalist Society of the Central Atlantic States (1967: 30) has tried 3½ x 3½ inches but it, ". . . does not solve the [house sparrow] problem completely". They currently use 4 x 4 inch boxes, as does Zeleny (1968).

For every suggestion to use a small floor area there can be found a source recommending a larger area. Among those preferring a 5 x 5 inch area are Laskey (1940), Terres (1953), U. S. Department of the Interior (1957), Highhouse (Neel, 1965) and "Bluebirds Unlimited" Committee (1966, 1967). Krieg (1964) recommends at least 20 square inches of floor area which is equivalent to 4½ x 4½ inches. Bell, Jr. (1967) uses a 5½ x 5½ inch floor area.

Both types have their advantages. The small box costs less. It is less conspicuous. In an area of dense House Sparrow population or where it is impossible to erect boxes far enough from farm buildings to avoid sparrows, the small floor plan would be preferred, but to be fully effective must be used with boxes that are placed three to five feet from the ground and frequently checked to expel those few House Sparrows which do attempt to nest in the boxes.

Generally there are more advantages to the larger floor area. The larger area by decreasing crowding helps reduce the effect of excess heat. Extreme heat may affect development of the eggs or young and even cause death (Musselman, 1935; Laskey, 1940; Thomas, 1946). Crowding especially affects the vigor of the young the first few days after hatching (Kendeigh, 1942). As the nestlings grow larger nest sanitation becomes a problem. More room reduces soiling from the excreta. Hartshorne (1962: 143), referring to a pair of bluebirds which had occupied a chickadee box with only nine

square inches of floor area states, "The pair kept the nest fairly clean until the young were about six or seven days old. Thereafter they paid progressively less attention to nest sanitation, and on the tenth day two of the five young died. I found a quagmire of filth covering the nest. The plumages of the young were matted and caked, and the young themselves were sickly and weak." McElroy (1960: 104) criticizes a box with a 3 1/4 x 3 1/4 inch floor area with an entrance hole six inches or more above it because it, ". . . acts as a trap for Tree Swallows as they cannot get enough wing span or "jump" to reach the exit."

Another important dimension which can vary over considerable range but to which relatively little attention has been paid is the height of the front panel. Varner (1964:93) feels, "the height of the box can vary from about five inches to twelve inches or more with little effect on the use of the box by Bluebirds." He uses a seven inch height to reduce House Sparrow competition. The majority of recommendations range from eight to ten inches. My own preference in height is 11 inches, with the bottom of the entrance hole eight inches from the floor. I reason that the deeper box, by making escape from it more difficult, will delay the departure of the nestlings. The more growth a nestling can attain while protected within the box the more prepared it will be for a precarious life outside the box. A bluebird nestling has completed most of its weight development by the 14th day (Hamilton, 1943) but feather growth continues beyond this time so that every additional day spent in the nest results in increased flying facility. Another advantage, at least to the bander, is that he has one or two days' more opportunity to band the young or adults. Should the nestlings be disturbed, for instance by a bander, they are less apt to plunge prematurely from a deep box. It follows from these comments that the various suggestions in the literature for aiding the escape of the young from the nest-box by providing toe grips such as steps, grooves or merely roughening the inner surface below the hole, are not indicated. I am aware of the concern expressed by Kelly (1968) about the ability of fledglings to escape from the box. He feels the hole should be no more than 5 1/4 inches from the floor. However, I have yet to have one young bluebird trapped in the box. A note of caution here, if a box is not protected adequately from predators additional time in the nest-box may be a hazard. Finally, a nest placed deep in the box where it is beyond the reach of a predator's limb is an obvious advantage to the occupant.

Approximately 20 percent of my bluebirds, in spite of these benefits, fill the box with nesting material until the nest cup is almost level with the hole. It is possible to lower the nest a bit at a time by removing part of the grass beneath the cup but there is the risk of causing desertion. Because of the deep boxes I have a high incidence of repeat nestings in a given box. If for any reason there should be a halt in nesting activities my boxes are less likely to be abandoned for the season. Frequently the nests will be relined by the same or another bird and nesting activities resumed. It is not unusual to have three or four layers of nests in a box.

