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BEHAVIOR OF THE BUSH-TIT IN THE BREEDING SEASON

WITH FOUR ILLUSTRATIONS

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The Bush-tit (*Psaltriparus minimus*) is a species which offers many problems for study and observation in connection with its flocking and nesting habits. The accounts of breeding behavior which are presented here are based chiefly on information obtained in 1932 and 1933 in Santa Clara County, California, and relate to the coastal race, *P. m. minimus*. Most of the observations were made on the Stanford University campus.

Beginning of the Mating Season.—As early as January and February flocks of bush-tits which have remained intact during the fall and winter start dividing into smaller and smaller groups. At the same time a few pairs may be found which have separated from the flocks and which have wandered off in search of nesting territory. In 1933 on the Stanford campus, two such pairs were found, one on January 4 and the second on January 11. A week of unusually warm weather may have accounted for the early mating; neither pair built a nest at that time. However, nests commonly are started in February, and the breeding season is at its height in March and April. After May 1 the number of nesting pairs diminishes as the season advances, but nests containing fresh eggs have been reported by Grinnell (Pasadena Acad. Sci., vol. 2, 1898, p. 50) and Willett (Pac. Coast Avif. No. 7, 1912, p. 105) as late as July.

At the beginning of the mating season, courtship may be observed in pairs which have separated from the flocks as well as within the small flocks which are existent during this part of the year. Courting consists chiefly of excited location notes, trills and sexual posturing.

A pair which has left the flock may wander away and forage separately for as long as a week before nest building is begun. In this period the birds appear at times to be seeking a nest site, for feeding is often replaced by rather aimless wandering through the territory. In the case of the January matings noted above, it is probable that the birds rejoined the flock.

The Nest Territory.—The size of the nest territory varies considerably, and it does not appear to be constant even for the same pair. It may vary from a diameter of fifty yards to one of three or four hundred yards, depending on the nature of the area and on the abundance of nesting materials and food.

Territorial ownership appears to be poorly developed. When a stray bird enters the territory of a nesting pair, the latter may respond by chasing the intruder for a few seconds, giving utterance to excited alarm notes and trills, until the intruder leaves. However, in many instances a stray bird is ignored, and it may even be allowed to forage with the mated pair. Toleration of stray birds may go even further than this. At the time of incubation, at one nest, three birds were found foraging together in the nest territory on two consecutive days for as long as an hour at a time. All three took an active part in nesting activities. While one bird covered the eggs within the nest, the other two foraged together, feeding and collecting nest material. When these two re-

turned, the one in the nest left immediately for another tree. One of the others entered the nest with nest material and then came out. The third bird then went into the nest and incubated the eggs for ten minutes while the second joined the first in foraging. The same toleration was noted at this same nest on the second day after the eggs hatched. In this instance three birds took turns feeding and brooding the young. The identity of the individuals was impossible to determine as none of the birds wore bands.

Such toleration suggests that the gregarious habits of the species carry over into the breeding season. It has been found in the study of the flocking habits of the bush-tit that the size of the flock territory is rather elastic. A flock remains within a general area, the limits of which, however, are not clearly defined. Flocks frequently enter the territory of other flocks, or part of any given flock may separate from the group and enter the territory of another for a time before returning. Frequently individuals from one group join an entirely new flock. This has been determined by observation of banded birds. It seems possible, then, that the sense of territory of a nesting pair may be modified by the characteristic tolerance and gregariousness of the species.

Construction of the Nest.—The nest built by the Coast Bush-tit is an intricate, pendant structure, hung in a concealing clump of leaves of an overhanging branch, and it is built of materials which blend with its surroundings, such as mosses, lichens, oak leaves and spider web. The entrance consists of a hole, usually placed on one side near the top, either above or below the supporting twigs. Above the entrance is the hood which is carefully woven around several twigs and which covers the top of the nest. Below the entrance is the neck which is the passage to the bowl, where the eggs are laid. The nest is entered horizontally, but the passage bends immediately and is vertical in the neck. At the bottom the passage flares to make the bowl. The neck is the slenderest, and usually the thinnest, part. The widest portion is the bowl, and here the walls are much thicker and are heavily lined. These features combined with the thick floor of the bowl, make the latter a warm place for the development of eggs and young. Nests average 23 cm. in length and the diameter of the entrance hole is between 2 and 3 cm. The widths of the nests and the thicknesses of the walls remain rather constant, but the total length, the internal length and the thickness of the floor of the bowl are variable. The distance of the entrance from the top of the hood depends on the type of entrance which is built.

The first step in the construction of any bush-tit nest is the building of the rim. This is a delicate circle of nest material bound together with spider web and supported between the forks of a twig or between two adjacent twigs to which it is firmly fastened (fig. 20A). This circular rim is almost always horizontal, or is nearly so, and in no case which has been observed does this hole ever remain as the final entrance of the nest. It is rather the rim of a preliminary open bag.

After the rim has been built, nest construction may proceed in either of two ways. In the first and most prevalent method, a small bag, perhaps an inch in depth, is hung from the rim (fig. 20B), loosely woven and very thin and delicate. In building, the birds cling to the edge of the rim and hang head down into the bag, adding materials to strengthen and thicken it. After this first tiny sac has been made strong it is stretched and extended from within, and then the thin places which result are filled in with more nest material. As the nest becomes longer, the birds enter it head first to carry on the work. After a bird disappears inside, the nest shakes violently and bulges out in place after place as the new material is added in the thin sections. The shaking apparently serves to stretch the structure. Most of the work is done from the inside, but some of the thick parts of the bowl are added to from the outside, the birds clinging to the sides as they work. The nest is now a long pendant bag, open at the top (fig. 20C).

