

the migration was general. Persons in the Los Angeles and Fresno districts reported great numbers, and Walter Powell, acting ranger-naturalist of Sequoia Park, stated the birds were observed near "Sunset Rock" (6400 feet) within the Park. B. L. Fredrickson, game warden at Gilroy, reported a flock of five to six hundred in a cherry orchard at that place and C. I. Holmes, of Auburn, stated that flocks of forty and fifty were observed in cherry orchards in that district.

It is to be regretted that complete records were not kept on arrival and departure during the past five years, the only complete one being that of 1934-35, when the last one was seen on May 19. The records show time of appearance in the fall and are as follows:

Year	First seen
1931 .....	October 10
1932 .....	October 30
1933 .....	October 2
1934 .....	October 12

On April 13 two indications of breeding were noted in a large flock that occupied the electric wires along side the trapping station. This consisted of two birds edging to and from each other along the wire for a period of two or three minutes. Then when finally they came close together the female allowed the male to contact it and perform the mating act which lasted but a few seconds. Just a month from this date my last bird was banded and but 200 were seen in the vicinity. One week later there was none.

*Modesto, California, August 18, 1935.*

## THE FAMILY RELATIONS OF THE PLAIN TITMOUSE

By JOHN B. PRICE

The family relations of birds furnish some of the most interesting problems of ornithology. Many questions arise in this connection and among them are the following:

1. Do birds nest in the same territory year after year?
2. Do birds keep the same mates from year to year?
3. Is there any difference between the sexes in their habits of retention of a nesting territory?
4. Do young birds stay in the same locality where hatched and nest there the following year?

This problem has been investigated for the House Wren (*Troglodytes aëdon*), a migratory bird, by S. Prentiss Baldwin (*Auk*, 38, 1921, p. 237) who finds that this wren does not keep the same mate but that "divorce" is the rule. The Plain Titmouse (*Baeolophus inornatus*) is similar to the house wren in readily nesting in bird houses or nesting boxes but differs from that bird in one important matter. The House Wren is migratory while at Stanford University, California, the Plain Titmouse is resident the entire year, usually raises only one brood a season, and is usually seen in pairs.

The writer started this study in 1928. At that time colored celluloid bands were not in use, so he used only the government aluminum bands. This of course made the securing of results more difficult as it necessitated the capturing of the birds each year for identification and this was not always possible. The birds were captured in the nest-boxes, each box having a removable top and a shutter that closed the entrance when a person at a distance pulled an attached string.

The capture of the first member of a pair feeding young was usually not difficult; but the resulting disturbance usually greatly alarmed the mate and made its capture much harder. Sometimes the birds deserted the nest after one had been banded. When they did not, it often took several hours or days to capture the second adult, and sometimes, in spite of great effort, it was not captured at all, thus leaving the records incomplete.

In the 1928 season only 12 nest-boxes were in place and 7 were occupied by birds. A short account of this was published (Wren-Tit, 1, no. 3, 1929). In 1929, 39 boxes were in place and by 1931, the total number was 60. The writer was absent from Stanford in 1930 and was able to spend only one day in the field there that season. The only birds then captured were incubating females.

Nearly all the boxes were placed in oak trees, where the birds secure most of their food both in summer and winter. They were distributed according to the density of the oaks in an area on the Stanford Campus approximately one and a quarter miles long by three-quarters of a mile wide. The titmouses were not the only animals to use these boxes. The Western Bluebird, Chestnut-backed Chickadee, and Slender-billed Nuthatch also nested in them as did also mice and bumblebees.

The work was sometimes interrupted by irresponsible persons who removed the boxes or so damaged them that they could not be used for nesting. The writer replaced these boxes, but the interruption often prevented any birds from using them that season and caused more gaps in the records. The California Jay (*Aphelocoma californica*) is an important enemy of the titmouse. Jays are often seen about nesting boxes containing young titmouses and sometimes perch on the box and peer inside. When the young birds leave the nest the jays often dive at them and kill them.

The sexes of the Plain Titmouse are similar in appearance and cannot be distinguished in the field. However, one member of the pair during the breeding season has a bare area on the breast called a "brood patch." Autopsy shows this member to be the female. The male does not have this brood patch and thus the sexes can be distinguished in the hand. Only females ever were captured incubating the eggs.

