



BRITISH BIRDS

CONCEALMENT AND RECOVERY OF FOOD BY BIRDS, WITH SOME RELEVANT OBSERVATIONS ON SQUIRRELS

By T. J. RICHARDS

THE FOOD-STORING INSTINCT occurs in a variety of creatures, from insects to Man. The best-known examples are found in certain Hymenoptera (bees, ants) and in rodents (rats, mice, squirrels). In birds food-hoarding has become associated mainly with the highly-intelligent Corvidae, some of which have also acquired a reputation for carrying away and hiding inedible objects. That the habit is practised to a great extent by certain small birds is less generally known. There is one familiar example, the Red-backed Shrike (*Lanius cristatus collurio*), but this bird's "larder" does not fall into quite the same category as the type of food-storage with which this paper is concerned. Firstly, the food is not concealed and therefore no problem arises regarding its recovery, and secondly, since the bird is a summer-resident, the store cannot serve the purpose of providing for the winter months.

In the early autumn of 1948, concealment of food by Coal Tit (*Parus ater*), Marsh Tit (*P. palustris*) and Nuthatch (*Sitta europaea*) was observed at Sidmouth, Devon (Richards, 1949). Subsequent observation has confirmed that the habit is common in these species and has also shown that the Rook (*Corvus frugilegus*) will bury acorns (*Quercus* spp.) in the ground, sometimes transporting the food to a considerable distance before doing so. This paper is mainly concerned with the food-storing behaviour of these four species, and is a summary of observations made intermittently between 1948 and 1957 in the vicinity of Sidmouth.

(1) COAL TIT

Throughout the autumn, from about mid-September onwards, parties of Coal Tits at beech trees (*Fagus sylvatica*) may be seen carrying away and hiding beech-nuts. They conceal each nut in a different spot, so that the food supply may be dispersed over an area of

up to 100 yards from its source. One bird flies to a larch and thrusts the nut into a tuft of lichen. Another drops to a bank, pushes the nut into the earth and, after tapping it in, rearranges the moss. A third carries its nut to the mossy trunk of an oak, taps it into a bark crevice and covers it with tufts of plucked moss. Where beech trees grow at the edge of a pine wood most of the nuts are hidden about the conifers, or on the ground under pine-needles and bracken. In gardens the nuts may be buried in flower beds and shrubberies. The intensity of these activities is naturally dependent upon the beech-mast crop. It was highest in 1948 and 1950, when the crop was heavy. In 1951 and 1957, when the crop failed entirely, very few Coal Tits were to be found in the woods during autumn and winter.

In spring and summer Coal Tits will store the seeds of Scots pine (*Pinus sylvestris*), which they pick from the open cones. The seeds are concealed about the lichen-covered branches or are carried to the ground and pushed deep into the roots of heather. Instances of this behaviour were observed on 12th June 1949 and 15th April 1955.

Two notes recently published by Hart (1958a and b) concern the storing of shelled peanuts by a Coal Tit and a Willow Tit (*P. atricapillus*). The Coal Tit deposited the nuts in a variety of places, including brussel tops, grass tufts, and between the petals of a chrysanthemum flower. The Willow Tit's favourite hiding-place was in the wire twists securing the chestnut palings of a garden fence.

(2) MARSH TIT

Marsh Tits hide large quantities of nuts in autumn, beech-nuts chiefly, but probably hazel-nuts (*Corylus avellana*) as well. On 22nd November 1948, when few nuts were left on the trees and the tits were foraging on the ground, a Marsh Tit found and secreted on a near-by bank thirteen beech-nuts in succession. The fourteenth it took to a branch and ate.

Marsh Tits are notoriously fond of the berries of honeysuckle (*Lonicera periclymenum*), but it would appear to be the seed rather than the fruit that is the attraction. On 20th October 1950 I watched a Marsh Tit taking honeysuckle berries from a hedge to the fork of an oak, where it extracted the seeds. It then concealed each seed separately in the lichen which covered the oak trunk just below the fork. A honeysuckle berry contains some six or seven seeds, but the tit disposed of only one or two before flying down for a fresh berry. In all, the bird dissected four berries and concealed nine or ten seeds. The skin and the pulp of the fruit were evidently left in the fork.