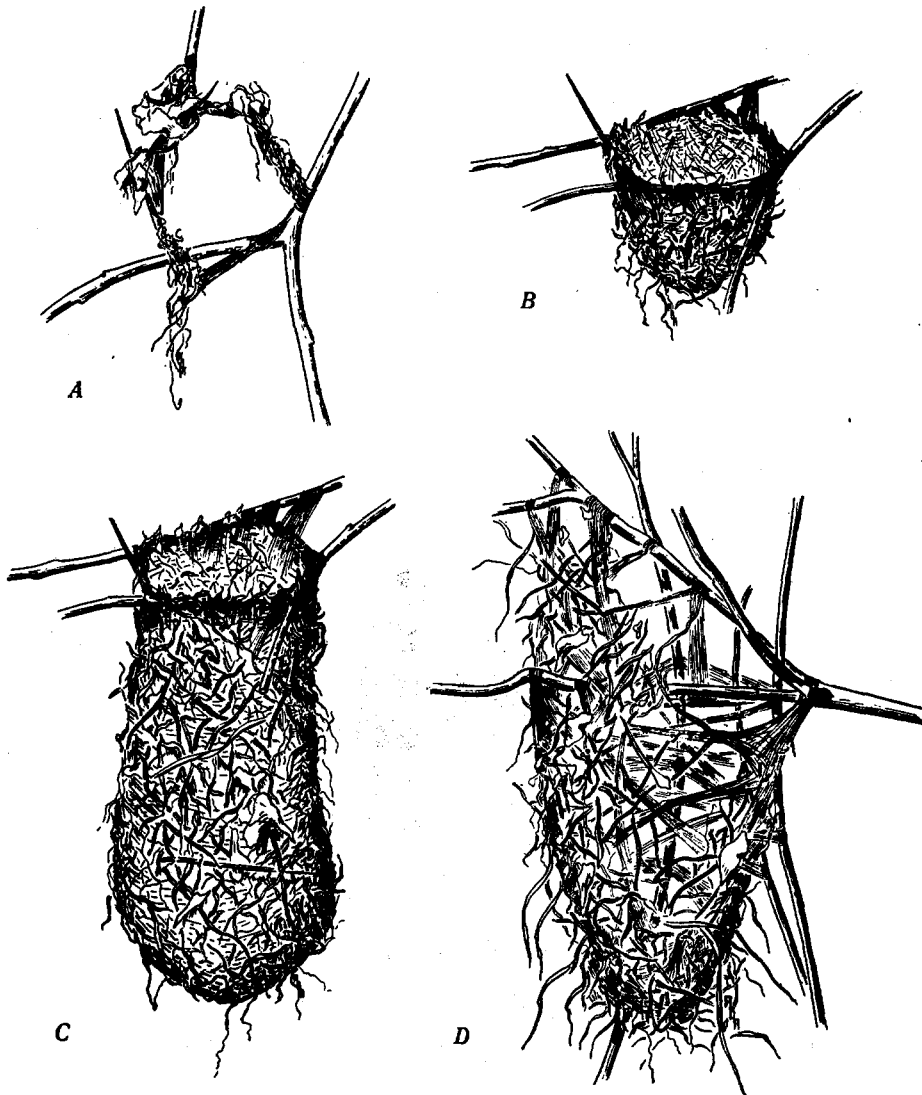


Fig. 20. Stages in the construction of bush-tit nests. *A*, the initial rim; *B*, small loosely woven bag hung from the rim; *C*, partly constructed nest before hood is built; *D*, a second-day nest showing loose type of construction.

When the hood and final entrance of the nest are built, material is added to the back and sides of the original rim. Material is brought over the top until the original hole has been roofed over and the entrance thus shifted to one side of the top (fig. 21). Rarely one finds a nest with the entrance hole only partly roofed over.

As the nest nears completion, a lining of spider web, down, or feathers is made for the passageway and the bowl. The bowl is thickened and filled in, and the walls above the floor of the nest for at least an inch are made quite thick. Material is added to the nest from time to time until the eggs have hatched, probably because the nest, being pendant, needs continual repairing.

In the second method, on the day following the building of a circular rim, a long extremely loose bag is constructed of strands of material hung from the rim (fig. 20*D*). Second-day nests as long as five inches have been observed, and Merriam (Auk, vol. 13, 1896, p. 123) reports one eight inches long. This long loose bag is strengthened with building materials added both from the outside and the inside, the thin places being filled in as before. Nests built toward the end of the season, or second nests, are usually constructed in this manner. They are built much more quickly, but are not as strong as those which are built more slowly.

The location of the entrance of the nest in relation to the supporting twigs varies. In some, the hood and entrance are built above the support (fig. 21). In such instances the nest is built as already described. In others, the top of the hood is fastened to the twigs and the entrance is below the support (fig. 22). In a structure of this latter kind, the original rim or hole between the supporting twigs is closed up when the nest is almost complete and a new entrance is made in the neck below. One nest that was observed illustrates this nicely. On the day that the first egg was laid the nest was fourteen inches long with a three-inch bowl and a long slender neck. The nest was entered