This study was carried on from 1928 to 1933 with a partial interruption in 1930. In addition, one age record was determined in 1934.

*Number of Eggs.*—For fear of causing desertion of the nests the birds were disturbed as little as possible and so not as many observations on the general nesting habits were made as would be desirable. However, some data were secured concerning the number of eggs laid. The published statements conflict on this matter. Dawson (Birds of California, 1923, p. 602) gives the number as 5 to 7; Keeler (Bird Notes Afield, 1899, p. 111) gives it as 6 to 9; Bailey (Handbook of Birds of the Western United States, 1902, p. 456), Wheelock (Birds of California, 1910, p. 348) and Hoffmann (Birds of the Pacific States, 1927, p. 229), each gives the number as 6 to 8.

At Stanford the writer took notes on 62 titmouse nests in which egg laying was known to be complete (by later hatching of the eggs) and found that the average number was 6.75 and that the number ranged from 3 to 9, with the following distribution:

3 eggs in 3 nests	7 eggs in 17 nests
4 eggs in 1 nest	8 eggs in 14 nests
5 eggs in 8 nests	9 eggs in 7 nests
6 eggs in 12 nests	

*The Age of Titmouses.*—The oldest titmouse recorded was a male B42172 which was banded as an adult in 1928 and was recaptured nesting in the same box in 1934 when it must have been at least seven years old. It was absent in 1935. Three birds (2 males, 1 female) were found to be at least five years old; and 8 birds (2 males, 6 females) were at least four years old.

*Numbers of Adults and Juveniles Recaptured.*—As is shown below, there were a great many more recaptures of birds banded as adults than of juveniles in the following seasons.

Year	Adults captured*	Adults re-captured in later years	Per cent	Juveniles banded	Juveniles recaptured next year
1928 .....	10	3	30	18	1
1929 .....	14	8	57	32	0
1930 .....	5	5	100	0	....
1931 .....	28	15	53	47	0
1932 .....	40	20	50	48	1

\*Including returns during that year as some birds were captured for more than two years.

*Does a Titmouse Nest in the Same Locality Year After Year?*—For the moment let us disregard the question of whether the titmouses keep the same mates and treat the birds as individuals in order to include those cases where only one member of a pair was captured. The following results for *adults* show the number of *cases* in each group. For instance a bird nesting in the same box for three years would be two cases of re-nesting.

Adults re-nesting in same box	Adults nesting 43 yards to 90 yards away	Adults nesting 200 yards away from 1st box	Adults nesting more than 200 yards away
33	17	1	0

Those cases above where the adults changed their nesting box for one less than 100 yards distant probably do not represent a change in nesting territory but rather only a new nesting place in the same territory occupied the year before. In the limited time at his disposal the writer was not able to map the boundaries of the territory of each pair, but boundaries probably nearly always included both nest-boxes; for the oaks where these birds forage are widely spaced. If the changing of nest-boxes were really a change of nesting territory one would expect that the former territory would be taken over by another pair of titmouses nesting in the first box. With the exception of the female that moved 200 yards, this never took place. The first box was always either empty or used by bluebirds or chickadees. Often a bird would alternate between two boxes from year to year.

Thirty-five titmouses banded as adults were never recaptured. Some of them doubtless came to grief. The question arises: Did the rest change their nesting territory or did each stay in its former territory but nest in some natural site where it escaped observation the following year? The latter supposition is at least possible, for the following reason. If a pair had vacated their territory one would expect that ordinarily other titmouses would take it over and use the nesting-box. But with one exception this did not happen, and in each case where the original birds were not recaptured the following year the nesting-box was either empty or out of commission.

*Returns of Juvenile Titmouses.*—In all, 145 juveniles were banded; of these only two were ever recaptured. One female B42178 was banded as a juvenile in 1928 and was recaptured in 1929 nesting in a box over a half mile (1200 yards) away. Unfortunately, later during the season it was found dead. The second, also a female,

F80550, banded as a juvenile in 1932, was recaptured in 1933 nesting in a box 700 yards distant. The mate of this one-year-old female was then at least five years old.

The following summary of the above results deals with individual birds, not cases. A bird nesting in the same box three years is counted only once.