I use a special front panel on my boxes but I cannot endorse them for general use because it calls for additional labor and time in the box construction. It saves time later, however, during the box-checking routine. For those who find lack of time a limiting factor in their box-checking I will describe it. The front panel is sawed in half on a 45 degree bevel. The lower part is permanently fixed to the box; the upper part with the entrance hole is hinged to one side of the box and fastened to the other side with a latch so that it can open as a door. When closed, the overlap of the 45 degree bevel occludes light and rain. In one movement, the door can be unlatched and opened. Access to the nest is easier especially when the boxes are mounted at eye level or above.

With two exceptions, the hole is universally recommended to be 1½ inches in diameter. When Musselman (1943) started making his houses he used 1 3/4 inch holes but Starlings (*Sturnus vulgaris*) were not a problem then. He has since reduced the hole to 1½" which adequately eliminates the Starling. An interesting variation is suggested by Terres (1953:264) who suggests the use of a square hole 1½ inches high and 1 1/4 inches wide in regions of House Sparrow competition. He states, "This will allow the slender bluebird to get in, but will usually keep out the pudgier sparrow." Assuming that the roof extends out about two inches the hole should be centered about two inches from the top. A perch should not be used below the hole. Bluebirds don't need them and its presence encourages undesired species such as House Wrens and House Sparrows.

The roof may be horizontal or gently sloped. It is easier to build a box with a flat roof but care should be taken to fit it well, otherwise seepage from rains and melting snow will dampen the contents. Ordinarily this is unimportant but during a cold wet spell when the food supply is limited it could be a critical factor in the survival of the nestlings. The roof should project over the entrance hole far enough to provide protection from sun and rain. As for attaching the roof, metal hinges rust or become stiff so that the screws holding them loosen. Fabric or leather fasteners deteriorate and crack. For these reasons it is advisable to use the type of roof which slips under a wood cleat on the back panel and has another cleat on the underside of the front part to wedge behind the front panel (Terres, 1953). An eye-screw thru the roof into the front panel will secure it against predators and high winds. The back panel should project slightly above and below the box to provide a place for attaching the box to its support.

If there is no need for access to the upper part of the nest for observation or banding, there is no need to have a removable roof. Construction is easier in this case. All that is needed is a front panel which swings outward on two nails driven through the sides into the upper part of the front panel. This will permit efficient cleaning of the nest-box (Bell, Jr. 1967). One screw at the bottom will secure it.

Most authorities recommend ventilation space somewhere near the top either by drilling 1/4 inch holes in the side panels, mitering

the upper-rear corner of the sides or making the front panel shorter than the sides by 1/4 inch so that there is a space between the top and front panels. In the northern states where cold is more of a problem than extreme summer heat, ventilation holes are probably not necessary but they are a must where summer temperatures range high (Thomas, 1946; Laskey, 1952). In studying the House Wren (*Troglodytes aedon*), Kendeigh (1963) reports that an hour's exposure of eggs to temperatures of 106 degrees may cause a 50 percent mortality of embryos.

Varner (1964:93) feels that the nest-box floor should not contain drainage holes because bluebirds, ". . . appear to prefer darkness except for light near the entrance." I am inclined to agree with him but for a different reason. The usual 1/4 inch holes drilled in the bottom become clogged with debris after one nesting. In effect the bottom is without drainage, but water entering the nest box percolates thru to the bottom leaving the upper functional part of the nest dry even though the bottom may be soggy. At any rate, under weather conditions which are likely to blow significant amounts of water into a box the female bluebird is usually found within the box covering the nest. If drainage holes are considered necessary, fashion them by a 1/4 inch bevel on each corner of the bottom piece. These are more satisfactory then the drilled holes because if a box is not level which is usually the case water will seek the lowest corner for an outlet. Furthermore they are easily cleaned by running a nail or slender stick down each corner. If the bottom piece is inset 1/8 inch to 1/2 inch from the bottom the sides of the box will act as a drip edge. This will help to keep the bottom dry.