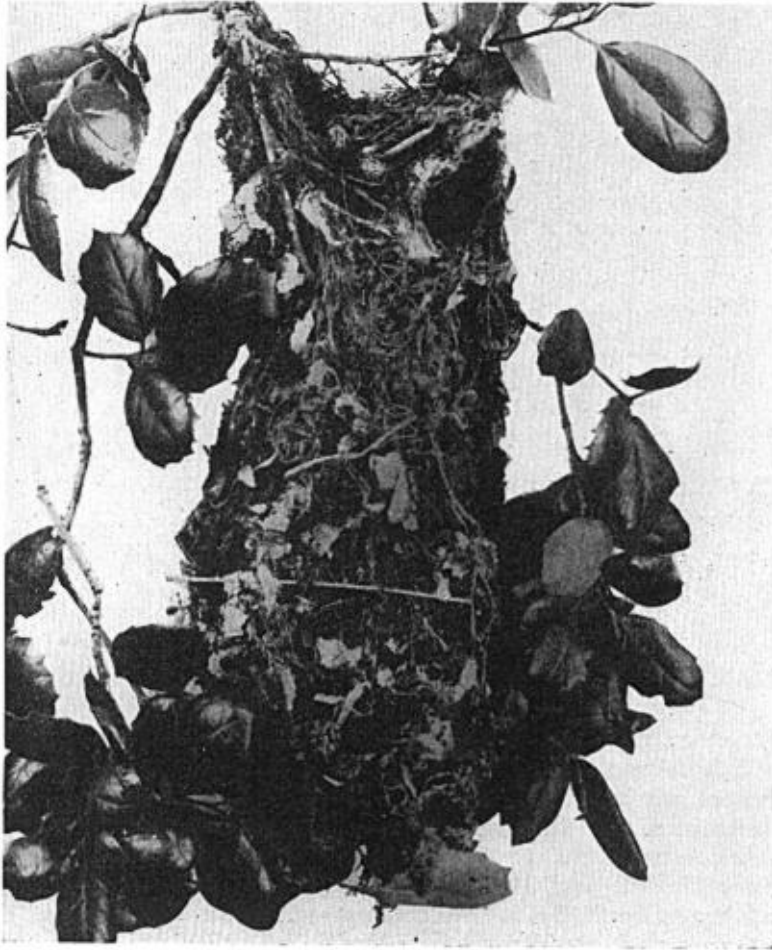


Fig. 21. Bush-tit nest with hooded entrance above supporting twigs.

by a hole at the extreme top between the forks of a supporting twig, and there was no hood. On the following day the birds opened a new hole a third of the distance down from the top and used this as an entrance, although the first entrance still remained. Occasionally one of the pair darted into the first hole, and then backed out as the passage just above the lower hole was blocked. Later the upper part was filled in solidly.

The construction of the nest is sometimes especially adapted to the immediate surroundings. One nest which was begun in the normal manner was bent to one side when a small branch directly below the three-inch bag prevented further extension directly downward. Another interesting nest was found, which, contrary to normal conditions, was not pendant, but lay almost horizontally on a thick tangle of branches. The bowl was slightly lower than the hood, and the nest was entered by a hole on the upper side of the hood, corresponding to the position in pendant structures.

Both members of the pair appear to share equally in the construction of the nest. They commonly search for materials together and return to the nest at about the same time. A careful study of the details of construction is instructive. The following account of the activities of a pair of mated birds is typical of the first stages of nest building:

The nest had just been started when found and consisted of a flimsy circle of spider webs and plant materials. The rim was supported in the angle of a forked twig and was attached by strands of spider web.

11:05. Both birds returned to the nest together, carrying nest material. One stood quietly on a twig while the other worked. When the first had finished, the second hopped onto the rim, thrusting its head through the opening. After fastening the material into the side of the nest, it moved its head rapidly up and down as though "sewing." Both left the nest and were gone fifty-five minutes.

12:00. One returned alone. It perched on a twig close to the nest and held the spider web which it had brought against the limb with its foot. Then, catching small bits of it in the bill, it pulled the web out into strands which it fastened to a near-by branch. The bird then darted to a large limb of the oak and, clinging vertically to the bark, removed a lichen. This was then poked in among the strands of the web.

12:10. The mate returned and added a little material to the rim, and both birds left together.

12:15. Both returned together. One hopped into the circle, fluttered its wings and poked at the sides of the rim. It appeared to be trying to keep the opening clear and large enough for entrance.

12:20. Both returned together. One bird took a strand of spider web and bound one end into the top of the rim, carried it up over a twig and fastened it into the nest again. Then it hopped into the circle and enlarged it with a flutter of the wings.

12:40. One of the pair brought a white mass of spider web to the nest. This it attached to the twig above the nest by holding it on the limb with its foot. With the bill it pulled out strands of the web and stretched them down to the nest; it "sewed" them in, and spun them back and forth over the upper twig several times.

It is noteworthy that the bush-tit nest should be started, as are those of other passerine birds which build pendant nests open at the top, by the construction of the rim. This suggests that the steps in nest building recapitulate the evolution of the nest building instincts.

Materials Used in Nest Building.—Bush-tit nests are built of materials found commonly in the breeding territory. Lichens, mosses, grasses and the staminate flowers of the live oak, *Quercus agrifolia*, are constituents of almost all nests. These are woven together with hundreds of strands of spider web. Other materials found less commonly are filaree fruits, bark fibers, various plant downs, fir or spruce needles, oak leaves, acacia blossoms, blossoms of other plants such as broom and the pappi of composite flowers, feathers, bits of paper and string, and insect cocoons. The material found in any nest is largely dependent on its surroundings. Thus, those built along creek bottoms contain willow and cottonwood down, those hung in fir trees have many needles, and those built near human habitations almost invariably contain some string or paper, which, although appearing decorative to the human observer, are probably used simply because they are abundant.

Since the largest number of nests hangs in live oaks, it is not strange that the most abundant materials should be from this tree itself or from plants on or near it. In nests which are started or are in the process of construction at the time when the staminate