	Number banded	Number renesting in same locality	Number nesting over ¼ mile away	Per cent recaptured
Adults .....	64	29	0	45.3
Juveniles .....	145	0	2	1.3

From these results it seems fair to say that an adult titmouse usually nests in the same territory year after year and that a juvenile does not nest in the same territory where hatched.

*Does a Titmouse Keep the Same Mate from Year to Year?*—During the period from 1928 to 1932 twenty-six pairs of titmouses were banded. Of these, 12 pairs were never recaptured although as is stated above it is possible that some of them were still in the same territories nesting in natural sites. The family relations of the 14 remaining pairs are shown in the table below. The birds were banded with numbered Biological Survey bands, but in order to save space in the table each individual bird is represented by a letter or combination of letters. For instance bird B42172 is recorded as B♂. An "x" shows a mating; "C♀ x ?" means that the mate of C was not captured that year.

#### PERMANENCE OF MATING IN PLAIN TITMOUSE

(Letters indicate individual birds)

1928	A ♀ x B ♂	D ♀ x E ♂		
1929		D ♀ x E ♂	H ♂ x I ♀	
1930	? x C ♀		? x F ♀	
1931	? x C ♀	E ♂ x F ♀	I ♀ x J ♂	
1932	B ♂ x C ♀	E ♂ x F ♀	I ♀ x ?	
1933	*B ♂ x C ♀	F ♀ x G ♂		
1929	K ♀ x L ♂		S ♀ x ?	
1930	K ♀ x ?	O ♀ x ?		
1931	K ♀ x L ♂		Q ♀ x R ♂	S ♀ x T ♂
1932	L ♂ x M ♀ (N juv.)	O ♀ x P ♂	Q ♀ x R ♂	S ♀ x T ♂
1933	L ♂ x —N ♀	O ♀ x P ♂	Q ♀ x R ♂	T ♂ x U ♀
1929		AA ♀ x BB ♂		
1930				
1931	V ♂ x W ♀	AA ♀ x BB ♂		
1932	V ♂ x W ♀	X ♂ x Y ♀	BB ♂ x CC ♀	DD ♂ x EE ♀
1933	V ♂ x W ♀	**Y ♀ x Z ♂	? x CC ♀	DD ♂ x EE ♀
1929		HH ♀ x II ♂		
1930				
1931		HH ♀ x II ♂	JJ ♀ x KK ♂	
1932	FF ♀ x GG ♂	? x HH ♀	II ♂ x JJ ♀	
1933	FF ♀ x GG ♂	? x HH ♀	JJ ♀ —x—LL ♂	

\*Also recaptured in 1934 (mate not captured).

\*\*In a nest-box 200 yards distant from the 1932 nest.

All the other above birds nested either in the same box year after year or in one less than 100 yards distant.

The above table shows that 11 of the 14 pairs were mated together for at least two years although some of them later took new mates. In only three pairs the birds

did not remate at least once. To summarize:

Same pair mated for 3 years.....	2
Same pair mated for 2 years.....	3
Same pair mated for 2 years and then another mate for 2 years and then another mate.....	1
Same pair mated 2 years, then new mate 1 year.....	4
Same pair mated 2 years, then a new mate 1 year and then another new mate .....	2
	<hr/>
	11
Different mate 2 years.....	2
Different mate each of 3 years.....	1
	<hr/>
	3
Number of "divorces".....	1

An interesting fact is that there was only one case of "divorce" where a bird took a new mate while its former mate was still known to be living. In all other cases where a titmouse took a new mate the former mate was never recaptured anywhere and quite probably was dead, especially as in several cases it was known to be several years old.

So far as the results go, then, they indicate that the Plain Titmouse stays in the same nesting territory from year to year and keeps the same mate.

*Is There a Sex Difference in Retention of Territory?*—In some species of birds the male establishes a territory and then by singing attracts a female. If the male is killed the female leaves for another male's territory. But in the titmouse in the only case of known "divorce" each female kept its old nest-box and the male moved 80 yards to the new mate (birds HH♀ II♂ JJ♀). In 1932 no male was captured at the box with the deserted female HH and it is possible that this was a case of polygamy instead of divorce.