For assembly, eightpenny coated box nails are used. The coated nails hold better under the stress of warping, expansion and contraction caused by weather. Glue is not necessary when they are used. Box nails are preferred to the common nails. Being more slender they are less likely to split the wood. Of course if exterior plywood is used warping and splitting usually does not occur. Brass screws are preferred for mounting rather than steel screws that will rust.

To each box I staple a small inconspicuous laminated sign which reads, "This Nest-Box is Part of a Project to Bring Back the Bluebirds. STATE AND FEDERAL LICENSE #8704. PLEASE DO NOT DISTURB. For information call . . ." and I give my name and phone number. My nest-box loss due to theft or destruction has been small, about one percent. I would like to think that it is because my sign has had a calming effect on some would-be thieves or irate property owners. The approach used by Varner (1964: 93) to reduce the disappearance of his nest-boxes is unique and probably is quite effective. He states, "It is not even desirable to have nice looking boxes since this invites theft of the box. An ugly box appears to be just as acceptable to bluebirds as a nice looking one."

Nest-Box Location:

The principles of box location have been well worked out and can be found in a number of the references cited. Zeleny's *Bluebirds for Prosperity* is an especially thorough paper. Briefly the boxes should be up by the last week of March in the latitude of New York State. Earliest nest construction begins the second week of April but there is a preliminary period of hole and cavity investigation which makes it important to have the boxes up earlier than this. The bluebirds of this area prefer the rolling forest-and-field uplands. The highest hills are about 2000 feet high with the intermediate valleys dropping to a 1300-1400 foot altitude. Fence rows along open fields, parks, old orchards, cemeteries, abandoned pastures and gently sloping hillsides grownup with scattered scrubby bushes and trees seem to be their preferred habitat. Part of this preference may be because the houses are more scattered and human population is not as dense in these upland areas. They do not seem to be bothered by the traffic along country roads. Expanses of flat treeless and shrubless terrain are not favored. In order to discourage House Wrens I avoid overgrown and forest edge situations. Rew (1965) points up the importance of keeping the undergrowth cleared from around a nest-box. Over a ten-year period she watched the percentage of bluebird occupancy drop steadily and her Tree Swallow and House Wren occupancy go up as her box locations became overgrown. I also avoid ponds or open water because Tree Swallows are more likely to use the boxes. Human habitations are avoided in order to cut down on House Sparrows, vandalism and dogs. If available a tree branch or telephone wire near the box will be regularly used as a perch. Bluebird pairs will usually not nest closer to each other than 700-800 feet. However, if boxes are closer than this it does no harm for it frequently happens that when one nest is deserted a pair will begin building in an adjacent empty box. Avoid locations in which insecticides have been used extensively.

Boxes are best placed on posts. A live tree is not satisfactory because as it grows the expanding bark pushes the box forward pulling the screws thru the wood. Eventually the box drops. I find that cedar posts, costing about fifteen cents, are ideal. They are light for carrying and long lasting. After a small hole is made in the ground they can be driven in with a sledge hammer. The ground holes are efficiently made with a two-inch earth auger available from Bartlett Mfg. Co., 3003 East Grand Blvd., Detroit 2, Mich. It takes about two minutes to drill a hole 18 inches deep into which can be firmly driven one of the posts. By placing the boxes 3-5 feet high House Sparrow occupancy may be reduced. The boxes are usually mounted facing south-east away from the prevailing winds. This gives the entrance exposure to the early morning sun while giving it protection from the hot afternoon sun. There are times when this rule has to be broken. If a fence post is used for instance, and there are cows or horses on the east or south side of the fence it is better to place the box on the side away from the cows even though this directs it toward the weather. Cows have a tendency to rub them off the posts. Make certain that the fence post chosen

is not rotted at the base. Don't use a leaning fence post because to straighten it a prop is needed and a prop against the post serves as a ladder for predators. The wire along a fence may permit a predator to climb past a predator guard as will nearby branches. Utility poles make ideal supports because they are usually in a cleared area and are close to the road making checking easier. Bell (1967) uses these poles in southwestern Pennsylvania. He feels they limit predation by snakes and small animals. He suggests that instead of screwing or nailing the boxes to the pole that they be hung by wire to avoid leaving sharp objects projecting from the pole which might injure a lineman. This also permits him to lower the boxes for inspection and then raise them again beyond reach of some predators. Before using the poles it is best to check with the local telephone and utility companies. Many companies do not permit the use of their poles.

