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ACORN-STORING BY THE CALIFORNIA WOODPECKER

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WITH FOUR PHOTOS

NOT MANY phenomena of bird life in California are more widely known and have been more frequently commented upon than the one which is the subject of this article. When, however, one inquires about the extent of accurate knowledge on the subject, he may well be surprised that it is so slight. Even the published references to it, though numerous, are mostly brief and general. And no ornithologist, so I am told by Professor Joseph Grinnell, the authority on the literature of California birds, has pretended to investigate the subject in any detailed way. The following pages contain the results of observations and reflections which, though extending over several years, were chiefly made during the last year and a half.

So well known are the facts in their general features that a very cursory statement of them is enough. The California Woodpecker (*Melanerpes formicivorus bairdi*) is resident in most of the wooded portions of California. It has the habit, especially in regions where oaks abound, of pecking holes on the surface of the trunks and larger limbs of trees, these holes approximating an acorn in size, and inserting acorns into these, usually one in each hole. I have, however, seen many holes containing two nuts, not very close-fitting at that.

Where oaks and pines are commingled, as they frequently are in California, the pines are usually taken as storage trees. So far as I have observed, only the older trees are utilized, this seemingly being due to the fact that only in such trees has the outermost bark layer become marked off into areas or blocks presenting considerable unbroken surfaces suitable for the holes. Query is frequently made as to whether this hole pecking is injurious to the trees. Although I have examined many storage pines in widely separated localities, I have never seen anything even suggestive of harm to the trees from the holes. Never, so far as I have noticed, do the holes pierce through into the deeper living layers of the bark.

Though pine trees are, according to my observations, by far the most generally utilized for storing, oaks are used to some extent, even in places where pines as well as oaks are available. But in no instance have I seen a living oak so used. Not only dead oaks but those from which the bark has been shed are usually requisitioned, so it seems. The possible bearing of this will be noticed later.

Although unusual animal performance like this is sufficient in itself to excite interest and elicit careful inquiry, the thoughtful naturalist is likely to be more attracted to particular phenomena by their probable bearing on some general problem in which he is interested, than by their uniqueness. The broader problem which, in this instance, has been the leading motive of my observations, is that of the efficiency of instinctive activity. How thoroughly do such practices meet the needs of the animals which perform them? In other words, how near to perfection is their adaptiveness?

Two early cursory observations raised the conjecture that the habit of the California Woodpecker might, if followed up, yield enlightening facts on this question. One of these was the very large number of holes I had seen in some trees. Thus, fifty feet of a prostrate pine tree which I saw in the San Jacinto Mountains several years ago, contained, according to an estimate made with considerable care, 31,800 holes. The query easily arises, Is every hole in such a case actually used as the receptacle of a nut? The account which follows will bring out rather convincing testimony on this question.

The other and much more striking fact bearing on the general problem of adaptiveness, was brought to my notice by Dr. Grinnell. It is that occasionally the woodpeckers gather pebbles instead of acorns and place them in the holes. The first instance of this which came to my attention consisted of a considerable section of a barkless oak log now in the Museum of Vertebrate Zoology at Berkeley (Fig. 2), in which there is a large number of holes nearly all of which contain pebbles. This specimen, which came from Sonoma County, California (where there are no pine trees) is conclusive proof to Dr. Grinnell that the pebble-storing as well as the acorn-storing is the work of woodpeckers. Grinnell tells me that he looked into the matter at the time the specimen was received and found that the location of the tree and other conditions were such as to preclude any likelihood that the work was done by humans. Nor is there any other animal resident in that locality to which the performance could be attributed with any degree of probability.

Nor does this case of pebble-storing stand alone. Mr. C. R. Orcutt, a naturalist of wide experience in the southwest, has recorded a similar instance observed by him in Lower California ("Stones placed in pine-trees by birds", *Science*, March 14, 1884, p. 305). The trees (Jeffrey pines) were in this instance situated at an elevation of 6,000 feet and in an almost uninhabited region, so there was practically no chance for the stones to have been put where they were by human hands.