With this one exception there seems to be no sex difference in territory retention in the titmouse. If one member of a pair, either male or female, disappears, the surviving bird regardless of its sex stays in the nesting territory and by the next season has acquired a new mate. For instance D♀ and E♂ were mated together for two years. Then D♀ disappeared and E♂ remained in the territory and took a new mate F♀ for at least two years. Then E♂, then at least six years old, disappeared and F♀ kept the territory and took a new mate G♂. Other cases are similar.

If as seems to be the case an adult titmouse spends its life in one small nesting locality the chance of a "widowed" bird getting a new mate would theoretically be small, as all other "widowed" adults would presumably be waiting in their own territories for mates to come to them. In a few cases, such as Y♀, birds may move to a new territory, but as the juveniles do not nest in the locality where hatched it seems logical to believe that those that survive their first winter spread out over the country until each finds a "widowed" bird of the opposite sex. This actually happened in one case where L♂ nested in the same territory for four years and the fifth year mated with N♀ which had been hatched the year before in a box a quarter of a mile away.

There are many unsolved problems about the Plain Titmouse. In addition to details of nest building and the care of the young it would be interesting to learn the action of the mates toward each other during the winter months; how long the young birds stay with their parents; why they eventually leave; and their actions in finding mates.

*Summary.*—A study of the family relations of the Plain Titmouse (*Baeolophus inornatus*), a non-migratory bird, was made at Stanford University, California, from 1928 to 1933. The birds were captured and banded in nest-boxes. The number of eggs laid ranged from 3 to 9 with an average of 6.75. One titmouse was found to be at least seven years old.

Forty-five per cent of all titmouses banded as adults were recaptured in following years and all except one were nesting either in the same nest-box or in one less than 100 yards distant. Of those juvenile birds banded in the nest only two, 1.3 per cent, were recaptured nesting the following year, and both were more than a quarter of a mile distant from the box where hatched.

A titmouse usually keeps the same mate from year to year and there was only one known case of "divorce." Of a total of 14 pairs recaptured, 11 were mated together for at least two years and only 3 were not. No sex difference was found in the retention of territory from year to year. If a bird lost its mate the survivor, whether male or female, remained in the nesting territory and secured a new mate. In one case the new mate was known to be a juvenile of the year before.

*Stanford University, California, July 26, 1935.*

## AN OBJECTIVE METHOD FOR MEASURING IRRITABILITY IN BIRDS

By SHERBURNE F. COOK and HELEN C. FREDRICKSON

The purpose of the experiments herein described was to work out an objective method for measuring the irritability of a bird. In this sense we take irritability to signify the degree of responsiveness of the bird to the sum of environmental stimuli, whether or not all the stimuli are recognized as such by the observer. Thus one bird may give the impression of extreme activity, another may be relatively quiet. If we conceive of the observed actions as representing motor responses to external stimulation, then under field conditions we have no quantitative reproducible method for determining whether the differences lie in variation of the external stimuli, internal stimuli, or the nervous system of the bird. Some of these variables may be ruled out, partly at least, if we study an individual under controlled conditions.

*Method.*—In these experiments a canary was used which had been kept in a cage in the laboratory for some weeks. The particular factor studied was light intensity and the reactions of the bird were recorded by the kymographic method.

The bird cage was placed in a photographic dark room for half an hour prior to a run with the light at a reduced but constant intensity. A kymograph was set up to revolve at a slow speed, at a considerable distance from the bird. A signal magnet with writing point was arranged for recording and wires run to a switch key near the observer. The latter was seated close to the bird, and made a contact with the key whenever the bird made any motion, thus getting a record of all motions. A time clock recorded 5-second intervals on the drum. Each run consisted of 30 to 60 minutes of continuous observation. After each experiment the bird was brought for at least 30 minutes into a normal light intensity to feed and drink. Then it was replaced in the room at the light intensity to be used in the following experiment. In all-day testing the period from the beginning of one experiment to that of the next was 3 hours.

The light intensity was determined in a purely arbitrary fashion. A 10-watt bulb was placed in front of a camera at a constant distance and side leakage prevented. The light passed through a ground glass plate at the back of the camera and illuminated the bird and its surroundings. By closing or opening the diaphragm the intensity could be varied—reproducibly—because the bird was always placed