Marsh Tits will also hide bread, or even fat, taken from bird-tables (Robinson, 1950; Almond, 1950) and there is a record of one bird storing a dozen small crab-apples (*Malus pumila*) in a recess at the base of a hawthorn (Campbell, 1950).

(3) BLUE TIT AND GREAT TIT

While Blue Tits (*P. caeruleus*) and Great Tits (*P. major*) often associate with the autumn hoarding parties I have never yet seen them conceal food. Southern (1946) and Hinde (1952, p. 25) have observed Blue Tits doing so, but I doubt if the habit is at all common in this species, though the bird may be in the process of acquiring it through imitation. The Great Tit has a less commendable habit. It spends much of its time watching Coal Tits and trying to find the nuts they have hidden. More often than not the bird is frustrated by the efficiency with which the food is concealed, but Long (1950) watched a Great Tit successfully robbing caches made by a Coal Tit under moss on the roof of a house. It would seem that the Great Tit is something of a parasite; it stores no food itself but keeps company with birds that do, and so benefits by their industry. Owen (1945) records similar behaviour in Blue Tits, which were observed to badger Coal Tits and Marsh Tits and apparently search for their caches. Hart (*loc. cit.*) watched both Blue Tit and Great Tit remove peanuts (*Arachis hypogaea*) stored by other species.

Haftorn (1944, 1953, 1954) made a detailed study of the food-storing of tits in Norway. He found that Crested Tit (*P. cristatus*), Willow Tit, Coal Tit, Marsh Tit and Siberian Tit (*P. cinctus*) all stored food, whereas Great Tit and Blue Tit did not. He points out that all the food-storing tits (with the exception of the Marsh Tit) haunt coniferous forests, in which they remain during winter, while large numbers of Great and Blue Tits move to inhabited areas in winter to supplement their diet from food supplied by human beings. The Marsh Tit is an "outsider". "It stores, in spite of the fact that it belongs to the deciduous forests and in winter keeps to the same areas as the Great and Blue Tit, neither of which store" (Haftorn, 1954, pp. 118-119).

It has been shown that both Great Tit and Blue Tit exhibit a tendency to search for and rob stores made by other species. It is not unlikely that this tendency would inhibit the development of the storing habit. True, the Blue Tit stores to a slight extent, but personal observation suggests that the robbing of caches is less pronounced in this species than in the Great Tit.

(4) ANIMAL MATTER STORED BY TITS

So far I have not seen tits hide anything but vegetable matter (nuts and seeds), but Southern (1946) and Owen (1945) observed Blue Tits, Coal Tits and Marsh Tits carrying away small black slugs and hiding them in ivy-clad stumps. Haftorn (1954, p. 45) refers to the storing of aphids by Coal Tits. He also found that 20% of the food stored by the Crested Tit consisted of animal matter (Haftorn, *op. cit.*, p. 39). This comprised largely insects in the early stages, especially larvae of Lepidoptera and Diptera, and saw-fly cocoons (Tenthredinidae). The methods used by the Crested Tit in preparing the victims for storing did not differ from

those used in preparing them for immediate consumption. Caterpillars were usually killed or paralysed by decapitation, after which they were beaten against a branch (*cf.* Nuthatch, below). Some of these larvae would struggle for days after the "execution" (Haftorn, *op. cit.*, p. 51).

(5) NUTHATCH

Nuthatches are inveterate hoarders. One or two of these birds will often consort with Coal Tits and participate with them in the garnering of beech-mast. Their methods and places of concealment are similar to those of the tits, and they invariably cover the nuts with the material nearest to hand. One bird that deposited food in a cavity on the bare trunk of a dead tree used chips and wood dust.

The Nuthatch probably hides food all the year round, except perhaps when feeding young. It certainly does so in the early part of the breeding-season. On 29th March 1949 a hen was seen to conceal food during a pause in the work of plastering the nest-hole. Other cases have been noted in April and May. In a note already published (Richards, 1949) I described a cock Nuthatch's concealing a hazel-nut on 17th May 1948. The bird inserted the nut into a small round hole in a slender ash-pole and then plugged the hole with a tuft of lichen. The place of concealment was only a few yards from the nest-hole in which the hen was incubating.