OBSERVATIONS

During a holiday outing at Cuyamaca reservoir, San Diego County, California, July 3-5, 1919, I found numerous pines (Jeffreys) used by the woodpeckers as storage trees. Some of these contained a large number of holes, the great majority of which were filled with acorns of the black oak (*Q. kelloggii*), the prevailing oaken neighbors of these pines. But while some of the trees were thus well stored, others had only a fraction of the holes acorn-filled; and two trees in particular, as thickly punctured as any I have ever seen, contained not a single acorn or any litter roundabout indicating that the birds had given the trees the least attention for many a month.

One of these abandoned granaries struck me as specially interesting from the fact that many of the holes, though not new, were to all appearances in perfect condition for the reception of nuts; and the further fact was clear

that both oaks and acorns were abundantly present all about the pine. Why was so much good store room unused? This query was made pertinent by the fact that many new holes had recently been made in near-by trees. Undoubtedly the suitability of the holes for storing suffers impairment with age. As the trees grow older, the outermost layers of bark gradually crumble away and reduce the depths of the holes so they would need re-drilling to keep them at full depth. Whether such renovation ever really takes place or not, I am not certain, but probably it does in some instances. Then, too, occasionally holes become more or less filled with pitch. But neither of these sources of



Fig. 1. NORMAL ACORN-STORAGE BY CALIFORNIA WOODPECKER, IN DEAD BRANCH OF BLUE OAK; PORTION PRESERVED IN MUSEUM OF VERTEBRATE ZOOLOGY TAKEN BY I. L. KOPPEL NEAR GILROY, CALIFORNIA, IN OCTOBER, 1919.

impairment applied to very many of the holes in the particular tree to which reference is now made.

By measurements and countings on one of the most abundantly stored trees of this lot, I estimated that there was an average of 60 acorns per square foot of bark and that in an area of the trunk surface, having an average girth of eleven feet, and a height of twenty feet, there were stored 13,200 acorns. Although many nuts could be seen above the elevation indicated, the size of the trunk and the irregularity of distribution of nuts made it impractical to estimate numbers. Since I shall have occasion to refer to this particular tree

in speaking of later visits, I will call it storage-tree A. Examination of the acorns in this and other trees of the locality yielded the following results that seemed significant.

Almost certainly a very great proportion of all the nuts were of the crop of the preceding year, 1918, and were garnered in the fall of that year. This conclusion I am able to draw now from observations made then and since. The evidence is in the state of weathering of the exposed butt ends of the acorns. Almost without exception the nuts are inserted tip in and base out, most of them fitting the hole snugly. Although I have never been so fortunate as to see the work done, residents of this locality with whom I have talked say that the birds "hammer the acorns in good and hard." The tight fit of many, though not all, of the nuts is in keeping with this statement.

The other fact which enables me to know now the age and storage time of the acorns examined in July, 1919, comes from my observations this, 1920, autumn. On visiting the trees October 18 and 19 this year, I found that practically the entire acorn crop of the season had either dropped to the ground, where the nuts were abundant under many trees, or had been gathered by the birds, squirrels, etc. Very few indeed were found on the trees. By comparing the condition of these new acorns with that of those taken from the storage trees in July, 1919, and that of those which had lain on the ground over a winter, it became clear that, as already said, the nuts examined in July were stored during the early fall of the year before, that is, of 1918.

The other significant fact brought out by the July examination was the prevailing freedom of the nuts from "worminess" and their generally excellent state of preservation. Few indeed of the many nuts opened contained either eggs or grubs of the nut weevil which typically infests the acorns of this region. The significant thing about this fact is that, taken along with the known developmental career of these weevils, we are able to see clearly that if the birds were going to utilize this year's stores for food, not grubs but the meats of perfectly good acorns would almost certainly have to be eaten. This would not be in accordance with a widely held theory as to what the acorns are stored for. According to this theory it is grubs and not acorn meats that the birds want. The conclusion my observations lead to, on this point, will be given presently.

