1. A single song is a mosaic of one dimension—a sequence of *motifs*.
2. Each *motif* is commonly repeated from three to nine times before shifting to the next *motif*, thus making up a unit.
3. The bird usually employs from thirty-five to fifty of these units to complete a mosaic, then pauses for a period.
4. An aërial performance may occur without interrupting the continuity of a mosaic.
5. The number of different units is actually smaller than the listener would at first suspect, so that the same unit may appear again and again in a completed mosaic.
6. The *motifs* are largely original. Rarely do as many as ten per cent of them resemble the notes of other species.
7. These resemblances may be purely fortuitous or they may be actually mimetic.
8. Mimesis of certain notes is so completely perfect as to be almost indisputable.
9. Certain mimetic notes are heard only in the area or at the season when the imitated species is present.
10. The fortuitous resemblance is held to be due, not to inherited mimesis, but to the great complexity of the mocker's vocal and psychic equipment.
11. Amplitude of variation in mosaic pattern is greatest in the spring months and may sink to the zero mark in winter.
12. During fall or winter the song may become almost ruminative in character. This effect may be the result of immaturity, sex, season, or momentary psychic state.

The mocker is not a plagiarist. He is, in my opinion, a true artist.

University of California at Los Angeles, May 3, 1938.

SOME FEEDING HABITS OF THE RED-BREASTED SAPSUCKER

WITH ONE ILLUSTRATION

By CHARLES G. DANFORTH

From February 12, 1937, to March 29, 1937, records were kept of the feeding habits of a single Red-breasted Sapsucker (*Sphyrapicus varius daggetti*) on the University of California campus, Berkeley. It was not until further study was made of other individuals, however, that I felt justified in reporting these records. The sapsuckers subsequently observed were on the Stanford University campus and at Echo Lake in El Dorado County, California. The following field observations start with the individual on the University of California campus.

Method and Location of Work.—The feeding actions of this individual corresponded to those of other sapsuckers that were subsequently observed. Clinging by means of toes and tail to a tree trunk, the bird generally held its body well off the tree, and maintained a pose of motionless alertness. When actually feeding or working, the bird changed its position by hitching up or down the limb without use of the wings. Little if any work was done when on the under side of a branch. As a general rule, no noise was made, either vocally or in working on the green wood. The actual drilling of the holes was accomplished by a side-to-side "chopping" with the closed bill, this often causing chips to fly to distances of ten or fifteen feet. There was an average of two strokes to the second, and the bird required one and one-half minutes to make, or at least to start, a hole. However, the work was never continuous, there being a period of about three minutes or less of work, followed by a resting time of often as much as fifteen minutes.

During the period of observation, the weather was poor and downpours were frequent. However, I never once saw the sapsucker during a rain, and only twice when the sky was overcast. Apparently little boring was carried on in inclement weather. In all, the bird worked on at least eight different trees on the campus in the season of 1937, and I found evidences of work during previous years, possibly by the same bird, on eight other trees in the same general locality. The trees bearing *old* workings were:

2 Acacias (*Acacia elator*) near Hearst Mining Building, south of the sundial
1 Mount Atlas cedar (*Cedrus atlantica*) southwest of the stadium
1 Eucalyptus (*Eucalyptus viminalis*) on Big C Hill
1 California bay (*Umbellularia californica*) on hill above the Greek Theatre
1 California live oak (*Quercus agrifolia*) south of Giannini Hall on Strawberry Creek
1 American elm (*Ulmus americanus*) south of Agriculture Hall, near creek
1 English oak (*Quercus rober*) beside the above-mentioned elm
1 Oak (*Quercus* sp.) at 1849 Arch Street, Berkeley

Each of these trees showed evidence of having been worked on for at least one year, and the number of holes ran from fifty, on the Arch Street oak, to at least three thousand on the eucalyptus. The trees upon which work was carried on this year were:

1 California bay (*Umbellularia californica*) by California-Giannini Hall road bridge
1 California live oak (*Quercus agrifolia*) at the same locality
1 Mount Atlas cedar (*Cedrus atlantica*) south of Agriculture Hall, on creek bank
1 Mount Atlas cedar north of California Hall
3 Poplars (*Populus nigra*) at northeast corner of Life Sciences Building
1 Poplar (*Populus nigra*) at 1849 Arch Street, Berkeley

