

## ANNUAL CYCLE OF THE BLACK-CAPPED CHICKADEE—2

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NEST CONSTRUCTION AND EGG LAYING<sup>1</sup>

*Cavity excavation.*—Most of the nest cavities were freshly excavated by the birds themselves. At least one nest was located in a woodpecker hole and several others appeared not to have been excavated during the current season. As has been already indicated, dead softwood early-successional trees, either well-decayed stubs or limbs, were most frequently selected for excavation. The eighteen nests (eleven 1940 nests plus seven located in 1941) were located as follows: pin cherry (*Prunus pennsylvanica*), four; paper birch (*Betula papyrifera*), three; beech (*Fagus grandifolia*), three; yellow birch (*Betula lutea*), two; willow (*Salix Bebbiana*), two; basswood (*Tilia americana*), sugar maple (*Acer saccharum*), white ash (*Fraxinus americana*), abandoned apple, one each. Mr. E. A. Preble tells me that among dozens of chickadee nests which he has examined in New England many were in stubs of the grey birch (*Betula populoides*), a species largely replaced by the paper birch in the Helderberg region.

The cavities dug by the chickadees themselves were very similar in inside dimensions. The depth (measured from lower edge of entrance hole to the bottom) of seven such cavities varied from 5 to 6.25 inches and the inside diameter at the bottom of the cavity varied only from 2.5 to 2.75 inches. The size of the entrance hole, however, varied considerably and was never completely round like a woodpecker hole. One nest had the entrance in the top as described by Stanwood (1911), but all the others had the entrance in the side. The outside diameter of nesting stubs or limbs varied from 3.5 to 6 inches. The height above ground ranged from one to forty feet, but only three were higher than fifteen feet and eleven were lower than ten feet. There was no particular exposure favored since entrances faced in nearly every direction.

Both sexes take part in nest excavation as has been recorded (Stanwood, 1911; Forbush, 1929). However, the female apparently takes the lead in the selection of the site and in the pair studied most closely she did about two-thirds of the total work. In two cases I happened to be present soon after a cavity was first started. In each case the hole was begun at a point where the bark was broken and the inner soft wood exposed. Also, several times during the

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<sup>1</sup> A few 1941 observations have been added to this section to supplement the observations made during the 1940 season.

pre-nesting period birds were observed to be attracted to loose pieces of bark or woodpecker diggings in dead stubs; they would fly down and pick away at such places momentarily. Chickadees apparently may explore about considerably and start several cavities before definitely selecting one as Butts (1931) also reports. Three pairs started cavities only to abandon them for other locations. In this early stage both male and female were observed to try out different places. In pair no. 3 both sexes were observed working at two different points on the same stub at the same time. In still another case the pair worked alternately at two stubs about 100 yards apart, gradually concentrating on one of them. In this case the female definitely led the way back each time to the cavity of final selection.

When the hole is first being started the bird may simply throw the chips over its shoulder, but once the cavity is well under way chips are carried out and dropped a short distance away, often with a flick of the head so that they are scattered somewhat. The bird may then return for another load or its mate may be working in the meantime. The pair do not necessarily take regular turns since one bird may make several successive trips while the other rests nearby. I did not observe one bird digging without the other being near. As in incubation and feeding of the young intermittent behavior characterizes nest excavation. The pair will work for a short while then move off to some other part of the territory to feed and rest. Digging activity was observed at all times of the day, but was most vigorous in the morning. An interesting observation of behavior during cavity excavation is recorded by the following field notes:

7.29-42 a. m. (13 minutes).—Female carried chips out of cavity 23 times and male 14 times. Female largely silent, male frequently whistles and calls softly. Female seems to have the right of way at the nest since the male gets out of the way when both birds happen to fly to the cavity at the same time (indicating female dominance at the nest?). Pair moves west, male going first.

7.42-58 (15 minutes).—Pair feeding quietly 100 yards from the cavity; male feeds female once but she does not beg. Then pair moves back to cavity, female leading.

8.00-05.—Pair back at cavity when a third chickadee appears suddenly. Male pounces on it immediately. All three birds make off to the north, both male and female apparently chasing the intruder.

8.05-08.—Female returns to work on cavity, male still chasing the intruder in distant treetops which apparently mark the north boundary of the territory.