Predator proofing:

Some authorities have recommended that extension pieces be placed over the hole to create a sort of tunnel, making it more difficult for an animal to reach effectively into the nest-box. The tunnels recommended by Webster and Uhler (1964) are ten inches long and were effective in excluding raccoons (*Procyon lotor*) from several hundred Wood Duck (*Aix sponsa*) boxes over an eleven-year trial period. I have not tried such a tunnel with bluebirds but it is likely that it would inhibit their hole-oriented courtship activities as well as their actual nesting in the box even as it occasionally does Wood Ducks. On the other hand I question the effectiveness of the modified tunnel recommended for bluebird houses by Bell, Jr. (1964) and the "Bluebird Unlimited" Committee, (1966). The one-inch-thick block of wood with a 1½ inch hole in it placed over the hole of the box does not make a tunnel long enough to predator-proof a box except possibly from small squirrels, very young raccoons and opossums. Musselman (1934) experimented with tunnels made from natural knot-holes fastened over the entrance and found that the boxes were accepted more readily when knot-holes were omitted. Metal posts or one-quart juice cans around the post as suggested by the "Bluebirds Unlimited" Committee (1966) and Bell, Jr. (1967) will not block a determined raccoon (Thomas 1946). Probably the most reliable protection from ground predators is the metal cone-shaped guard. If it is high enough from the ground, away from nearby trees and fences and firmly attached so that the animals cannot reach around it or dislodge it, it will prevent molestation by cats, raccoons, opossums (*Didelphis virginiana*), red squirrels (*Sciurus hudsonicus*), chipmunks (*Tamias striatus*) and snakes. On two occasions deer mice (*Peromyscus sp.*), in a way not understood by me, have been able to get past the guards to build and rebuild their nests in the box.

Average losses to predators on an unguarded bluebird nest-box project run about 25 percent (Laskey, 1939; Bluebirds Unlimited, 1967) although last year my predator loss was 33 percent. In 1967

"Bluebirds Unlimited" indicated they may change their recommendation for a predator guard from the modified tunnel type which in combination with metal wrapped around the post still resulted in 13 percent predation (Bluebirds Unlimited, 1966). They have called for volunteers to field-test the cone-shaped guard to determine which is more effective. In anticipation of the results they state that the coneshaped guard is probably the most effective but also probably the most expensive and difficult to install. They recommend a cone of about 15 inches at the base made of number 28 gauge galvanized metal. Webster and Uhler (1964) give direction for fabricating this type of guard but with a cone about 30 inches across made of number 26 gauge galvanized metal. This size is more effective.

Another useful measure against predators is to surround the entrance hole with a ring of metal or series of small nails driven in around the edge of the hole. This will prevent distortion of the hole by sharp-toothed squirrels seeking to enlarge the holes of boxes not protected by guards.

Predators:

In my experience cats have not been a threat to the nestlings. A number of times I have watched cats pass directly beneath a nest-box without showing any sign of being aware that there were young birds in the box above. After the young have left the nest cats become more of a threat. Laskey (1942) and Wolfling (1954) strongly incriminated the cat. Laskey had 18 females and 46 nestlings killed by cats in her 61-box series one year.