February 8, 1920, was the date of my next visit to the trees, this time in company with Professor C. Judson Herrick of the University of Chicago. That the acorn stores were being drawn upon by the birds for food, was the most striking fact which met our view, as we came to the storage trees one after another. Although we were not fortunate enough to catch any of the birds in the act, what they had been doing was clear enough, speaking generally, by the marks they left, especially around some of the trees. These marks consisted of quantities of litter on the ground around the bases of the trees, this consisting of acorn shells and bits of bark from the trees. Examination of the shells told much of the story of woodpecker dining methods when acorns are the chief food. That it is at least very common for the nuts to be taken whole from the storage places and opened either on the ground near the tree or in the branches of the same tree, is manifest from the numerous instances in which the nuts were opened on the side, the opening frequently being relatively small and quite regular of outline. Such openings could not, of course, be made while the nuts are close-fitted into the storage holes. But even when

the shell leavings were proof that the opening process consisted more in tearing than puncturing, the pieces were of such form as strongly to suggest that the nuts were operated on after having been taken from the holes. Not many empty shells were found in situ, or even in the litter, opened at the butt, as would generally have to be the case had they been opened before extraction from the store-holes. These and later observations effectually disprove the theory that the holes are used by the birds as a sort of vise for holding the nuts in order that they may be opened.

Another fact brought to light by examining the shell litter was that most

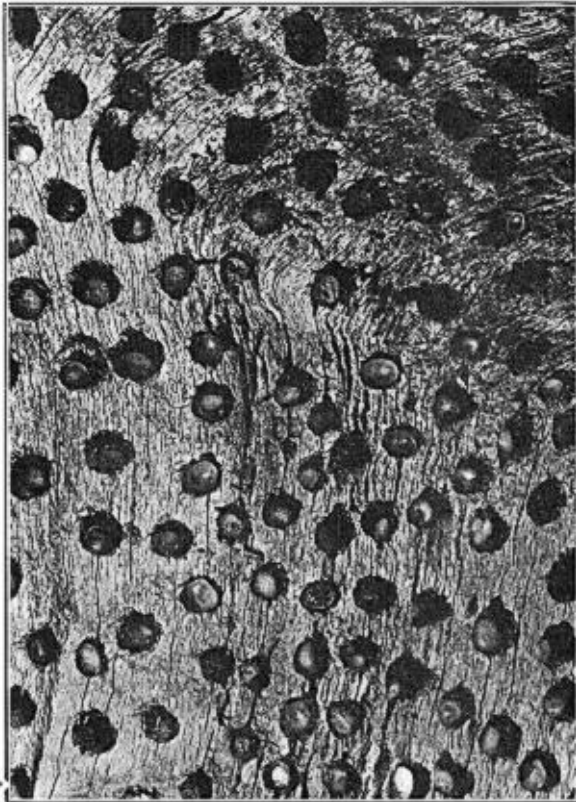


Fig. 2. PEBBLES INSERTED IN ACORN-PITS; SUPPOSED TO HAVE BEEN DONE BY CALIFORNIA WOODPECKER; PART OF SPECIMEN IN MUSEUM OF VERTEBRATE ZOOLOGY PROCURED ON SONOMA MOUNTAIN NEAR SANTA ROSA, CALIFORNIA, IN MAY, 1913, BY GEO. P. MCNEAR.

of the nuts which had been opened so far this winter were grub-containers. This was easily recognizable by the excrement, etc., of the grubs still clinging to the inner surfaces of the shells. The clean inside of the shell of a grubless nut as compared with the dirtiness of a grubby shell makes it possible to recognize at a glance even as to rather small pieces of shell, whether the nut was "wormy". Furthermore, examination of many acorns still in the store-holes, found many more "sound" than "wormy" ones. The impression gained from the examination at this time was strongly to the effect that while the birds

were opening some grubless acorns, they were really after the grubby ones. For instance a few cases were noticed where sound nuts had been opened, but where the meat was still in place—as though the bird had opened the nut in the expectation of getting a grub, had recognized its mistake, and had then discarded the nut. But systematic, quantitative study of nut remains through a winter would be necessary to prove such a selective process of food consumption as is here indicated.