8.10-23 (13 minutes).—Male returns; female makes 14 trips to cavity, male three, then birds move to the south.

8.23-30 (7 minutes).—Feeding quietly several hundred yards from cavity. Pair slowly returns, female leading.

8.30-41 (11 minutes).—Female makes eight trips to cavity carrying out chips each time; male makes three trips, carried no chips on one trip. Pair moves southeast.

8.41–9.27 (46 minutes).—Pair working south and east to extreme boundaries of territory, feeding silently or with soft *seep* calls. Spend ten minutes resting in low bushes. Finally return to cavity, female again leading.

Only four days were required to complete the above cavity, but the time probably varies widely depending on the amount of excavation that has to be done and on the weather. It is interesting to note that in most European Paridae (but not in *P. atricapillus*) the female alone digs the cavity (Steinfatt, 1938).

*The nest.*—The chickadee's nest consists of a soft wad of plant and animal fibrous material. It really represents a lining for the bottom of the cavity since no coarse supporting material is included. Seven nests were collected after the birds were finished with them and these were examined in detail. All seven contained rabbit hair (from *Sylvilagus floridanus*) and this item formed the bulk of five nests. Horse hair formed the bulk of one nest located in the only territory which included the edge of a barnyard. Soft plant down (from several unidentified plants) and moss were present in all nests. Thin strips of bark and a piece of string turned up in one nest. Thus, while the nest composition varied according to availability, there was a definite preference for hair, moss and other soft materials, which agrees with descriptions of nests in other localities. Two nests studied by Stanwood (1911) in Maine were made of rabbit hair, moss, plant down, and cedar bark. Chapman (1900) speaks of a nest being composed of rabbit fur.

The nests were weighed after they had been kept in the same room for a week or more so that they would presumably have the same relative water content. The weight varied from 1.6 to 10 grams with an average of 4.3 grams.

Apparently only the female carries in nesting material although my observations of the nest-building behavior are limited. In the case of two pairs the male accompanied the female to the nest as she carried a load of nesting material, but remained outside calling and whistling softly as she worked on the nest within. In one of these cases the nest was virtually completed (material may be added during egg laying as indicated below) in two days, the female working at least to some extent both in the morning and in the afternoon. Four loads of material were carried in during thirty-seven minutes of observation in the morning of the first day, and three loads during forty-one minutes in the afternoon of the second day. There then followed a lull of two days before the first egg was laid. In six hours of observation during the daylight portion of these two

days, the pair visited the cavity only four times, the female merely entering and leaving quickly. However, she spent the nights in the cavity. The roosting of the female in the cavity prior to and during egg laying was observed in several other cases also. In these cases the male was observed to accompany the female to the cavity and then to seek a roosting place nearby. One male roosted in the foliage of a small maple about twenty yards from the nest.

*Egg laying.*—Eggs are laid one a day, before 7 a. m in the case of one female. The first several eggs, at least, are partly or completely covered with nest material by the female after she lays them, as Stanwood (1911) has reported. It may be that fresh material is brought in each day to cover the eggs since I once observed the female carrying in material during the egg-laying period. As the set nears completion the eggs may be left uncovered as is also the case during incubation.

During the egg-laying period the sexes remain closely associated as during cavity construction and nest building. The pair spends most of the time ranging over the territory, feeding and resting. The male may feed the female occasionally and she may beg, although the begging-feeding behavior becomes more pronounced with incubation. One pair was followed for three hours in midday during the egg-laying period without their once going near the nest. The female, however, spends the night in the cavity as during nest building. Apparently little incubation takes place at this time since the eggs in all sets hatched within one or two days. Regular incubation in one case was begun the day before the laying of the last egg.

Chickadee eggs are very thin-shelled. Compared with the House Wren's (*Troglodytes aedon*) egg which can be safely handled, the chickadee egg is so fragile that it can be removed from the nest only with care. Allen (1929) has commented on the thin-shelled nature of the egg. The number of eggs in known sets was as follows:

5 eggs.....	1 set (a second brood)
6 eggs.....	1 set
7 eggs.....	4 sets (one a second nesting attempt)
8 eggs.....	1 set
Average: 6.7 eggs per set	

Sets of nine or ten eggs have been reported (Forbush, 1929). Seven sets found by Harlow (1918) in Pennsylvania ranged from five to eight, averaging seven. The number of eggs laid by the English *P. atricapillus* ranges from five to thirteen, usually eight to nine (Witherby et al., 1938), while migratory European titmice may average as many as twelve per set (Steinfatt, 1938).