The black snake (*Elaphe obsoleta*) and other snakes prey on both the eggs and nestlings. In approximately 1,400 visits to my boxes over a four year period I have never noticed a snake near them. In other areas where snakes are more prevalent they contribute significantly to bluebird mortality. Schreibner (1938) mentions seeing one black snake eat two nestlings and reports the observation by an acquaintance of a chicken snake (? species) consuming three young bluebirds. Musselman (1938) found a black snake in one of his boxes. It had consumed four eggs or young birds. Broderick (1938) tells of the death of an adult female by a snake. In 1940 and 1952 Laskey lists snakes as predators but does not give specific examples. In 1942 she cites a 54-inch southern pilot snake caught in one of 42 nests rifled by snakes. Later (1956:30) she wrote, "Snakes are the worst natural predators. They leave the nest intact after robbing it of eggs or young. Occasionally large *elaphe* snakes are found resting in the nest; these are killed and opened to verify the record of predation. . . . If the snake is not destroyed, the nest-box must be removed to a new location, because after predation is started all subsequent nestings become prey also." Kendeigh (1942), out of 2,725 nesting attempts by 51 species, cites two examples of black snake predation and one each by the garter (*Thamnophis sirtalis*) and milk snake (*Lampropeltis triangulum*).

The principal source of predation in my nest-boxes, accounting for about one-third of my losses last year, is yet unidentified. It is nocturnal in habits, leaves a characteristic set of scratches on the sides and roof of the box, and produces a characteristic disturbance of the box contents in which the nest itself is completely stirred up with the eggs unbroken but scattered about in the nesting material. The invader is apparently seeking the brooding female since a nest is never disturbed in this manner until after the female has begun setting. In two instances wings of the female have been found on the ground near the box. Each year the visits from this animal have become more frequent. It is probable that as the location of the boxes is learned a regular visiting routine is established. I suspect that this is the work of an opossum or a raccoon, most likely the latter. Until this year my nest-boxes have been unguarded but since mounting cone-shaped guards of the type recommended by Webster and Uhler, the problem has been solved.

Ants often inhabit nest-boxes yet in my experience cannot be classed as predators. Their presence is usually not suspected until after the young have left and the box is cleaned out. Laskey however cites an instance in which ants (*Solenopsis*) devoured a brood of newly hatched birds. There are instances in the literature of other nestlings, especially ground nesters, being devoured by ants. Pyrethrum powder has been used to solve this problem (Laskey, 1940; Thomas, 1946).

Red squirrels and deer mice are known predators.

Competitors:

There is a surprising array of other animals competing for the bluebird nest-box. Many of them can be limited or eliminated by the nest-box construction or placement. In addition to the birds previously mentioned, the House Wren is known to be a major problem in some latitudes (Gardner, 1920; Reed, 1924; Bent, 1949). At the latitude of 42 degrees (southern New York State) the bluebirds begin to nest before the Tree Swallow and House Wren arrive. These early nesting bluebirds are frequently caught in a late spring cold snap and the attempts are often terminated unsuccessfully. Their next nesting attempt may coincide with the House Wrens' nesting. The bluebird then may find his nest-box already occupied by a wren or the new clutch of eggs pierced (Musselman, 1939; Krug, 1941). For this reason the House Wren is regarded with disfavor by most bluebird-box keepers. During the nestling stage however, the wren may make partial amends for its misdeeds. I once watched a wren furtively enter a bluebird's box, disappear for up to 30 seconds, reappear to wipe its bill as if just having eaten something and then reenter the box. This act was repeated nine times over a three minute period. I presume its interest within the box was related to the numerous *Apaulina* larvae infesting the nest.

With the elimination of the raccoon and other ground predators by the use of cone guards, the House Wren has become in my series the most significant contribution to bluebird morbidity other than weather factors. It is interesting to follow the spirited discussion

carried in *Bird-Lore* during 1925 when S. Prentiss Baldwin, Allan Brooks and some ten other contributors argued back and forth the malevolence or benevolence of the House Wren. Numerous examples are given of bluebird eggs being punctured, broken or removed from nests by House Wrens and one writer even describes a fledgling being thrown from the nest. Reading these accounts makes one wonder whether the House Wren was not a major factor along with the House Sparrow and Starling in driving the bluebird from our urban areas.