On this visit some attention was given to the hole-drilling itself. One tree in particular contained a considerable number of perfectly fresh acornless holes, some of which were completed while others were in various stages of advancement. That these had really been only recently made seemed highly probable. But if so, wherefore had this been done, the storing period for the season having ended some four months ago? I have seen no indication that acorns are garnered at any other time than in early fall when the crop is freshly ripe.

Another observation at this time was suggestive of an answer to the question just asked, this observation tending to confirm the occasionally expressed surmise that the hole-drilling is not primarily for acorn storing but is an incident to the bird's pursuit of insects in the bark itself. An instance was found of a dead pine, the bark of which showed many small holes made by an insect, probably. Some woodpeckers, presumably the California, had been prodding the bark of this tree almost certainly after the insects responsible for these minute holes. Although in some cases the woodpecker work was rather diffuse, and quite unlike the clear-cut acorn storage holes, in other cases the perforations were quite similar to those made for acorns.

Assuming, now, that this bark puncturing was done by the California Woodpecker (which, however, is not quite certain), an instance is furnished which might be interpreted as reminiscent, so to speak, of the bird's original purpose of hole drilling. Though very fragmentary, this observation was sufficiently suggestive to warrant considerable effort at extension. But the circumstances under which this mid-winter visit was made were such as to preclude the possibility of following the point farther then. On later visits a few additional facts were observed bearing on the general question of hole drilling. These will be presented in due course.

My next visit was on June 7-9, 1920. Several of the trees from which the acorns had been partly used in February, were now almost entirely acornless, not even empty shells being left in the holes, excepting here and there. Examination of shell fragments in the litter furnished evidence that the meats of sound nuts had now been used as well as grubs from "wormy" ones, this evidence consisting in applying the criteria already mentioned as to shell remains of sound and wormy nuts. Many shell pieces, some of them half shells or even more, were seen containing no remnants of meats, but likewise no tracts of worm leavings. The meats had surely been removed, in all likelihood, by the woodpeckers, and for food. But certainty, on the last two points, was impossible since my efforts to catch the birds in the act were as little successful on this as on previous visits. It is, of course, possible that sound nuts opened by woodpeckers and cast aside when found to contain no grubs, may have been deprived of their meats by other animals, as mice or rats. However, ample indirect evidence of the sort here indicated, coupled with the direct evidence afforded by examination of stomach contents (Grinnell and Storer, Yosemite

Report, MS) makes it all but certain that the woodpeckers make extensive use of the meats of sound acorns as well as of grubs of wormy ones.

But, while some of the storage trees were completely emptied of nuts, tree A (so designated in the account of my July, 1919, visit), and the others of its group, had hardly been drawn upon at all. The acorns were in place much as they had been since stored away in the fall of 1918, and there was almost none of the litter on the ground around the trees which was so abundant around the emptied trees a half mile away.