## INCUBATION

*Rôle of the sexes.*—Forbush (1929) states that both birds incubate. Allen (1929) says that in the Black-capped Chickadee the sexes "take turns" incubating. On the other hand Chapman (1900) and Butts (1931) in observing nesting habits "assumed" that the female did the incubating.

A total of 31 hours was spent in observation periods of an hour or more at four different nests during incubation. Also, scattered observations were made on other pairs. In all this there was no evidence that the male takes any part in incubation at any time. While the male regularly comes to the nest to feed the female and was observed once or twice to enter the nest (when the female was absent) he never remained in long enough to do any incubating. It was always the female that entered the nest for the night. As further evidence, the male does not develop a brood patch. During incubation the down-feathers on the breast and sides of the belly of the female are absent and the skin is loose and wrinkled. In the male, on the other hand, the breast and sides of the belly are covered with down-feathers as is normally the case in both sexes during most of the year. Incidentally, the brood patch is a reliable method of sex identification during nesting as is also the behavior outlined below. Only the female *P. atricapillus* in Europe incubates (Witherby et al., 1938).

Just when the brood patch develops was not determined since no birds were caught between April and the beginning of incubation. It persists at least until the young leave the nest and perhaps until the fall molt.

*Incubation behavior.*—Rhythmic behavior involving attentive and inattentive periods ('on' and 'off' periods) characterizes the activities of the incubating female. While the female is incubating, the male regularly comes to the nest and feeds her. As he approaches the nest he gives a low whistled *phoebe* exactly like the regular song but much softer. Either the two- or three-note version may be given or sometimes only the first note is given. Such a 'signal song' used by the male approaching the nest has been recorded as a regular habit in many passerines; for example, the Song Sparrow (Nice, 1937), Hooded Warbler (Odum, 1931), and Black-throated Green Warbler (Pitelka, 1939). The female may answer the signal song with a low twitter. I cannot say whether she always responds vocally or not since one has to be very close to the nest to hear the twitter at all. Invariably, however, she comes up to the entrance to receive the food.

If the female has been on the nest only a few minutes she usually returns below; however, if she has been on ten or fifteen minutes or more she may leave the cavity either just before or just after receiving the food from the male and fly away for an inattentive period accompanied by the male. Thus, the male plays a rôle in regulating the behavior of the female by providing a stimulus for leaving the nest. However, the male controls the female's movements only within certain limits. If the male does not appear in twenty or thirty minutes the female will leave the nest of her own accord.

As mentioned under courtship, the signal song and the answering twitter may represent a repetition of courtship ritual. Only once was the female observed to whistle softly on approaching the nest; she usually approached the nest silently during both incubation and feeding of young. Chapman (1900), however, records that both sexes gave soft whistles at the nest.

Table 1 summarizes approximately 16 hours of observation of the incubation behavior of three pairs. Observations at a given nest were not made continuously but in one- to three-hour periods at different times of day (early morning, mid-day and late afternoon were times selected) and on different days during the latter half of incubation. The table, therefore, is intended to present a picture of the average inherent behavior (disregarding or 'canceling out' for the moment the variations due to environmental or individual differences) determined by the sample method. From this table we see that the average attentive period was 24 minutes, and average inattentive period 7.8 minutes. The male fed the female at the nest on the average of once each attentive period; about two-thirds of the time he caused the female to leave the nest and begin an inattentive period and about one-third of the time she left of her own accord. The time relations of the behavior of the three pairs were very similar. However, pair no. 15 differed in that the male was not observed to bring food to nest but called to female from a distance, and fed her after she left the nest to join him. Since in all other pairs observed, the male usually brought food directly to the nest, the behavior of the male of pair no. 15 may be atypical. A female Marsh Tit averaged 37.09 minutes on and 7.1 minutes off the nest during an all-day observation (Steinfatt, 1938). The female House Wren (*Troglodytes aedon*), although having about the same body size as the chickadee, averages only about 14 minutes on the nest as compared to 6 off (Baldwin and Kendeigh, 1927). Perhaps the longer attentive period of the titmice is related to the feeding by the male.