The peak of the Tree Swallow (*Iridprocne bicolor*) incubation period in this area normally falls midway between the two peaks of the bluebird's incubation period (Krieg, 1965) so that there is relatively little competition between the two species. Due to delays in nesting from weather or predation however the same coincidence of nesting activities may occur as with the House Wren resulting in competition. When a Tree Swallow does find itself competing with a bluebird, it is a matter of opinion whether the Tree Swallow or the bluebird prevails. According to Reed (1924), Hersey (1933), Low (1933), and Krug (1941) the Tree Swallow wins. According to Bent (1949) the bluebird usually wins.

One must be prepared to find even other species in his nest-boxes. Listed in various bluebird nesting project reports have been the Blackcapped Chickadee (*Parus atricapillus*), Carolina Chickadee (*Parus carolinensis*), Tufted Titmouse (*Parus bicolor*), White-breasted Nuthatch (*Sitta carolinensis*), Red-breasted Nuthatch (*Sitta canadensis*), Red-headed Woodpecker (*Melanerpes erythrocephalus*), Crested Flycatcher (*Myiarchus crinitus*), Carolina Wren (*Thryothorus ludovicianus*). and Prothonotary Warbler (*Pronotaria citrea*). Whether to permit these unsolicited nestings to continue will present to some a moral problem. Those who are committed to the maximum production of bluebirds will find that by persistantly evicting the nests of unwanted birds their bluebird occupancy rate will improve. Some species are very obstinate in their attempts to nest. Varner (1964) feels that the most effective way to eliminate a House Sparrow is to kill the male of the pair. If only the female is killed the male will have a replacement in short order. My policy has been to remove the nests of Tree Swallows, House Wrens and House Sparrows. It is not unusual in these cases to have a bluebird eventually move in.

There are a number of non-avian competitors; I have had red squirrels, deer mice (*Peromyscus* sp.), bumble bees (*Bombus*), paper wasps (*Polistes*), and spiders use the boxes. Flying squirrels (*Glaucomys volans*) have been reported. An entrance hole deformed by teeth marks, or nut shells scattered on the ground may be the first clue pointing to a red squirrel occupancy during the winter. In summer the finding of unusual items as cherry pits, bits of apple or nuts in the nest is often the first clue. Two of my boxes have had litters of five young red squirrels each. Squirrels are difficult to dislodge. It takes a lot of prodding with a stick. The presence of mice is indicated by a round mass of soft shredded cloth, wool, plant

fibers, etc. They are most likely to move into the nest-box when the fall days become cold. Up to seven adult mice have been found wintering in one nest box. They usually jump out with a little rapping or poking of the nest.

Paper wasps respond to a spray of insecticide.

Parasites:

I have never found a Brown-headed Cowbird (*Molothrus ater*) egg in my bluebird nests, but Musselman (1935), Hamilton (1943), Thomas (1946), Wolfling (1954), and Highhouse (1964) have had this experience. Friedman (1934: 33) states, "Although the bluebird is still to be considered a rather infrequent victim of the cowbird, it is by far the most often parasitized of hole-nesting birds".

Probably the most important parasitic influence is the larva of the blowfly (*Apaulina sialia*) called in earlier literature *Protocalliphora splendida* or *Phormia chrysorrhoea* and also known as the bird nest screwworm fly (Hall, 1947). Since the early 1900's a rather involved and extensive literature has built up on this subject. The larvae are bloodsucking and are capable of producing weakness in the nestlings sufficient to bring about their death directly, or indirectly by compounding factors such as cold weather or persistent rain both of which increase the energy drain and reduce the food supply available to nestlings (Mason, 1944). The degree of parasitism and the degree of resulting mortality vary with the locality, year, and season. Actually deaths occur only occasionally but infestation of the nestlings runs 80 percent or more during the second nesting period in this region. As a control measure Johnson (1932) and Mason (1944) recommend removing and burning the nest material after the first brood has left the box in order to prevent their parasitizing the second brood. They suggest leaving the last nest about a month before removing it. This permits time for the small wasp, (*Mormoniella vitripennis*), parasitic on the pupa of *Apaulina* to breed and thus to build up its numbers for the following year. To my knowledge this practice has not been proved to contribute significantly to the number of *M. vitripennis* available for destroying the *Apaulina* pupae. *M. vitripennis* utilizes the pupae of numerous other *Dipterae* (Whiting, 1967) and so is not dependent solely on those from bluebird nests. A more effective plan as far as improving one's bluebird reproduction efficiency is suggested by Highhouse (1963), who reduces infestation with cat flea-powder, or spray (Leberman, 1961) applied to the nests before the eggs hatch. Potter (1967) for two years has used about 1/4 inch of 1 percent rotenone on the bottom of his nest-boxes. He has been able to increase his nesting production 70-100 percent.