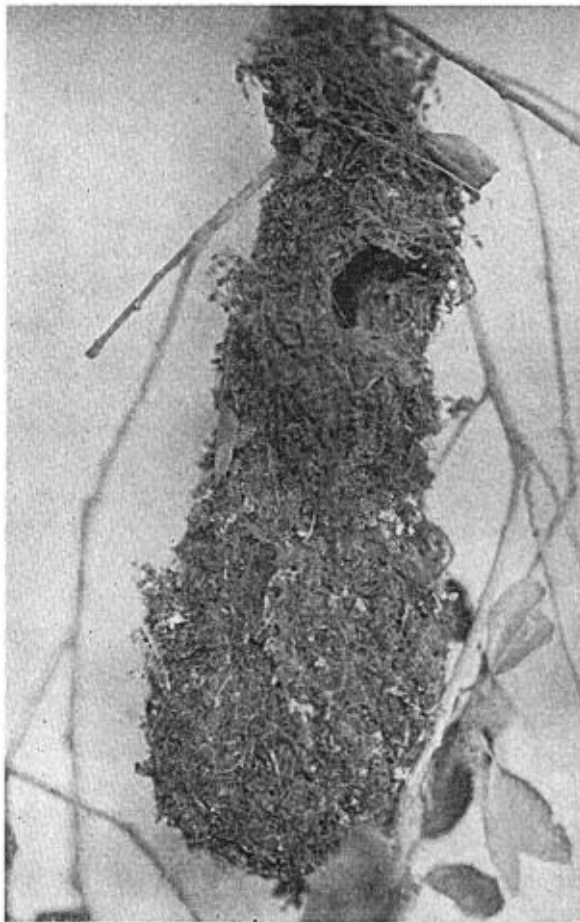


Fig. 22. Nest with entrance below supporting twigs.

flowers of the oak are in blossom, large numbers of these structures are found, the whole inflorescence being used. They are woven into all parts of the nest, but are especially common on the outside, where they serve to make the nest blend with its surroundings. There is no reason to believe that this protective camouflage is purposeful. The bark of the live oak and the branches of black oaks, toyon and other plants are covered with various lichens and mosses. These are found in all nests and throughout the entire structure, giving the nest strength and body as well as an inconspicuous neutral color. Many grasses also are used.

Feathers are woven into the body of the nest whenever available, as many as three hundred having been found in one nest. Frequently they line the bowl, but in nests in which no feathers are found, the bowl is lined with spider web or plant down.

By far the most essential material in bush-tit nests is spider web; it is found in every nest and throughout all parts of it. In 1932, two birds were observed in an *Araucaria imbricata* tree, north of the Stanford Mausoleum, as they collected huge bill loads of the spider webs which were stretched between the sharp scale-like leaves. On one occasion a pair of bush-tits discovered a low dead bush near their nest. One branch in particular was covered with a thick mat of webs and the birds returned to it frequently. Grasping a part of the mat in the bill, they would back off from it, fluttering and hopping, and pulling with the head. Often they both worked on the same section of web, pulling in opposite directions. Each carried a portion of it to the nest and returned for more. The web is an excellent binding material, being more or less adhesive, and it is easily pulled out into long strands. The entire success of the nest is dependent on the strength of the web.

The parts of the nest differ in the proportions of various materials used. In the neck the proportion of webs is high, since this part must carry the weight of the nest, and that of grasses and plant down and feathers is low. Large quantities of lichen, moss and oak blossoms are woven into the meshwork of spider webs in the neck. The bowl and hood have a large proportion of grasses and a smaller amount of web. The lichens and mosses are present here also. The web is apparently not as essential in these parts, as the materials tend to bind themselves together. Often the floor of the bowl is several inches thick and quite solid. It has been suggested (Dunn, Warbler, vol. 2, 1906, p. 29) that the thickness of the bowl is correlated with the amount of wind which blows in the region, but it seems more likely that it is related to the time spent in building. Second nests, and those built late in the season, are constructed quickly and the bowl is not thick.

Time Devoted to Nest Building.—The time required for the completion of a nest varies to a considerable extent. As a standard of measurement, the number of days between the beginning of nest building and the laying of the first egg was adopted. Building is rarely stopped in the course of this period and is usually continued after egg-laying. The shortest time recorded is 13 days, and the longest is 51. The following table presents the dates on which various nests were started and completed and the number of days occupied in construction:

Nest	Date started	Date completed	Number of days
1932 1	February 13	April 13	51
(San Jose)	February 2	March 26	49
9	February 12	March 26	42
1933 2	February 27	April 6	38
11	February 28	April 3	34
10	March 12	April 3	25
9	March 24	April 7	14
13	April 9	April 22	13
		Average	33.2

Nest 1 (1932), which took the birds 51 days to build, was not worked on for seven days in the course of the building period. This has already been subtracted from the total. Severe cold weather occurred three days after construction had started and during this time no work was done. It will be noted that this is an early date.

Nest 2 was disturbed on two occasions while it was being built. The birds were removed from the nest at night and one of the pair was banded. In both cases the banded bird deserted. Building was continued with a new mate within one day and the total number of days was but 38. Nest 9 was a second nest built after the desertion of the first due to banding. Only 15 days were used. Nest 10 was the third started by the same pair of birds. Each of the first two nests progressed as far as the rim stage and was

then abandoned. The third was rather loosely built, and the eggs were laid 25 days after the nest was started. No. 13, which was completed in 13 days, is interesting from two standpoints. First, it was started a month later than any of the others. Second, it was begun as a long loose bag as described previously. On the first day, the rim was constructed, and on the second the loose five-inch bag had been completed. The finished nest was not as strongly built as those which took longer to build.

The graph (fig. 23) shows the difference in the length of time taken to build nests in February, March and April, combining the years 1932 and 1933. Whether the decrease was due to the advance in the season or to increasing amounts of nest material is

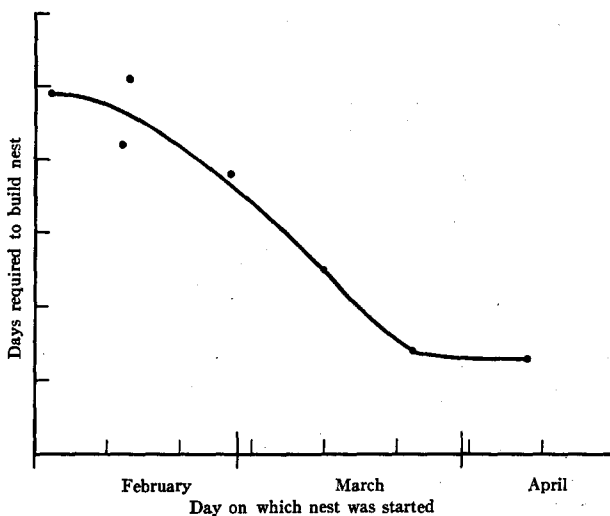


Fig. 23. Graph showing diminution in time required to build nest with advance of the season.

not known. Most of the later nests are second nests, and it has been found that these are built more quickly. This may therefore be an important factor influencing the curve.