TABLE 1  
SUMMARY OF INCUBATION BEHAVIOR

Pair No.	Attentive Period				No. of times ♀ leaves nest		Inattentive Period			
	Number recorded	Length in minutes		No. of times ♂ feeds ♀ during one period		When ♂ calls	Of her own accord	Number recorded	Length in minutes	
		Average	Variation	Average	Variation				Average	Variation
7	15	26	15-36	1.6	0-5	11	5	16	5.6	2-10
4	7	23	6-48	1.3	0-8	7	2	9	9.6	3-23
15	7	22	11-61	0.0	—	3	5	8	8.3	7-11
Totals	29	24	6-61	1.0	0-8	21	12	33	7.8	2-23

There did not appear to be a pronounced difference in the rhythmic behavior of the birds at different times of day; that is, the behavior and the length of the off and on periods was about the same in the morning as in the afternoon. However, extreme weather conditions certainly modify the behavior. The longest attentive period, 61 minutes, was recorded during a cold rain; the longest inattentive period, 23 minutes, was during a hot July afternoon.

During the inattentive period, the female keeps up a continual begging (so long as the male is present) giving the *tee-ship* note which is almost identical with the food call of the fledgling. The male feeds the female at intervals and she also feeds herself in the meantime. He may accompany her back to the nest but more frequently she returns alone and very abruptly. While the female is incubating and when not carrying food to the nest, the male moves leisurely about the territory feeding and resting. He may sing occasionally or answer a neighboring male, but compared to many passerine males he expends very little energy singing while the female is incubating.

A vigorously begging female being fed by a male is almost a sure sign of a female with eggs, most likely incubating. If incubating, one need only to follow the female to find the nest, but this is easier said than done since she often returns silently and rapidly and the feeding is not generally done near the nest at this stage.

Some incubating females could be dislodged from the nest only with difficulty. Such birds may puff up and hiss at the intruder (see Forbush, 1929). Other birds, however, flushed immediately when the nest was approached; such females did not give the puffing-up defense reaction.

*Incubation period.*—The incubation period was determined accurately in only one case, roughly thirteen days. The time between the laying of the last egg and the hatching of that egg was approximately thirteen days and six hours. Forbush (1929) gives the incubation period as 11–13 days. Stanwood (1911) records the incubation period as being twelve days in one case.

#### CARE OF THE YOUNG

*Hatching.*—In two cases where hatching was closely observed, the eggs hatched within a period of twelve to twenty-four hours, and they hatched approximately in the order laid. The eggshells were immediately carried away, but I was not fortunate enough to observe whether they were eaten or discarded.



*Feeding of young.*—The behavior of the adults during the first week or ten days after the young hatch is much the same as during incubation, except that the male, which has been hitherto feeding the female, now feeds the young, while the female brings food to the young when returning from an inattentive period. The female shows the same rhythmic behavior as during incubation; she broods the young for twenty minutes or so and then is off for five or ten minutes. If the male arrives with food while she is on, he passes the food to her at the nest entrance. She may swallow it herself, or I believe she may turn around and pass the food on to the young below. If the female is not on, the male enters and feeds the young. He may remain in as long as two minutes, perhaps looking for excreta. For the first day or so after the eggs hatch the female may continue to beg from the male while she is off the nest. However, only rarely have I seen the male feed the female away from the nest after the young have hatched; instead, he ignores her and feeds the young. Very soon the female stops begging except for an occasional weak effort and both birds devote full energy to caring for their young. The male continues to give his signal song when approaching the nest whether the female is on or not. The female, as a rule, does not announce her arrival. If both birds arrive near the nest at the same time there is mutual wing fluttering. Only twice was a bird seen to enter the cavity when the other was already in.

During the first few days there was usually a noticeable difference in the way in which the sexes approached the nest. The female generally approached more directly and she entered the hole rapidly without pausing on the threshold. The male, on the other hand, usually paused at the entrance, before entering. The early difference in entering technique I interpret as being due to the female's habit of entering rapidly and the male's habit of stopping at the entrance during incubation. As feeding of young progressed, however, this behavior difference tended to disappear and both male and female entered the hole rapidly.