Now, indications of weathering of the exposed ends of the stored acorns

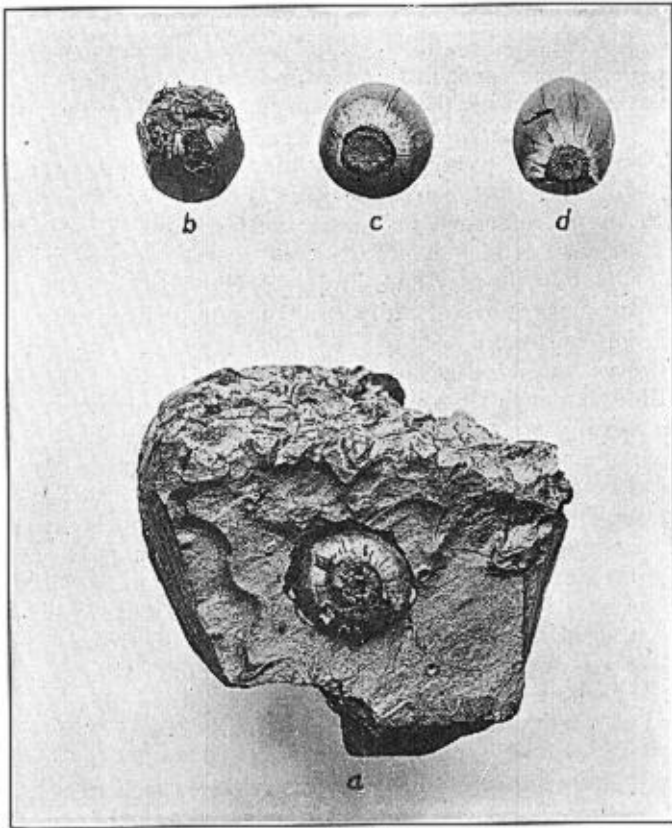


Fig. 3. *a*, BLOCK OF BARK, JEFFREY PINE, WITH ACORN IN PLACE, SHOWING CLOSE FIT, BUTT OUT, AND OLD AGE OF ACORN AS INDICATED BY WEATHERING; *b*, *c*, AND *d*, ACORNS TAKEN FROM HOLES, THREE STAGES OF DETERIORATION (*d*, *c*, *b*) FROM AGE AND EXPOSURE.

(previously noticed, but only cursorily) attracted my special attention. Such indications consist in a bleaching of the shell and a fine cracking of its surface. Following this intimation as to the keeping qualities of the acorns, I opened many sound nuts to see if the meats were showing signs of age. Without exception the meats thus examined were much darker in color than are those of fresh nuts. In many cases the color was a decided brown and in some this had advanced well toward black. The impression one got was that unless

these acorns were utilized before long they would be "spoiled". What had happened in this regard at the end of another four months will be seen presently.

At this time attention was given to the suggestion gained on previous visits as to the hole-boring business itself—as to its origin and extent. The suggestion made by a single observation on the February visit was, it will be recalled, that pursuit of insects in the bark itself might be the inception of the habit. But such following up as could be made, of the clues then obtained, yielded no additional affirmative evidence on the point. Indeed it tended to disprove, if anything, the insect hunting hypothesis. For example, a few other dead pines were examined, the bark of which was thickly punctured with the small insect holes, but these had elicited no hole-picking by woodpeckers. In fact, so abundant was the evidence of insect life in and under the loose bark of one of these trees, that it struck me as rather surprising that woodpeckers had not made use of it in any way so far as could be judged.

But even if true that pursuit of bark-inhabiting insects were the original impulse to hole-drilling by the woodpeckers, almost certain is it that now the habit has little or no reference to its original purpose. I examined several holes during this visit, which had been very recently made in the healthiest, most perfect of bark of Jeffrey and Coulter pines. If the birds were after insects in these instances they certainly could not have been worse fooled as to where prey might be found.

And this observation raised again the question of the effectiveness of the habit. Recalling that the time was now June, a period when no acorns are available for storing, we should be obliged to suppose that these recently drilled holes were made in anticipation of the next crop of nuts still some three months from ripe. Perhaps it is permissible to reason that since there is a measure of foresight in storing the acorns, there may also be something of the same sort in making the holes. Why not the holes as well prepared some months before they can be filled, as the acorns stored some months before they are eaten? The question is a fair and interesting one and involves the further question of the specificness of the entire group of instincts involved. Does each bird make its own holes, and collect and store its own acorns for its own use? Or is the entire performance a generalized one, one, that is, in which hole-drilling, nut-storing, and nut-eating are all rather indiscriminate for the birds of a given locality?

So far as I know, absolutely no direct evidence is available on which to base answers to these questions. But from our general knowledge of bird instinct, it is highly probable that the operations are of the generalized type. Several of my observations are confirmatory of this view. Those on off season drilling are most readily interpreted from this standpoint. I revert to the point shortly.