The matter of bird and nest parasites is in need of much more study. A bander with a nest-box project is in an excellent position to contribute to this field. (Kibler, 1968b). It is not unusual to see nestlings with feathers "moth-eaten" by bird lice (*Mallophaga*), or to find a flattened, side-walking bird-fly (*Hippoboscidae*) dart out from the feathers onto one's hand and back into the feathers again.

Ticks, trematodes, mites and fleas can all be found as well as a long list of organisms saprophytic on the nesting material (Peters, 1930; Dobroscky, 1952).

There remains one more significant factor to which the bluebird is subjected and this factor is perhaps more devasting than the competitors, predators and parasites together. Bent (1949: 253) calls Jack Frost, ". . . the bluebird's most formidable enemy, the enemy that has destroyed more of them than all other enemies put together . . .". In the northern states many of the first nestings are interrupted because of early spring freezes. That inclement weather can be a significant factor in bluebird mortality is borne out by the results of my first nesting period in 1968, in which 76 percent of 51 nestlings died in the nest. This was an exceptional spring however; mortality from unfavorable weather is normally much less than this. The years of 1895-96, 1939-40, 1950-51, 1957-58 are classical examples of the decimation of bluebird populations during winter freezes in the south (James, 1961). In 1966 the first country-wide Breeding Bird Survey was conducted by Robbins and Van Velzen (1967). This annual survey will provide a much needed continuing check of the bluebird population fluctuations. It may be expected that it will show a correlation with one's nest-box project results. The population trend during the years 1958, 1959 and 1960 are discussed in detail by James (1962).

It should be pointed out that the various factors entering into the bluebird's behavior and survival are relative to the local conditions e.g. latitude, local weather conditions, local fauna, etc. Comments in this paper should be evaluated in this light. For instance, one gets the impression that black snakes are a more significant predator in the south whereas the raccoon is more important in the north; that excess heat is a problem in the south whereas excess cold is the problem in the north. Three nestings are the rule in the south but are rare in the north.

Maintenance and Banding:

I have tried to work out a routine which would utilize my time efficiently while not jeopardizing bluebird production. Five years of trying one thing and another have left me more respectful of nature's original plan and less desirous to manipulate her plan to my own ends. Some of the things I have learned and mistakes I have made are presented below.

The commonest means of catching the bluebird is to hand-trap the female in the nest-box. There usually is no danger of desertion if the female is brooding. There will be an occasional desertion if the female is laying or incubating. The closer to hatching the less likely desertion becomes. Because the female is almost always found in the box at night I have tried trapping at night but this seems to disturb her more and I no longer do this. I once checked the rectal temperature of five females at night. Every one deserted.

The best time to trap is in the morning or late afternoon when they are feeding more actively. The female is usually not on the nest during midafternoon but this is dependent on the nest air

temperature (Kendeigh, 1963). If the day is cold she will spend more time on the nest.