During the final week or so of nest life the adult's behavior is rather different from that of the early period. Brooding stops almost entirely except during cold or wet periods and during the night. Ceremonies are dispensed with as both sexes settle down to supplying the increasing demand for food by the young. The male no longer announces himself by the signal song except occasionally when he may lapse into his old habit in a half-hearted way. Vocal activity in general is quite reduced. The male rarely gives food to

the female at the nest and does not feed her when away from the nest. Wing fluttering may still take place, however. Both sexes now behave nearly alike since the several pronounced differences in behavior have largely disappeared.

Even though there is little brooding, a rhythmic behavior with definite attentive and inattentive periods is still evident in the activity of each parent. Thus, birds tend to feed several times in succession, then be absent for a period, resting or feeding themselves. As already mentioned in the discussion of territory, most of the food is obtained within a short distance of the nest. During inattentive periods, however, the pair may move farther away from the nest, but from my observation they do not cover as large an area (at least not regularly) as during the less strenuous days of incubation. Inattentive periods are often spent in resting quietly and preening. Sometimes the rhythm of the two sexes did not coincide so that one bird might be feeding while the other was off somewhere resting as Butts (1931) also noted. In general, the cooperation between the sexes decreased as the young increased in age.

Observations on the rate of feeding by pair no. 1 were made when the young were one day, four days, eight days and thirteen days old. At the first two ages the male fed two to three times more frequently than the female which spent about two-thirds of the time brooding. At eight days the male still fed about twice as much as female but at 13 days the sexes were feeding about equally and the female did not brood. The total number of feedings per hour by both sexes increased from 6.5 when the young were one day old to 14.4 when they were 13 days old. A similar trend was noted with several other pairs. Butts (1931) found that both sexes share about equally in feeding the young, but his observations were made toward the end of nest life. While the female is brooding regularly, the male apparently feeds the young more frequently than the female.

That feeding six to eight young would put a strain on the energies of the adults can well be imagined, but I did not appreciate the extent of the drain until male birds were brought into the laboratory for physiological measurements. The birds were caught in the late afternoon at the nest, and were kept overnight to be released in the morning, a confinement without food of not more than fourteen hours. Some twenty birds were thus handled during the winter, some kept at low temperatures, with none showing any ill effects on release in the morning. However, the first two males which were feeding advanced young, when given this treatment, were dead in the morning. In subsequent experiments birds were force-

fed at 11 p. m.; these all survived and when released in the morning returned to their nest duties. Thus, the birds worked so hard feeding the young as to deplete their own reserves and reduce their survival time markedly.

During the last week when the young are in the nest the female may not spend the night on the nest; in five observations the female entered the cavity for the night only once when the young were from ten to sixteen days old. Since the young are well feathered at this time and the cavity is well filled by them, it is not surprising that the female might choose to remain outside.

As a rule, chickadees in this area were little perturbed by my presence 15 to 30 yards from the nest and no blind was needed for observation or photographing. Some pairs would not even scold when I examined the contents of their nest. However, as is generally true among birds, the parents seemingly become more concerned about the young as the latter increase in age. In the case of pair no. 1, the birds paid no attention to me when stationed only ten yards from the nest until three days before the young left the nest, when they refused to enter until I retired some fifty yards away.

*Length of nest life.*—Allen (1929) states that the young remain in the nest twelve days. This is much too short since at twelve days the young are not only unable to fly, but hardly able to climb out of the cavity. In three cases where development was closely watched the young left sixteen days after the day hatching began. If disturbed, the young may leave prematurely. The young of one nest left at fourteen days when the cavity was attacked by a red squirrel; at this age they could not fly more than three or four feet. At sixteen days, however, young made flights extending thirty or forty feet from the nest and were able to keep well off the ground. In order to prevent premature departure it is best to band the young at between nine and twelve days, as later they become excitable.

#### DEVELOPMENT OF NESTLINGS

Nestlings were removed from the nest from time to time for morphological and physiological measurements. This part of the study will be briefly summarized, leaving the details for a later publication.