Another observation made during this visit bears on the question of whether all holes made are actually used for storage. One tree in particular presented conditions in the height distribution of the stored acorns which seemed to have such a bearing. This was the circumstance that a distinctly larger proportion of the holes toward the base of the trunk contained acorns than did those up toward the middle of the trunk. By examining the higher parts of the trunk with glasses one could easily see that acorn-containing holes thinned out on going upward considerably more rapidly than did the holes

themselves. The impression from this was that while hole-drilling had been as conveniently and largely done high up as low down on the trunk, nut storage, since probably done for the most part, as previously seen, from nuts gathered on the ground, had been more convenient and so more practiced on the lower portion of the trunk.

On this visit the stub of a long-dead, bark-denuded oak, probably a black oak, was examined, which was used by the woodpeckers as a granary, though

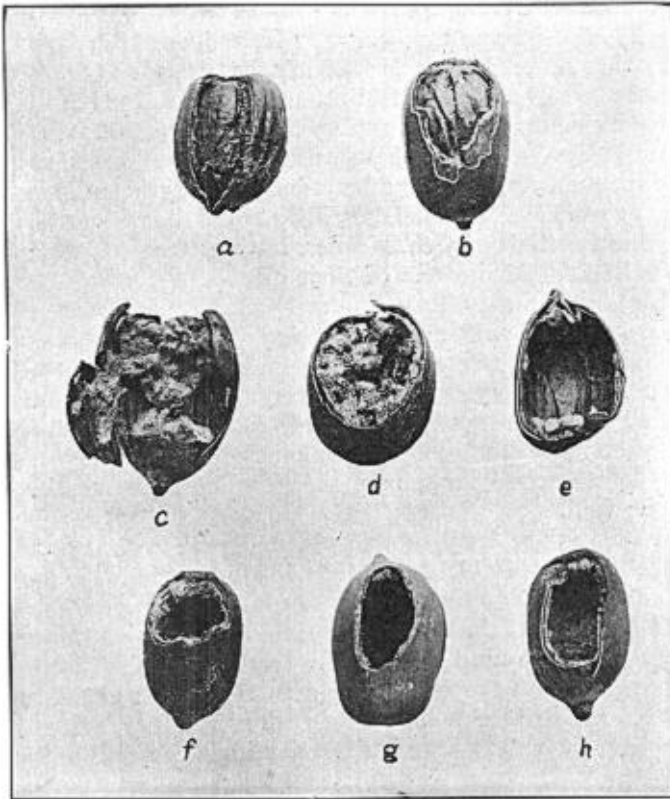


Fig. 4. *a*, A SOUND MEAT BUT NEARLY BLACK FROM AGE (HAD BEEN IN HOLE ABOUT 20 MONTHS); *b*, A SOUND MEAT HARDLY DARKENED AT ALL (HAD BEEN IN HOLE OVER ONE WINTER); *c* AND *d*, SHELLS CONTAINING WORM LEAVINGS, BUT WORMS GONE; *e*, SHELL, FROM WHICH A SOUND MEAT HAD BEEN TAKEN—NO WORM LEAVINGS; *f*, *g*, *h*, SHELLS OPENED ON THE SIDE; THE OPENING OF *g*, ESPECIALLY, IS SO FAR TOWARD THE TIP THAT IT COULD NOT HAVE BEEN MADE WHILE THE ACORN WAS IN PLACE IN THE BARK.

a majority of the holes contained no acorns and there was no evidence around the tree of recent acorn consumption. One of the most striking things here was the relation of the holes to cracks in the wood. In many instances a row of holes, some mere beginnings, followed, and were made as local enlargements of a crack. Some of these holes contained acorns and some did not. Again, acorns had in some instances been placed in larger cracks where no drilling

had been done. Such a case readily suggests that the hole-drilling habit may have been connected originally with the habit of probing cracks and other natural cavities in dead trees while searching for insects. But since there were probably more holes in this tree not connected with cracks than were so connected, but were in the solid wood, we may suppose the crack-probing instinct being a generalized one, easily over-flowed as one might say, first to produce the hole-drilling habit in solid wood of the same dead tree, and afterward to the bark of live trees containing no cracks.