In observing the workings on these latter trees, a surprising amount of data was obtained. I counted 2000 holes bored on the bay tree, 6 on the oak, 85 on the cedars, and 189 on the poplars—a total of 2280 holes bored during a few months. Of these, 574 were made as I observed the bird working. Inasmuch as the period over which I kept notes was forty-two days, this means an average of over thirteen holes a day. However, since the bird was not observed working on overcast days, and since twenty-eight of these days were overcast, the daily average bored on "working days" was forty-one. Because it was impossible to watch the bird continuously, and because there may have been other workings of which I was unaware, I feel that an average of twenty-five or thirty holes bored a day is a conservative estimate. It must be remembered that the above estimates are of averages, since I have seen a working increase fifty-six holes between dawn and dark of the same day; and I once saw eighty-five holes bored within a period of thirty-six hours.

Types of Boring.—A study of the workings themselves leads to a better understanding of the feeding habits of this species. There seemed to be a stable "ground plan" for all of the holes bored (fig. 60 A, C). They were usually broader than high, and their depth depended upon the thickness of the bark, since they generally went only to, or more rarely through, the cambium. They were usually of a tapered form, but occasional large ones were undercut at their sides. Large compound holes were formed by merging two or more holes vertically, a horizontally compound hole being rare. These compound holes, as contrasted to what I called the single or simple holes, often had the bases of the septa remaining, so that the number of borings making up a compound hole could readily be computed. A simple hole was usually about 6 mm. wide, 4 high, and 6 deep, while the largest compound hole I observed was 110 mm. high, 16 wide, and 8 deep.

There were two types of workings (fig. 60 E, F), which I have designated as "spiral" and "grouped." The spiral type consisted of a circle of simple holes surrounding the trunk, but often ending at a level below that of the starting point, thus making a spiral. When this occurred, the holes of succeeding turns tended to be directly below those of

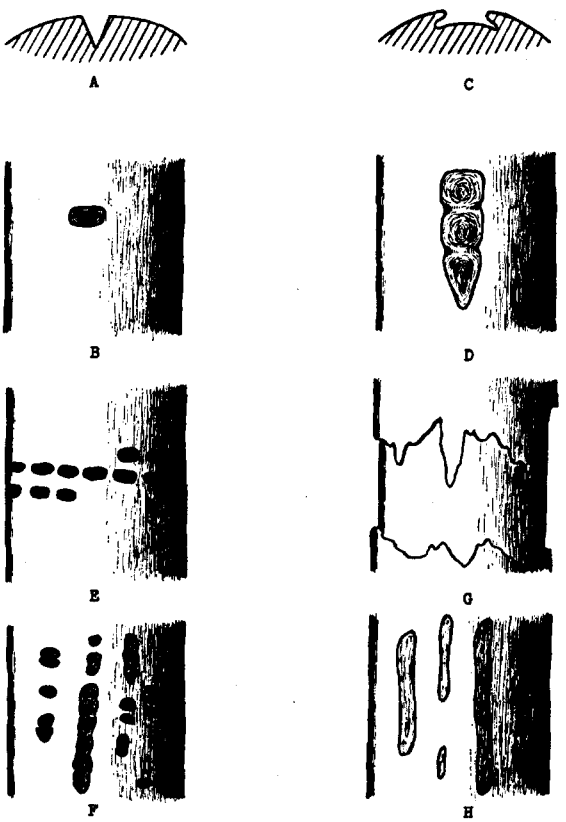

Fig. 60. Types of sapsucker workings. *A*, sectional view of simple hole; *B*, surface view of same. *C*, sectional view of compound hole; *D*, surface view of same. *E*, spiral working. *F*, grouped working. *G*, girdling working. *H*, early stage of girdling.

the turns above, so that there would be present both horizontal and vertical alignments. This type of working was limited to tree trunks of small diameter. The borings used on large trees were of the grouped type, the workings consisting of vertical lines of compound holes in which there was no horizontal alignment, and only one side of the trunk was worked over. There was still a third type of boring which consisted of a simple hole and which evidently was made by the bird as a "test boring." I have called these "adventitious holes."