*External appearance.*—The chickadee is an altricial species, hence is hatched in a nearly naked, helpless, blind, cold-blooded state, and with a well-developed mouth and abdomen and, in comparison, poorly developed limbs. Down feathers are located in six small patches, all on the dorsal surface as follows: capital tract, two tufts

(superciliary region); humeral tract, two tufts; and dorsal or spinal tract, two tufts (one each on cervical and dorsal regions). There are only two to twelve feathers in each tuft; one bird had only 29 down feathers in all. There is little or no sign of developing contour feathers or feather tracts in a newly hatched bird, but these appear as dark points in the skin very soon. By the fourth day all the future feather tracts can be made out; the ventral tract generally lags behind the dorsal tracts in development. The 'pin-feather stage' is reached about the ninth day and by twelve days the body is nearly covered with feathers although there are still bare patches on the body and the remiges are partly sheathed. By fifteen or sixteen days the nestlings resemble the adults in plumage except for the short tail, somewhat shorter primaries, and the yellow corners of the mouth.

*Weight.*—Nestlings weigh slightly over a gram when hatched (average of two broods, 1.13 gms.). When ready to leave the nest they may weigh as much as or even more than their hard-working parents (between 10 and 12 gms.). Increase in weight is rapid during the first nine or ten days with little or no increase between twelve and sixteen days.

*Physiological development.*—Temperature control begins to develop about the fourth day; that is, muscle tremors (indicating a beginning of a heat-production mechanism) were first detected at that time and the body temperature was maintained slightly above that of the environment at the higher temperatures. Development of temperature control is gradual, but the most rapid changes accompany the period of most rapid growth. However, physiological development is more rapid than feather development. At nine days the heat-production mechanism is well developed but feathers are poorly developed; hence, temperature control is easily broken by a drop in air temperature. By twelve days, feather development has caught up and for all practical purposes the bird is 'warm-blooded' although it does not have the resistance of the adult. The heart rate as well as the breathing rate at average nest temperature (95° F.) is highest at about nine days. This is interpreted as due to strain placed on the circulatory system as a result of lag in feather development (hence poor heat-loss control). Physiological and morphological development of the chickadee, in so far as preliminary measurements show, is very similar to that of the House Wren, which has been studied in greater detail.

*Behavior.*—The behavior of nestlings closely follows morphological and physiological changes. Nestlings in the cold-blooded stage react

to most stimuli either by opening their mouths for food or by 'squirring'. There is no 'sense of fear' whatsoever. The development of fear coincides with the development of temperature control and the opening of the eyes, which begins at seven days but the eyes are not fully opened until twelve days. By twelve days nestlings may make a hissing sound somewhat similar to the hissing of the incubating female, when the nest is disturbed. Newly hatched birds have a very faint food cry, a very high pitched *eee* which develops into a noisy clatter as they get older. The characteristic begging note (*tee-ship*) is ordinarily not given while the young are in the nest, unless left for sometime without food.

Nestlings of all ages are quite active, moving around in the nest. This activity increases with hunger; when nestlings were removed from nest to laboratory and placed under simulated nest conditions (darkness, proper nest temperature) they remained fairly quiet for the first hour or so but became increasingly restless thereafter. In the nest as the young get larger they become more and more closely packed in the cavity which may be only 2.5 inches in diameter; under such conditions there is apparently a rotation of the young with the hungriest bird tending to struggle to the top of the mass to receive food. Stanwood (1911) observed that the young continually changed positions in the nest. This author also noted that the young excrete immediately after being fed (a gastro-colic reflex common in altricial birds) and that the excreta are taken away immediately, which explains why the excreta rarely remain in the nest long enough to soil it. The excreta were usually carried from the cavity and dropped as the bird alighted, but sometimes were eaten.

*Number of broods.*—One brood was apparently the rule for chickadees during the 1940 season. However, female R-RB raised successfully two broods, having a different mate for each brood as already explained. It is possible that with an earlier season more second broods might be attempted.<sup>1</sup> There was also one late second nesting following the destruction of the young in the first nest. The nest (pair no. 4) was destroyed on June 10, when the young were less than a week old. On June 14, the pair was observed showing interest in several dead stubs, and eventually they shifted their territory somewhat to the east and dug another cavity (not shown in Text-figure 1) about 300 yards from the first. The seven eggs hatched on July 9 so that the first egg must have been laid about June 20 or 21, ten or eleven days after the first nest was destroyed.