Second Nests.—One sees frequent references in the literature to bush-tits which have rebuilt after the first nest has been disturbed (Merriam, *Auk*, vol. 13, 1896, p. 123 and Osgood, *Oologist*, vol. 9, 1892, p. 227). Out of 15 nests under observation on the Stanford campus in 1933, 10 were deserted, and of these, second nests were located for 6 of the pairs concerned and the collection of nest materials was noted in the remaining cases. In one instance the birds deserted when the nest was half built. Two of the pairs which rebuilt had completed the first set of eggs. One pair had laid but two eggs. Osgood (*loc. cit.*) reports having twice taken a full set of eggs from one pair. New nests were built in both instances.

The material of the first nest is frequently utilized in building the second. The birds may be seen tugging at the outside of the old nest, freeing some of the material and flying to the new structure with it. On one occasion, the first nest had fallen to the ground, and the bush-tits alighted on the ground to pull it to pieces.

Return to Nest Site in Subsequent Years.—The birds of nest 1 of 1932 were banded so that the two could be distinguished. In 1933 a nest was built in the same tree, and one of the building pair was a bird banded at the nest in 1932. The mate was unbanded. This is the only instance where the identity of the bird has been definitely known. It was reported to me that in two previous years (1930 and 1931), a nest was built in this

same tree. Again in 1934 a nest was built in this tree, but the identity of the birds was not determined.

That return to the same nest site is fairly common is indicated by the remains of old nests found in the same trees with those of the current year. In one case the second year nest was built in the identical twigs, with the entrance facing in the same direction as the nest of the previous year.

Second-season Nests.—Rarely nests may last through the year to be used again the following spring. The majority of them fall to the ground a few weeks or months after being deserted, the break occurring in the neck just below the hood. Usually those which last over the winter are not used a second time. But one nest was reported to me by A. H. Miller as being used a second season. This nest was built in a pepper tree about 20 feet from the ground above a sidewalk in Berkeley, California. The birds raised a family in the nest in 1932. In 1933 it was remodeled. New lichens and mosses were added to the outside and materials were carried inside as well, so that the structure took on a fresh appearance. Later activities of the pair indicated that young were being fed. The nest dropped to the ground during a light wind before the nestlings flew. The identity of the parents was not known, but since it is known that individuals do return to the same nest site in the second year, it is possible that at least one of the above mentioned birds had occupied the nest in the previous spring.

Tendency of Mated Birds to Separate.—In the spring of 1933 it was found, that, in many instances, when birds were disturbed in the course of building, egg-laying, or incubation, the pairs separated and remated with other birds. If only one deserted, the bird which remained at the nest brought a new bird to it. These facts were brought out by color-banding. In no instance was the sex of the banded bird known.

At nest number 2 one bird was banded on March 16, 1933. In subsequent observations it was noted that neither of the birds working on the nest was banded. The banded bird had either deserted or had lost its band. The nest was not deserted. On March 22, 1933, both birds from this nest were banded, as were both from number 1 and from number 11. Observations made on the following days revealed that neither of the birds working at nest 2 wore bands, and that the banded bird from nest 11 was not in evidence. Nest 1 was deserted and one of the pair was later found building in another tree with a new mate. In order to determine whether the birds were deserting their mates or losing bands a new experiment was attempted. On April 7, 1933, both birds working at number 2 were banded and, as a double check, the feathers of the wings and breast were colored with oil paint dissolved in carbon tetrachloride. The mates of nest 9, a new one built about 100 yards from 2, were captured and one of these was banded and painted. Its mate was one of those which had been banded on March 22 at nest 2. It had abandoned its first mate, found a new one and built the new nest. One egg had been laid. On the day following, the two painted and banded birds from nest 2 were seen foraging together, much occupied with preening. On the second day they had deserted the nest and joined a small flock. Both birds exhibited mating actions with new birds. Granting that the disturbances caused by banding and painting were unnatural, the effect on the birds could not be greatly different from those which might be caused by the invasion of the nest by a jay or snake.

In summary, it may be said that bush-tits exchange mates quite readily when disturbed at nesting. When one bird deserts a nest another mate is found to take its place. If both desert, they separate and seek new mates. It is more than likely that there is some correlation with the sex of the deserting bird, but at the time of these marking experiments it was not possible to distinguish between the sexes. It might be suggested that

the gregarious habits of the species during the rest of the year and the constant presence of unmated birds in small flocks during the nesting season are of significance here.

Egg Laying.—When the nest is essentially complete, the eggs are laid. It is, however, rather difficult to determine just when the nest is complete, for the birds often continue building operations during the egg-laying and incubation periods; but the nest always is strong, the hood completed and the lining finished before the first egg is laid.

One egg is laid each day until the set is complete. It is usually laid before 10 a. m. On several occasions the exact time has been determined. In three cases the egg was laid between 9 and 10:00 a. m., one at 9:15 and two between 9:30 and 10:00. One egg was laid before 8:30. When the female lays the egg, she quietly enters the nest and remains there for from ten to twenty-five minutes. She utters an occasional trill. The male sometimes remains silently in the tree, and at other times he flies off into other trees, foraging by himself. If the female is flushed off the nest she goes back immediately. There is little movement within once she has settled herself.

As soon as the egg is laid, the birds resume foraging activities together. The nest is entered from time to time and new material may be brought and added.