Animals near the Workings.—In watching these borings, I kept records of animals which might have been attracted by the sapsucker's work. On March 13, I found an isopod in a simple hole on one of the cedars, but I do not believe that it was there for the sap or pitch. Most birds seen near the workings seemed to regard them with indifference, but there were a few exceptions. A Ruby-crowned Kinglet (*Corthylio calendula*) was frequently seen fluttering at the fresh holes on the bay tree, although whether for insects (none was ever seen) or sap, I could not determine. At this same place, a Red-shafted Flicker (*Colaptes cafer*) hopped and peered about the workings, but did not seem to eat anything. At the poplars, a Nuttall Sparrow (*Zonotrichia leucophrys nuttalli*) flew up and appeared to drink the overflowing sap, and later an Audubon Warbler

(Dendroica auduboni) did the same. Observations along these lines could not be continued because a heavy green fungus soon appeared and covered up both the exuding sap and the borings.

Theory of Workings.—As a matter of curiosity, I tasted sap which oozed from the bay, poplar and cedar trees. That from the bay tree gave the impression of sweetness, but left a very bitter after-taste. The sap from the cedar was flavored by the pitch, but was palatable. That from the poplars was extremely sweet, and suggested sugar water.

On all of the workings observed, the oldest holes were simple and at or near the tops of the trees, while the more recent holes were compound and nearer the tree base. In attempting to explain this, it is necessary to refer to the flow of sap in both deciduous and evergreen trees. At or just before the period of flowering or budding, the sap in a tree rises through the xylem from its place of winter storage in the roots, parenchyma and medullary rays. Soon after budding and flowering, this sap recedes down the phloem and is re-stored. An evergreen, such as a bay, would have to keep a fair amount of sap up the tree at all times to take care of the leaves; and a conifer, such as a cedar, would do likewise, even though anthesis in the conifer and flowering in the bay occurred at different times. I also noted that the great majority of holes were bored on the shady sides of the trees. This probably is due to the fact that the sap flows more freely there. Also sap would evaporate more readily from holes exposed to the sun. A natural dislike of light on the part of the bird itself may be a factor.

The foregoing considerations seem to explain the bird's choice of trees and the regions of the trunk upon which to work. Upon its arrival in late fall, the bird would, and did, attack the bay tree first, since this tree was flowering, and hence had the sap at a high level. The bird then would be expected to make the borings farther and farther down the trunk as the sap receded, and this it did. By this time (late in February), the poplars began to bud, implying the presence of sap, and the sapsucker turned its attentions to them, again working down the trunk as the sap receded. Holes made on the cedars were few in number, and evidently indicated that these trees were "second choice," although the bird was undoubtedly after the sap which was not subject to such abrupt rises and drops as in deciduous trees. Why or how the sapsucker can ascertain the presence of sap, I do not know, but it probably makes a great many errors in finding a tree which is in the process of flowering or budding. So it seems that this sapsucker, and one may infer, all sapsuckers of this subspecies, has one or more "stand-by" trees from which it can obtain sap at almost any time. Then, in the winter and spring, the bird works on trees in which the sap has risen, and moves the borings so as to follow the sap down, making compound holes to more readily facilitate gathering of the sap. I presume that the sapsucker does not work *up* with the rising sap, because this rise occurs mainly in the xylem, which is deeper within the tree and therefore more inaccessible than is the phloem.

This hypothesis is further borne out by records made of a Red-breasted Sapsucker observed working on a poplar (*Populus nigra*) on the Stanford University campus. This bird had been seen at irregular intervals from October 31, 1937, to February 2, 1938, working near the top of this forty foot tree. In previous years this, or a similar bird, worked extensively in winter on pepper trees (*Schinus molle*) at the same locality. This year it apparently did not touch them. Workings of the grouped type from past years are evident high on the trunk of the poplar, while this year's borings are fresher farther down the tree.