<sup>1</sup> In 1941, when the spring was considerably earlier than in 1940, at least two second broods were successfully completed in the same area.

Steinfatt (1938) reports that among European Paridae, migratory species raise two broods, resident species raise one.

#### DISPERSAL OF THE YOUNG

Nestlings generally left the nest in the morning although one brood left in the afternoon. I happened to be present when one brood left. The young were very restless prior to leaving, continually coming up to the entrance hole and returning below. Finally, four young left the nest in rapid succession at 9.20 a. m., and the remaining three left in rapid succession at 10.00 a. m. Their first flight was strong even if labored and landed them in bushes twenty to thirty yards from the nest. While the young were leaving the nest both parents flew about excitedly, calling and whistling *phoebe* softly. The parents, therefore, seemed to give vocal encouragement to the young when they left, but did nothing so far as could be seen to coax them out of the nest. After the first group of young left, one parent continued to feed the others in the nest. Very soon after all the birds had left, the whole group began to move south toward the heavy woods (nest was in a small willow bog), in the direction in which the parents usually flew to get food; it seems clear that the young followed in the direction of the parents' movements. By 10.40 the group was in the forest edge and the young were forty feet or more up in the trees. By nightfall the family was at the extreme opposite end of the territory where they all roosted in hemlocks for the night.

A very interesting 'injury feigning' was observed on the day the young left in the case of two different pairs. In each case I captured one of the young whereupon it squealed loudly. Immediately both parents flew at me scolding loudly then perched on a nearby low limb and performed the following antics: wings were held outstretched and slowly flapped back and forth over the back; the head was held straight out and moved slowly from side to side in a grotesque manner. Squeaking on the back of my hand to imitate the cry of the young produced exactly the same result. This 'injury-feigning' behavior seemed to be similar to that encountered in shorebirds and other ground-nesting species except that it did not take place on the ground. Also, apparently, the particular outcry of the young (or imitation of it) is necessary to bring about the behavior since I never observed it when flushing a bird from the nest or while examining nestlings before they left the nest; on these occasions the adults merely scolded vigorously. However, Pettingill (1937) observed 'injury-feigning' in the Acadian Chickadee (*Penthestes hudsonicus littoralis*) when a red squirrel approached the nest.

Five broods of nestlings were banded with colored bands in order to follow their movements and to find out how long they stayed with their parents. One brood was not seen again after they left the nest; the history of the four others is as follows:

*Pair no. 16.*—Young left nest June 18. June 21, failed to locate family in a search through territory and adjacent areas. June 29, encountered both parents and young at extreme north end of nesting territory (see Text-fig. 1); young begging and being fed by parents, also feeding themselves. July 10, one young moving with a flock of unbanded birds north of the territory; both parents later seen on their territory and not accompanied by any young. July 16, one of marked young in flock with unbanded birds, and the adults of pair no. 15 on the latter's nesting area. Adults have returned to old nest site for second nest.

*Pair no. 15.*—Young left June 29. June 30, family at extreme south end of territory. July 1, failed to locate birds. August 3, adults in a flock which contained unbanded young birds, one young of pair no. 16, but none of their own young; flock was in center of pair no. 15's old nesting territory.

*Pair no. 4* (second nesting attempt).—Young left nest July 23. July 24, still within territory. July 26, could not be found. August 27, one of marked young located in flock with unbanded birds, young and adults of pair no. 17; flock in vicinity of cottage at south end of Lincoln Pond. August 30, marked young again in flock as above; this flock thus contained a pair, marked young from two different nests, and unbanded birds which by their appearance and actions represented young of still other nests.

*Pair no. 19* (second brood).—Leave nest August 10. August 15, family together just beyond former territory. August 27, family has been joined by a number of unbanded birds and a banded young from nest of pair no. 4 (see above). August 30, family still together although adults only rarely feed young. September 6, one of young at least with adults in flock. Other young seem to have moved away.