The main items stored by Nuthatches are nuts, acorns and small seeds, but they will hide almost anything edible. Birds which live near gardens will make repeated visits to a bird-table and carry off pieces of bread, which they stow carefully away into bark crevices, covering each with a wisp of moss or lichen. Large crusts are broken up and hidden piece by piece. A nut or acorn may also be hidden piecemeal.

The Nuthatch does not confine itself to the storing of vegetable matter. On 13th April 1953 a hen, presented with a large caterpillar or grub by her mate, shook it several times before banging it against a branch, evidently to incapacitate it. Then she carried it to another tree and stowed it away into a tuft of lichen.

The following October (10th) I watched a Nuthatch banging at an oak branch, flicking out its wings as if it were hammering a nut, and prising off small pieces of wood. Presently it extracted a grub, which it took to another part of the branch and, with screwing movements of head and bill, inserted it deep into the lichen. Returning to the source of supply, the bird soon found another grub, which it concealed near the first. It then found a third and concealed that also before flying to another tree. In instances of this kind it would be interesting to know whether the victims are killed, or merely disabled, before being stored.

(6) JAY AND ROOK

In my experience the Jay (*Garrulus glandarius*) and the Rook are the only corvine birds that conceal food anything like as

intensively as Coal Tit, Marsh Tit and Nuthatch. Jays are especially fond of acorns and in autumn take a good many from the trees and bury them in the ground (see also Goodwin, 1951, 1956; Chettleburgh, 1952; and others). The acorns may be buried in meadow and parkland, close to the parent tree, or in woodland, often a considerable distance from the source. Jays will also carry acorns well out into open moorland and bury them in heath and heather. This transportation of acorns by Jays is a common enough sight in autumn, but it is not so easy to observe these wary birds in the act of burying the food. The planting of acorns is more easily observed in Rooks.

In early autumn Rooks begin to frequent the oaks, fluttering awkwardly on the outer sprays to take the ripening acorns. Some of the birds eat the fruit at once, hacking it to pieces on a branch or on the grass below; but observation will often show that many are burying acorns. On the few occasions when I have obtained a clear view of a Rook's burial of an acorn its methods were as follows. Gliding 30-40 yards out into the meadow, the bird alights with its acorn and struts about in search of a suitable place to bury it. Suddenly it pauses, tosses the acorn aside and proceeds to dig a hole with its bill. It then drops the acorn into the hole, taps it home and covers it with soil and loose grass. Occasionally a bird will bury the same acorn several times before the job is completed to its satisfaction. Rooks will work thus for a considerable time, yet a subsequent examination of the field will reveal no sign of their labour.

Goodwin (*in litt.*) states that the above observations seem to show that the Rook's technique differs from that of other corvine birds. He writes:—"All those I have seen bury food—Carrion Crow (*Corvus c. corone*), Hooded Crow (*Corvus corone cornix*), Magpie (*Pica pica*), Blue Magpie (*Urocissa erythrorhyncha*), Green Magpie (*Cissa chinensis*), Azure-winged Magpie (*Cyanopica cyanus*), Lanceolated Jay (*Garrulus lanceolatus*), Pileated Jay (*Cyanocorax cyanopogon*), British Jay—have first pushed the food into some existing cavity or into the earth, grass or other substrate and then covered it up. In no case have I ever seen the bird dig a hole for the food first."

However, after writing the first draft of this paper I came across a note which corroborates my own description of the Rook's methods (Gibbard and Bolderston, 1947). On 28th October 1947, at Thorverton, Devon, these two observers watched a party of some 25 Rooks which "carried acorns to two fields half-a-mile away, and after digging holes in small depressions in the fields, carefully planted them in the holes, tapping them in with their bills". The birds were observed for upwards of an hour, and it was estimated that at least 300 acorns were planted.