Incubation.—Incubation apparently is started on the day the last egg is laid, or on the day before. The burden of incubation seems to be shared equally by the male and female. Incubation activities of banded birds have not been observed where the sex was known, but careful observation has shown that as soon as one bird leaves the nest, its mate enters, and there is no appreciable or regular difference in the length of time which the two birds spend on the eggs. It might be added that only the female develops a brood patch, in spite of the fact that the male also incubates the eggs. In the female the down feathers on the breast region are lost and the area without down is about twice as wide as in the male and extends from the anterior portion of the breast to the anus. As far as has been determined, the brood patch is the only character by which the sexes may be distinguished. In these studies this method was used as often as possible, both birds being captured in the nest at night in the egg-laying or incubation periods, the brood patches examined and the birds banded with distinguishing colors. During egg-laying the female is further distinguished by distention of the abdomen by the egg to be laid the following morning. Eye color was not analyzed carefully.

Several puzzling problems are presented by the activities of a pair of incubating bush-tits. Often, especially on warm days, one gains the impression that the birds do not incubate. Conversely, the eggs are covered almost constantly on cold days. At such times the birds alternate on the nest for periods of from two to fifteen minutes, the average being about ten minutes. One bird enters the nest, and, except for a preliminary trembling of the structure, there is no movement. Often material is carried in and put in place before the eggs are covered. The mate usually leaves the tree, foraging within hearing distance of the nest. The incubating bird remains inside until the second one returns to the tree. The utterance of location or alarm notes by the returning bird serves as a stimulus for the one within to leave. Frequently the mate perches within six or eight inches of the entrance and darts in as soon as the first bird leaves. At other times the bird in the nest leaves it as soon as the notes of the returning mate are heard. This may leave the eggs uncovered, and on cold days the eggs are left for from two to twenty minutes. The bird within generally is silent. There follow the records of the activities of a pair of incubating birds in the course of an hour on a day (May 5) when the temperature averaged 14.5° C. and the sky was overcast:

- 8:30. Neither bird in the nest. Temperature outside, 14.2° C.
 8:31. One bird (1) returned to the nest and entered it immediately.
 8:40. Bird 2 came to the nest with a bill full of feathers and entered the nest when 1 left it.
 8:42. 2 left the nest as 1 was returning from a near-by tree. 1 entered the nest. Temperature, 14.5° C.
 8:58. 1 left the nest and joined its mate foraging in another tree.
 9:10. Both birds returned and one of them entered the nest. The mate remained in the tree.
 9:11. The mate also entered the nest with nest materials and one of them left immediately.
 9:25. The bird in the nest left. Its mate approached, but did not enter the nest and both went off together.
 9:30. One bird returned alone and entered the nest. Temperature 14.7° C. Raining.

At 11:00 a.m. on the same day the temperature had risen to 17.6° C. and between 11:00 and 12:00 the birds continued incubation as indicated above. At 1:00 p.m. the thermometer registered 18.6° C., the sun was shining, and there was a breeze blowing. Between 1:00 and 2:30 incubation proceeded as before. Nest materials frequently were carried in.

On warm days there seems to be considerable departure from this method of incubation. One seldom flushes a bird from the nest on such a day. The birds spend much time foraging together, and in carrying material into the nest, but they remain within for only a few minutes at a time. Thus there is correlation of time spent on the eggs with warmth of the day. The closely woven and thickly lined bowl probably is relatively warm inside. In order to check on this assumption a thermometer was inserted into a nest containing eight eggs, while another was hung outside. Readings were taken every half hour all day. Unfortunately the pair deserted the nest after this was done, but the existent difference in temperature throughout the day is of some interest. The sun shone on the nest only between 3:00 and 3:30 p.m.

TEMPERATURE WITHIN NEST IN COMPARISON WITH EXTERNAL TEMPERATURE

Time of day	Temperature within nest, degrees C.	External temperature degrees C.	Degrees differences
10:00 a. m.	17.6	15.2	2.4
10:30	17.7	15.6	2.1
11:00	17.8	16.9	.9
11:30	19.2	17.9	1.3
12:00 m.	20.6	18.3	2.3
12:30 p. m.	21.2	19.0	2.2
1:00	21.8	19.8	2.0
1:30	22.0	19.5	2.5
2:00	23.1	19.7	3.4
2:30	23.6	19.6	4.0
3:00	23.7	19.6	4.1
3:30	23.8	19.4	4.4
4:00	22.5	19.2	3.3
4:30	21.5	18.6	3.9
5:00	21.2	17.0	4.2
5:30	20.4	17.3	3.1
		Average difference	2.8

It will be noted that the differences are smaller in the morning than in the afternoon. In some instances the nest is over 4 degrees warmer than outside. This suggests that possibly in warmer weather the temperature would be high enough to make incubation by the birds unnecessary during the middle of the day at least. The difference may also explain why the eggs can be safely left uncovered on cold days for as long as twenty minutes.

Both birds sleep within the nest at night from the time the structure is strong enough to support them until the nestlings have flown. Thus the parents both spend the nights

in the nest during the egg-laying period before incubation is presumed to have begun. If incubation takes place during egg-laying, the eggs should hatch on successive days. Actually, all but one of the eggs hatch on the same day, indicating that although the birds sleep in the nest, there is not enough heat generated to start development of the embryo.

Length of Incubation Period.—In the one set of eggs which was observed closely, the incubation period lasted twelve days, the eggs hatching on the morning of the thirteenth day. Shepardson (*Oologist*, vol. 33, 1916, p. 116) also records an incubation period of twelve days. In three cases all but one egg hatched on the same day, one hatching on the day following.

Development and Care of Young.—The following accounts are based on detailed studies of one family of bush-tits, and less extended observations on a second. In the first case the nestlings were observed from a few hours after hatching until the morning of the seventh day, when they were killed, presumably by a California Jay. They were removed from the nest between 10:00 and 11:00 a.m. each day, weighed, measured, and photographed.