Fischer (1944) has covered the mechanics of trapping hole-nesting birds. I have used a levered platform activated by pulling a long string. When the trap is set it rests beneath the hole at a right angle to the front, like a perch or landing platform. When the string is pulled the platform swings up blocking the hole. By trapping after the young are hatched no desertions occur. In shallow boxes the male is reluctant to enter the box after the young are old enough to reach up to the hole. Unless a deep box is used this allows only about four-five days in which to trap the male using this method. When the young have grown and are about to fly there is not room for either parent in the shallow type box and the female also becomes difficult to catch.

Trapping in cold or rainy weather is risky because if the parents are alarmed they may leave the young unfed and cold for long periods. I once lost five nestlings while trapping near sundown on a cold day. The young were dead the next morning. It saves time to mount the trap 24 hours earlier to allow time for the birds to become accustomed to it. The string may be run out to the hiding position in advance but it should not be attached to the trap lever unattended. Dogs, deer, cows and even the wind may be enough to trigger the closure of the trap. Adults also may be trapped with mist nets set up near the box or decoyed into ground traps using shelled chopped raw peanuts (Lewis, 1928; Thomas, 1946; Fast, 1955). I am currently using a radio-controlled trap which eliminates much of the work connected with the above methods (Kibler, 1968a).

Despite the advantages of facing the boxes away from prevailing storms as mentioned earlier, I have modified the direction of my boxes so that the entrance may be viewed from my car along the roadside. The car makes a good blind and this cuts down on trapping time.

The young should not be banded before 5 days of age; a 1-B band will slip off the leg if banded earlier. Most nestling bluebirds defecate shortly after being picked up from the nest. The banding of six nestlings could result in the deposit of six fecal sacs. Since the parent birds are careful to carry the sacs some distance from the nest it would seem logical to take similar precautions when banding.

The nest-box is cleaned out after each nesting. I find that by doing this nest boxes are more likely to be used again later in the season either by the same pair or another pair. It also makes for easier detection of fresh nesting activity in a box. By examining the nests before discarding them, unexplained events during the nesting may be discovered; for instance an egg which had mysteriously disappeared earlier may be found buried in the nest. Or the dessicated remains of a nestling or even an adult may turn up. Or one can estimate, from the number of larvae and pupae in the nest, the degree of *Apaulina* parasitism.

After the last cleaning in the fall one may cork the holes. This prevents deformity of the hole over the winter by gnawing rodents

and prevents their setting up a winter nest inside. In this latitude the corks should be removed by the first week in March. The mice and squirrels are not likely to move in at this late date and with the corks out the boxes are available to the bluebirds for overnight roosting or protection from winter storms (Frazier and Nolan, 1959, Bell, 1964 a, 1964 b). Boxes protected with cone-shaped guards should be corked for an occasional deer mouse may circumvent the guard.

The number of unnecessary trips to a box can be reduced by planning to arrive at whatever period in the nesting cycle one is interested in; e.g., the fifth or sixth day after hatching for banding the young or before the fourth day for banding the male. This timing can be achieved by estimating the age of the egg or nestling on the first visit and gauging subsequent visits accordingly. The age of an egg may be judged from its translucency or by the progressive change in the air space size. The nestling's age can be estimated by the change in size, coloring and plumage characteristics.

As a final word I would like to repeat what others have said before, that information laboriously collected but not organized and put to use benefits no one. If one is not inclined to write up his data three organizations that have requested data on bluebird nesting activities are: "Bluebirds Unlimited", Grand Rapids Audubon Club, 54 Jefferson, S. E., Grand Rapids, Michigan 49502; Dr. Douglas James, Associate Professor of Zoology, University of Arkansas, Fayetteville, Arkansas; and the North American Nest-record Card Program, Laboratory of Ornithology, 33 Sapsucker Woods Road, Ithaca, N. Y. 14580.

Summary:

After reviewing reports of various bluebird nest-box projects the author makes recommendations for a definitive nest-box. He emphasizes adequate floor area and depth. Advice in construction and placement is offered. Various factors that enter into the nesting cycle such as competitors, predators and parasites and the weather are discussed. Experience and suggestions for the maintenance of the nest-boxes, trapping and banding are recounted.

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21 Porter Avenue, Jamestown, N. Y. 14701

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