Rooks may bury acorns a mile or more from the parent tree. The Sid Vale is bounded on the west by Peak Hill, which terminates at the seaward end in a triangular escarpment some 500 ft. high. From the summit of this escarpment, during any

year from October to mid-December, Rooks can be seen carrying acorns from one valley to the next. As the crow flies the distance is approximately one mile, but as these Rooks fly it is at least double that distance. The birds take the acorns from trees in the Sid Vale and fly down the valley for about half-a-mile until they reach the coast. Then, utilizing upward air-currents, they drift westward along the cliffs to the next valley, where they turn inland, glide down to the grass fields and bury the acorns. By taking this route the birds save themselves the trouble of labouring over the hill. Two-thirds of their journey is accomplished with hardly a flap of a wing. Sometimes, however, when the wind is in the north or north-east, they pass directly over the hill, often circling at first to gain the necessary elevation. The return journey is almost invariably made by the most direct route.

The birds travel singly and in small parties, but it is difficult to estimate the total number of participants. While work is in progress the flock is dispersed over two valleys and along the routes between. In an hour 30 Rooks may pass westward, conveying in all something like 40 acorns. For the most interesting feature of this long-distance transportation is that some birds carry two acorns—one between the mandibles and one in the throat-pouch. Rooks which bury acorns only a few yards from the tree always appear to take them singly; and it is tempting to infer that some of the long-distance travellers realise that they make their journey more worthwhile by conveying a double quantity. Although this inference seems highly anthropomorphic, it is not easy to find an alternative explanation. Goodwin (*in litt.*) informs me that Jays, which are capable of carrying six or more acorns, also take fewer when burying them close to the tree.

The carrying and planting of acorns by Rooks may continue for about 10 weeks. Late in the season, when the supply of acorns from common oak (*Quercus robur* and *petraea*) and Turkey oak (*Quercus cerris*) is exhausted, the birds take the acorns of holm oak (*Quercus ilex*). Why they should carry the food for a distance of some two miles before burying it is not entirely clear, but two points are worth noting: one, that oaks are comparatively scarce in the valley to which the acorns are conveyed; and two, that the fields of this same valley are regularly used as feeding-grounds by Rooks in winter. Some 20 pairs of Rooks breed at the lower end of the Sid Vale; these are presumably the birds that transport and bury the acorns.

(7) RECOVERY OF CONCEALED FOOD BY SQUIRRELS

Before we can assess the value of the food-storing instinct to the animal possessing it we must know something of the extent to which that animal recovers the food it has hidden, not only from other creatures but from itself. Although we are primarily concerned with this question in relation to birds I feel it would not be irrelevant to include a short digression on the means by

which hidden food is recovered by the Grey Squirrel (*Sciurus carolinensis*).

The old idea that squirrels accumulate many nuts and acorns in one place and draw upon the store in time of need is now unacceptable. On the other hand, there is a common belief that, because the animals bury the nuts haphazardly, one here, one there (and most likely forget where they have put them), they recover only a fraction of the hidden food, and that by chance. The truth seems to lie between these two conceptions. Squirrels undoubtedly disperse the food over a wide area, burying each nut or acorn separately, and almost certainly forget the hiding places. Yet when food becomes scarce they probably recover 80-90% of their scattered hoards.

Grey Squirrels appear to spend autumn and winter, singly or in pairs, within a definite territory, over which they distribute the buried food. Watching them, not only burying the food but also digging it up and eating it later in the year, I became convinced that they found their caches by sense of smell. This was not difficult to prove. In areas occupied regularly by squirrels, nuts and acorns were buried about one inch deep in moss-covered soil and the places marked. Many of my caches were situated on low banks frequently traversed by the animals; others were made in mossy places between the roots of trees. Of 21 nuts or acorns buried between mid-October and the end of December 1952, only 4 had not been found and removed by 31st January 1953. The time taken to discover the food varied from 2 to 27 days.

The experiment clearly showed that a squirrel in search of food does not scratch at random. Having detected—presumably by smell—the presence of a buried nut, it digs a neat hole straight to it. So neat were some of the excavations that I at first suspected that mice were raiding the caches. To make sure, I erected small crossed arches of bent twigs over some of the caches, so that a mouse could gain access to the food without seriously disturbing the twigs. Over others I placed stones which were too heavy to be moved by any creature smaller than a squirrel. The stones were always removed, sometimes to a distance of a foot or more; the twigs were scattered or pushed roughly aside. Moreover, where an acorn or nut had been eaten on the spot the rejected skins or shells provided evidence that was significant to one who knows the squirrel's feeding habits.