First day. At hatching the bush-tit is completely naked. The color is light flesh pink in all portions except the bill and the abdominal regions which are a decided yellow. The only evidence of feather tracts is in the region of the primaries and secondaries and on the tail. In these regions points of dark gray indicate the positions of the feathers. The birds are completely blind and the posture is that of the embryo, the neck flexed so that the head rests on the abdomen when the bird is not disturbed. The young are very weak and hardly able to raise their heads to open their mouths for food. No sounds have been noted from first-day birds. The egg tooth is present.

On the first day both parents collect food. Behavior is much the same as during incubation. A parent entered the nest, carrying visible food in the bill. The nest shook for a few seconds and the parent gave utterance to a series of odd chattering notes, which were the only evidence of solicitation noted. They are never uttered outside the nest. Parents remain within the nest, apparently brooding the young, for a period of ten minutes or less. As in the case of incubation, when the mate returns, the bird in the nest leaves and the second one enters. Feeding occurs from eight to twelve times an hour. Since the food is visible, it is therefore not predigested or regurgitated as stated by Wheelock (*Auk*, vol. 22, 1905, pp. 67-68). Lepidopterous larvae found on the leaves of the live oak are brought throughout the nestling period.

Second day. The feather tracts on the wings and tail noted on the first day show darker pigmentation. The oil gland is evident anterior to the tail. Pigmented feather tracts show in the rectal area. The young are now able to turn themselves over.

Third day. The egg tooth is still present and the eyes are closed. The feather papillae on the primaries and secondaries show pigmentation under the skin for a length of three-quarters of a millimeter. The papillae of the rectrices on the tail have pricked through and the papillae of the upper tail coverts show pigmentation under the skin. Pigmentation also shows on the frontal and coronal portions of the head and on the middorsal regions of the body.

A faint note is uttered by the juvenile at this age. When it is disturbed it raises its head feebly and opens its mouth. So faint is the sound that the bird must be held close to the ear if one is to hear it.

Fourth day. The eye slits are more distinct than previously. The rectal bristles have broken through the skin. Pigmented feather tracts are darker on the frontal, coronal and dorsal regions and are evident in the cervical and interscapular regions, completing the line from bill to the end of the dorsal region. Colorless papillae show on the femoral tract. Similar papillae also are evident posterior to the bill, extending along the ventral tract of the cervical region and dividing laterally to form the sternal and abdominal regions.

Fifth day. The eyes are still closed. A spot of brown has appeared on the top of the bill. A second row of rectal bristles has appeared. Pigmentation is evident in the postauricular regions and a semi-circular line of papillae has appeared on either side of the midventral line in the coronal region. The primary and secondary feathers are three-quarters of a millimeter long and the greater coverts of both have just broken through the skin. Pigmented papillae appear under the skin on the alula and on the marginal coverts and humeral tracts. The rectrices are half a millimeter long and the tail coverts are broken through. Pigmentation shows in the pelvic region on the femoral tract and on the crural tracts of the legs. Color has not appeared on the ventral side. The auricular papillae show pigmentation. The faint notes of the bird have become louder. The young are able to pull their heads up and sit up for a few seconds.

Sixth day. The top of the bill is darker than on the previous day. Feather papillae have appeared in two rows in the ocular region and are darker around the ear. All along the middorsal line the feathers have broken through. On the wings the primaries and secondaries are one millimeter long, the greater coverts one-half millimeter, and the middle coverts and humeral tracts have the pin feathers pricked through. The rectrices are one millimeter long. The pelvic region has joined the dorsal region. The papillae of the malar area are pigmented. The wings are held close to the body.

Seventh day. The eyes are still closed. The pin feathers along the back have all broken through the skin. The primaries, secondaries and rectrices are a millimeter and a half long. Pigmentation shows under the skin on the crural region of the legs, the femoral tract and the malar and submalar regions. Papillae of the under greater coverts show.

The weights and measurements of the birds described above are given in the following table:

WEIGHTS AND LENGTHS OF NESTLING BIRDS

Age	Weight		Length	
	Bird hatched first day	Bird hatched second day	Bird hatched first day	Bird hatched second day
1	.65 g.	.72 g.	23 mm.	25 mm.
2	1.05	1.07	27	26.5
3	1.32	1.27	28	31
4	1.75	2.12	29	32
5	2.62	2.32	33	35
6	2.85	2.75	36	37
7	2.98		39	

The nestling period of the second brood was fourteen days. On the sixth day the feathers on the wings and tail were just unsheathing. The birds were trilling weakly for food. On the eighth day the feathers of wing and tail were unsheathed to the extent of eight millimeters. One nestling fluttered to the ground from a box about a foot high. On the tenth day one nestling flew out of the hole in the nest through which I had removed two others. The corners of the bill were still yellow, but the remainder of the bill was brown.

The parents of the second brood were banded so that their activities could be followed. As early as the third day careful observation of the behavior of the two birds revealed that one bird did much more feeding of the nestlings than the other. For example, number 1 entered the nest with food ten times within the space of an hour contrasted with three times for number 2. Number 2 spent most of the time hopping quietly about in the nest tree while 1 foraged throughout the territory. The parents of these nestlings did not brood. This may be attributed to the warm weather during the nestling period. In sharp contrast to this, the parents of the first group of nestlings both brooded the young, definitely alternating on the nest. Both birds fed the nestlings equally. In both cases lepidopterous larvæ were fed to the nestlings throughout the period. Fecal sacs were carried as far as fifteen feet from the nest.

Behavior at Nest-leaving.—When the nestlings are ready to fly, the slightest disturbance sends them out of the nest. As one juvenile starts to leave, the impulse apparently spreads rapidly to the others. So quickly do they pop out of the nest, that one has the feeling that the nest has suddenly exploded. There is an incessant medley of juvenal trills.