And by a parallel development the present acorn storing habit may have been perfected. At the beginning this may have operated only in using cracks and decay cavities, in dead trees for storing, but later extended to the drilled holes of the same trees, and later still to those drilled in the bark of living trees.

Conclusive evidence that nut-eating rodents (squirrels, rats) prey upon the acorns stored by the woodpeckers was first obtained on the present visit. Two trees were found on which the bark immediately around acorn holes had been gnawed by rodents, as unmistakably proved by the tooth marks. The acorns were gone from some of these holes, but not from all, thus showing that the marauders had failed in some of their efforts.

Squirrels (the Anthony Gray Squirrel) and rats (Southern Brush Rat) are both common hereabouts, and one or the other of these was in all probability the culprit. This observation clearly indicates an advantage in counter-sinking the nuts, as one may say, in the holes, and also in "hammering them in tight". With a little care and extra work the nuts could be so stored as to protect them pretty effectually against rodent pillage. And to a great extent, though by no means wholly so, as we shall see later, the storing realizes this protection quite well.

The next trip to the locality was planned with reference to the harvest time for the acorn crop of 1920. October 18-19 was the date on which it was made. The crop seemed to have been only moderately good this year. This was indicated by the fact that almost no nuts still remained on the trees, that very few were on the ground under some trees, though under many others a fairly generous number were present, and finally that while a goodly number of the storage trees had been moderately stored with fresh nuts, several of those most richly stored last year had received none or only a few this year—though, of course, the season was not far enough gone to make it impossible that more garnering would yet be done.

Attention was again given to the two trees having many holes but no nuts, mentioned in connection with previous visits. As before, neither of these contained a single nut or any other signs of having been recently worked at by the birds. Since this makes the third consecutive season in which these trees have been observed to be unused, it looks as though they are wholly abandoned. The general appearance of desertedness of one of them especially favors this conjecture.

The group of trees of which storage-tree A is one, presented the most interesting facts this time. These were now quite as heavily stored as when first seen, July, 1919, but not more than one-half of the nuts were of the 1920 crop, and very many of them were clearly the same as those seen on the first and all the intervening visits. The state of weathering of nuts, previously mentioned, was the decisive pointer to this conclusion. The darkened condition of the sound meats of the old nuts, referred to in connection with the visit of June,

1920, had now gone so far that many of the meats were thoroughly black. And besides, they now showed other clear evidences of deterioration. For one thing, they were more brittle than before. That they were well on the road to disintegration was clear. If not already beyond serviceability as woodpecker food, they surely soon would be if left unused. But with the new crop at hand and upon which the birds were already feeding, why should these old decaying nuts be eaten? Here was a store of several thousand acorns (6,000, say, in tree A alone—see estimate on previous page) destined to great if not complete loss. For even if consumed at once the old nuts could be of small food value as compared with the new ones.

A fortunate circumstance made possible an observation at this time which is probably significant as bearing on the spoiling of the acorns. A hard rain, which had been in progress all the night before, was falling while I was examining these particular trees. As a result of the downpour the acorns were thoroughly wet, the old ones especially being in a genuinely "water-logged" condition. Such soakings of the acorns as this must hasten their deterioration, especially since they are badly circumstanced for drying out.

I was considerably surprised this time by noticing that many of the newly stored acorns were protruding from the holes—not infrequently as much as a quarter or even a half inch. Although my attention had not before been drawn to the point, I am quite certain that I have never before seen acorns so much exposed. Indeed, as a rule, they are, as previously mentioned, more likely to be sunk below the surface of the bark than to project above it.

The point is significant as bearing on the exposure of the nuts to the deprivations of squirrels and rats. Hundreds of the nuts of this year's harvest projected enough from the holes to make them easy plunder for the rodents; whereas as previously pointed out, when the nuts are counter-sunk, it is no simple thing for the marauders to get at them. Query: Is it possible that the absence of nuts projecting from the holes, as the rule is, is due to the fact that those left projecting when the new crop is garnered are soon taken by the robbers? Only much more observation than we now have on the actual performances of both woodpeckers and rodents, can answer this question. In the meantime what we can say with certainty is that many acorns are so stored as to be easily accessible to rodents*.