Echo Lake Individuals.—On September 12, 1937, four sapsuckers were observed working on a willow (*Salix* sp.) at Berkeley Camp, 7400 feet, El Dorado County, California, and these were observed for the following eleven days. All were in good plumage,

and judging by their actions, three were in a group, the fourth being an intruder. They were extremely quiet, and allowed me to approach to within six feet, and even on occasion to bring my hand to within six inches of them before they flew. When first seen, the four of them were clinging to neighboring branches of the twelve foot willow, and were so close to each other that all of them could have been enclosed in the space of a cubic foot. They apparently concentrated their work on this one willow, although a few simple holes were evident on a nearby white fir (*Abies concolor*). On the whole, the actions of these birds were similar to those of the sapsuckers previously described. Here, however, the work period was from four to five minutes. They frequently took drinks of the sap, and occasionally snapped at flies that came close. For all of the birds, the rest and work periods coincided as if by agreement, but during work periods there were evident individual differences in technique. The rest periods were from two to four minutes, during which time the birds continually blinked, often making enough noise to be heard a short distance away. The birds had about twenty-four distinct workings on this tree and frequently rotated between borings, as if by common consent. This to me, was one of the most surprising features of the entire study. Previously I had regarded the sapsucker as a solitary and non-gregarious bird, but here four of them were working and acting as a unit or community. Presumably they were immature birds, perhaps some of them from the same brood. Occasionally two birds drank from the same large working, but whenever the birds came too close (less than two inches) immediately there were sharp squeals and hasty retreats, although no actual conflicts. At times the birds raised their crests and chased each other from the more desirable workings, but there was no "peck order" evident during the many days of observation. The fourth bird, or intruder, could readily be told from the others because of its more pugnacious manner, restlessness, and frequent absences from the other three.

The workings of this group differed from the types found on the University of California campus, in that there were neither compound nor simple holes, but large areas and often complete bands on the stems which were laid bare to the wood (fig. 60 G, H). These bare regions were never longer than five inches, which is approximately the reach of the sapsucker, and they frequently had shreds of bark left adhering to them. I presume that the bark particles were left in order to provide a foothold for the birds, since in their work, the sapsuckers frequently slipped on the fresh glazed wood.

This "girdling" working lent itself to a rapid flow of sap, and there were hundreds of flies (house and stable) and two wood nymph butterflies continually near the copious supply of sweet-tasting sap. At one time I observed a sapsucker snap at and actually catch a fly which was about to land on the working; but the wood nymphs were undisturbed.

Unlike the holes on the University of California campus trees, which went only to the cambium layer, these girdling workings went through the cambium to the wood or xylem. Upon watching, it could be seen that the birds frequently ate tiny shreds of this cambium, but at no time did they seem to prefer it to the sap.

These birds bore out my surmise that the sapsucker works from the top down, following the descending sap. The older, smaller workings were at the tips of the stems, and the new, fresh ones were near the bases and at the junctions of the larger branches. When actually working, the birds would tilt their heads and probe under the bark at the top or bottom of the workings, presumably to drink the sap, start it flowing, or to eat the cambium. At this high altitude, the willow produces its leaves in early summer, and hence would have the sap still comparatively high in September, thus accounting for the birds' choice of a tree upon which to work at this time.

On September 22, I collected two of these birds for stomach analysis. Both were males. With the kind assistance of Dr. G. F. Ferris, of Stanford University, the stomach contents were analyzed, and, for bird number 1 were found to be: remains of an arachnid; a down feather; two wings of a winged ant; three legs and a head of a maculate carpenter ant (*Camponotus maculatus*). The entire stomach was filled with a yellowish cottony and opaque viscous liquid, probably the gastric fluids and the sap. The stomach contents of bird number 2 were: hundreds of heads and legs of the maculate carpenter ant surrounded by the same yellowish mass.

The occurrence of these ants was surprising, since they are not known to be great climbers, and therefore the sapsuckers must have obtained them from low branches or from the ground, possibly after the manner of a flicker.

SUMMARY

1. The Red-breasted Sapsucker, either by an innate sense, or by use of "test holes," can determine the presence of sap in a tree.

2. The upper portion of trees in which the sap has risen for flowering or budding is chosen for extensive feeding by the bird.

3. The bird follows the sap down the tree on the shady side, making borings which transect the transmitting phloem, and which collect the sap to the best advantage.

4. A cycle in the utilization of food trees is followed by the bird through its choice of trees which flower or bud in sequence.

5. When sources of abundant sap fail, the bird resorts to gymnosperms or evergreens in which there is a fairly constant, if meagre, supply of sap.

6. In late summer and autumn, insects and cambium augment the regular diet of sap.

7. There is a regular routine of action during working periods. The bird sometimes averages thirty or more new holes a day.

8. Community feeding has been noticed in the early fall, possibly due to a shortage of feeding areas or to a natural gregariousness on the part of immature birds.

Palo Alto, California, March 25, 1938.