The juveniles fly a little awkwardly and to a lower level when they leave the nest. They scatter in all directions, often alighting in the grass, uttering the trill all the while. The parents immediately become excited, uttering a rapid succession of alarm notes as they dash from one young bird to another in an evident effort to protect them and to get them together. This is quite a task, for the juveniles fly as far as twenty-five yards from the nest tree.

The parents spend from fifteen minutes to half an hour gathering the scattered family in low bushes or in a small tree. In the meantime the young birds try their wings and trill, but the parents are far too busy to feed them. Feeding starts as soon as the brood is in one place. Often three or four young perch along a limb in a fluffy row with feathers interlaced, in the manner of adult roosting birds. The more precocious members of the brood flutter clumsily from one twig to another and seem to find it difficult to maintain a firm foothold and a good balance. Fifteen minutes after nest-leaving one juvenile was observed making several attempts to secure insects from the limb on which it was perched. It was very clumsy and almost lost its balance each time. The juveniles of one family interspersed normal location notes with the juvenal trill. Half an hour after nest-leaving the young start following the parents in their search for food, begging with trills as they go. They frequently wipe the bill off on a twig, in the manner of adult birds after feeding. The parents spend almost their entire time searching for food for the young. When an adult approaches a young one, it attempts to put the food into the mouth, but if the juvenile does not take it immediately, the adult passes on to another. In this way a fairly even distribution of food is effected.

Subsequent Behavior.—As soon as the juveniles are able to fly well enough to follow the parents, the family moves about in typical flock formation, the parents doing all of the foraging for the young. This takes place at least the day after nest-leaving, and frequently only a few hours afterward on the same day. In one instance the juveniles were still perching in a bush near the nest on the second day after nest-leaving, but this may not be normal, since the birds left the nest early due to banding. Their wings were weak, and they were much clumsier and less active than others.

Feeding by the parents is continued from eight to fourteen days. One family was fed till the eighth day after leaving, when two of the juveniles were seen foraging for themselves, clumsily hanging upside down in search of food. It seems likely that the shortness of the juvenal tail makes this process difficult, since it has been observed that it is impossible for an adult without a tail to do this. The third juvenile of the family was still following its parents and begging with juvenal trills. It was fed by them from time to time, but not as frequently as previously noted. Although trills were still being used, location notes were common.

Begging and feeding were observed in another family up to the fourteenth day after nest-leaving. Feeding of the entire brood lasted nine days, after which one or two individuals were fed at long intervals.

SUMMARY

1. Territorial boundaries are poorly defended. Intruders are weakly repulsed and are often tolerated. A third bird is sometimes allowed to incubate the eggs and feed the young.
2. Nest construction is started by the building of a rim of spider webs. It may be continued by making a short bag which is slowly extended from within, or a long, loose bag may be built as a foundation. The hood and entrance are made by adding material to the back and sides of the original rim until the original hole has been roofed over and the entrance shifted to one side of the top.
3. Time devoted to building varies, the longest time being taken for February nests and the shortest for April nests. Second nests are built more quickly than first nests.
4. Pairs disturbed during building, egg-laying or incubation frequently desert and build second nests, usually with new mates.
5. Individuals have been found to return to the site of the previous year's nest in the second year. Occasionally a nest lasts through to the second season and is remodeled and used again, presumably by the same birds.

6. During egg-laying the parents spend the daytime out of the nest, foraging or collecting nest materials. The nights are spent in the nest, but incubation does not begin until the day before the last egg is laid.

7. On cold days the eggs are incubated almost constantly, the parents alternating about every ten minutes on the nest. On warm days much shorter periods are spent on the eggs, and the parents forage together to some extent. The temperature within the nest averages about 2.8° C. higher than outside. Both birds spend the nights in the nest.

8. Incubation lasts for twelve days, the birds hatching on the thirteenth.

9. The young are naked at hatching and down does not develop. The eyes are closed and remain closed at least through the seventh day.

10. The young are fed solid undigested food from the first day on, and lepidopterous larvæ are carried into the nest a few hours after hatching.

11. During early stages the young are brooded and fed as much by one bird as by the other. Toward the end of the period, one parent does about two-thirds of the foraging and feeding. The mate spends most of the time moving about in the nest tree.

12. The young apparently leave the nest on the fourteenth or fifteenth day.

13. They become independent of the parents within eight days after leaving the nest, but have been seen to feed themselves on the day of nest-leaving.

Palo Alto, California, August 25, 1937.

RELATIONS BETWEEN MAN AND BIRDS IN WESTERN EUROPE

WITH THREE ILLUSTRATIONS

By TRACY I. STORER

There is marked contrast between the conditions surrounding birds in western Europe and in California due to physiographic and climatic differences in the two areas and to the influence of man. In both regions primitive races of mankind levied upon birds for food and for other purposes, but the small human populations in those times left no obvious effect here, and the same may be inferred in Europe. Modern man has been in California for little more than a century, while in Europe his influence reaches back fully two thousand years. There his activities have altered profoundly the conditions of existence for birds. Discounting, for the moment, the important seasonal differences in weather of the two areas and the unlike size and shape of the land masses in the New and Old worlds in their bearing on bird populations and bird migrations, we may examine, in a comparative way, some of these human influences on birds. Observations made in 1934 in France (January), Italy (February), Switzerland and Germany (March-April), England and Scotland (April-July), while studying economic relations of birds and mammals in those countries, form the basis for this discussion.

To aid in visualizing conditions, the land areas and human populations of certain European countries may be compared with those of California. England and Scotland together are about one-half as large with seven times the population, France is a third larger with seven times the population, Germany is a sixth larger with ten times the population, and Italy is three-fourths as large with seven times the population. Thus, these countries, individually, are not greatly different from California in area but have enormously larger human populations. Much of the human population in Europe is grouped in cities and towns, so that there are many local areas with few or no human habitations, while in California people are scattered on farms over much of the non-mountainous part of the state.