In the literature one finds two opinions regarding dispersal of the young. Many authors have suggested that family ties remain strong and the family group forms the basis for the fall and winter flock. Butts (1931), however, did not find this true, since of two families banded in June, three of the adults but none of the young were present in the vicinity during the winter. Two of the young were later located about a mile away. However, it still remained to be determined exactly how long the young remained with parents.

From the history of the four families outlined above, it seems fairly certain that the young are able to feed themselves independently in about ten days and do not remain with the parents more than three or four weeks. Specifically, young still with parents were observed eleven days and twenty-six days after departure from the nest; conversely, marked young separated from the parents were observed 22, 33, and 34 days after leaving the nest. The young do not necessarily keep together; a few marked individuals were located not very

far from their parents but most of the banded young were not seen again. The large number of unbanded juveniles that appeared on the Preserve in July and August is also evidence of the quick separation and movement of juvenile birds. These can be distinguished with adequate certainty from adults in late summer by their plumage, behavior, and notes. Young birds have fresh clean plumage as compared with worn (particularly the tail) plumage of adults; the young are noisy, fight much among themselves, and their notes are hoarse and immature. The *phoebe* song is given frequently but is often imperfect and readily distinguishable from the song of the adult which is infrequently heard in late summer.

The first flock that was not a family group, was observed on July 10. It was composed of one marked and four unmarked juveniles. All of the subsequent flocks that were observed during the rest of the summer contained predominantly young birds, although as the adults finished nesting duties they would join the flocks of young. As observations given above indicate, the late-summer flocks were composed of adults and young from as many as three or four different nests. Consequently, it seems fairly certain that family groups do not start the flock behavior, but that the young themselves (with perhaps non-breeding birds) form loose flocks and wander about extensively. The adults, for the time being at least, remain on or fairly near their former nesting territory (but not near the nest) and join such birds as appear in the area.

#### NESTING MORTALITY

*Adults.*—From the ten nesting pairs watched most closely, three adults were lost; two females disappeared and one male was accidentally killed. The male (of pair no. 16) was replaced by male of pair no. 6 (to form pair no. 19) whose mate was one of the two females lost; neither of the latter was replaced, so far as known, so that the result was the breaking up of two nests. Mortality from natural causes was two out of twenty birds or 10 per cent. The fact that the birds had difficulty in replacing lost mates indicated that there were few if any unmated birds in the region after May 1.

*Nestlings.*—Of the ten nests shown in Text-fig. 1, six or 60 per cent were successful, four were unsuccessful. Two were abandoned because of loss of females and two (pairs no. 4 and 7) were destroyed by predators after the young had hatched. In the latter cases, the predator reached into the cavity through the entrance and pulled out the contents. Hair found near one cavity indicated that a raccoon may have been the culprit in this case. Pair no. 4 nested success-



fully a second time although the nest was attacked by a red squirrel with loss of one young. Pair no. 7 did not re-nest as far as was known. To sum up, out of eleven sets known to be laid (representing all nesting attempts) comprising approximately 74 eggs (the exact size of two sets was not known), a total of 53 nestlings was fledged. Nesting success figured in this manner comes to approximately 70 per cent.

Nice (1937) has summarized data on nesting success. The average of successful nests was 46 per cent for passerines having open nests and 65 per cent for hole-nesting passerines. The percentage of eggs from which young were fledged averaged 43 per cent in six studies involving mostly open-nesting species. Compared with this, from 61 to 76 per cent of eggs laid by titmice (in nesting boxes) in Holland were successfully fledged (see Nice, 1934). These figures indicate that hole-nesting as compared with open-nesting passerines have a high percentage of nesting success. The 60 per cent nesting success and 70 per cent egg success of chickadees on the Huyck Preserve in 1940, accordingly, is comparable to the averages found in other studies involving hole-nesting passerines of temperate regions of Europe and North America.

Regarding the increase in population, the twenty birds present at the beginning of the breeding season produced 53 young or a percentage increase of 265. This might be compared with the average of a fourteen-years' study of the House Wren, *Troglodytes aëdon* (Kendeigh, 1937), where the average number of adults nesting on fifteen acres was 19.7 and the number of young produced was 56 or a percentage increase of 284. Since at least three adults were lost, the net increase in chickadee population was 17 adults plus 53 fledglings or 60 birds as compared with 20 present at the beginning of the season—a three-fold increase between April and August.

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