SUMMARY

Our observations and reflections on acorn storing by the California Woodpeckers in the Cuyamaca region, having now been presented as a running narrative, the main results may profitably be summed up in a few brief statements.

1. The storing habit of this woodpecker is an important element in the bird's solution of its food problem, both the grubs contained in many of the acorns and the meats of sound acorns being utilized as food.

2. There are indications that grubs are the chief objects of consideration and are eaten first after the new crop is garnered, while the meats of sound

*Mr. Frank Stephens (*California Mammals*, p. 88) mentions that although the Anthony Gray Squirrel does not hibernate neither does it seem to "store up much food for winter use". Can it be that pillage of acorns stored by the California Woodpecker is a real factor in enabling this squirrel to live without either hibernating or food storing? The question certainly deserves looking into carefully.

Since the above was written the Museum of Vertebrate Zoology has received a piece of trunk of *Q. douglasii* (fig. 1) from near Gilroy, Santa Clara County, California, in which acorns of the same oak are stored, many of which protrude as did those described above. This specimen was taken in October, 1920, and as the acorns are of this year's crop, not much time could have elapsed in which they could have been preyed upon by other animals. However, gray squirrels are said not to inhabit this locality. Consequently the nuts would not be in danger from this animal at least.

nuts are mostly eaten after no more wormy acorns remain in the stores. But the observations pointing in this direction are too scanty to prove the suggestion.

3. The acorn storing operation is seemingly confined to a rather brief period immediately following the ripening of the acorns each year. The nuts seem to be picked up mostly from the ground soon after they have fallen, though they may be taken from the trees to some extent. The acorns used in this locality are chiefly those of the black oak, *Quercus kelloggii*.

4. Although the entire store, consisting of several thousand acorns on some storage trees, may be used up during a season, it may also happen that thousands of sound nuts in other trees are left unused and spoil from weathering and other destructive processes of nature.

5. Suggestions as to the origin of the hole-drilling part of the habit are found in the way holes are sometimes still connected with cracks in the wood of old dead trees. Also there is some indication that hole-drilling in the bark of pine trees was originally done in pursuit of insects inhabiting the bark itself. The fact that acorns are sometimes placed in cracks and decay cavities of dead trees suggests that this sort of storage may have preceded and led to storage in holes made expressly for the reception of the nuts.

6. But whatever may have been the origin of either the hole-drilling or the nut-storing habits, there can be no doubt that now the holes in the bark of living pine trees at least are mainly purposeless except as storage places for acorns, and that nearly all the storing is in holes made for no other purpose.

7. The acorns stored by woodpeckers are subject to plunder by nut-eating rodents, presumably squirrels and possibly brush rats.

8. As to what light these observations throw on the general problem of the efficiency of instinctive activity, the following conclusions seem justified, the facts here presented being taken along with others made known by other observers.

(a) As to hole drilling: While the holes are made expressly for the reception of acorns, many holes are probably made which are never used, holes are made at seasons of the year when there are no acorns to store, and large numbers of perfectly serviceable holes seem to be abandoned even in localities where both birds and acorns are abundant, and new holes are being made.

(b) As to the storing business itself: While this is of distinct service to the food necessities of the woodpeckers, the instinct sometimes goes wrong to the extent of storing pebbles instead of acorns, thus defeating entirely the purpose of the instinct. Again, large numbers of acorns are sometimes stored, the use of which is so long delayed that the acorns become wholly or largely unfit for food, and this in places where the bird population seems normal. Finally, acorns are sometimes stored in such fashion as to make them easy prey for marauding rodents, when with some definite foresight and a little more work such exposure could easily be largely avoided.

(c) From the facts, and the conclusions based immediately upon them, it seems justifiable to conclude finally that the acorn-storing habit of this woodpecker, though having much of specificity about it, is still at bottom a rather generalized one and perhaps on this account frequently exhibits serious maladaptations.

Scripps Institution for Biological Research, La Jolla, California, November 19, 1920.