We see then that the Grey Squirrel, aided by a keen sense of smell, has no difficulty in recovering its buried nuts. The question how the animal knows where to look for the food is not so easily answered. To recall the exact situations of several hundred buried nuts would be beyond even the powers of Man. But is it not possible that squirrels at least remember that they *have* hidden food and know approximately where to search for it? Grant the animal a glimmer of memory, and with its highly-developed sense of smell it would be well equipped for recovering its dispersed store.

After I had carried out my experiments and had drawn my conclusions a paper by an American observer came to my notice (Cahalane, 1942). Cahalane conducted similar but more elaborate experiments on the Western Fox Squirrel (*Sciurus niger rufiventris*). He not only planted caches of his own, he also marked many of those made by the squirrels. By the spring about 99% of the squirrel-made caches, and 83% of those made by the observer, had been emptied. The results indicated that memory is used to some extent in recovering food; but they also showed that the sense of smell is the chief faculty employed. Captive Fox Squirrels had no difficulty in locating nuts buried in moist soil, but if the soil was dry they were frequently at fault. Moisture intensifies the odour of the food. Cahalane concluded "that the memory pattern may be of assistance in general location, but that the sense of smell is depended upon and is highly accurate in locating particular nuts".

(8) RECOVERY OF CONCEALED FOOD BY BIRDS

It is much more difficult in birds than in squirrels to estimate what proportion of the concealed food is eventually recovered. From casual observation I should say that birds recover a large proportion, though it is not suggested that they, any more than squirrels, remember the exact hiding-places. It is not necessary that they should. The food has been widely distributed over areas where they habitually forage in winter. Parties of tits and pairs of Nuthatches may be seen working limited areas throughout the winter, tirelessly examining tree-trunks, twigs and branches, flaking off bark, moss and lichen. Haftorn (1954, p. 20) could find marked tits day after day throughout the winter in the same district. As I have observed in November, December and January, tits and Nuthatches certainly find many of the nuts they have hidden, sometimes only to hide them again in different places. This "store transplanting" also occurs in the Crested Tit (Haftorn, *op. cit.*, p. 94) and in the Jay (Goodwin, 1956). Rooks, too, as they prod about in the fields, must unearth a considerable proportion of their buried food. On 6th February 1950 Rooks were observed digging up and eating acorns in a meadow where this species had been seen burying the food the previous autumn.

Recovery of food by the smaller birds is perhaps largely a matter of trial and error, but aided to a small extent by the "memory pattern". Haftorn (*op. cit.*, p. 122) concluded that "the tits store collectively and therefore find and eat one another's stores. This means that they do not need to remember the exact situation of each stored object".

On the other hand, certain corvine birds do appear to remember the exact sites of their caches. Goodwin (1956) witnessed the retrieval of food by Jays on many occasions. Successful recovery is preceded by two different types of behaviour. First, the bird goes straight to the hiding-place and uncovers the hidden food (here everything suggests that the Jay had remembered the hiding-

place); second, it finds the food after prolonged searching in just those places in which a Jay would be likely to hide food. Two possible explanations for the latter behaviour are suggested: "Either the bird is seeking food which it has buried, but owing to subsequent alteration of the earth's surface (through growth or death of herbage, treading of cattle, working of moles and so on) is unable to re-locate with exactitude, or else it is deliberately searching in likely places for food which its mate has hidden". In either case all evidence points to the fact that the Jay recovers its stored food by means of a remarkably retentive memory. A recent note by Hayman (1958) suggests that the same applies to the Magpie. Yet there are some aspects of food-recovery which are difficult to explain purely in terms of memory, e.g. a bird's ability to locate buried food when the ground is covered by deep snow.

On 22nd February 1947 I saw a Jay dig straight down through snow, pick up what appeared to be a hazel-nut, and fly off with it. It seems unlikely that the bird found the nut by chance, but it is equally unlikely that it remembered and recognized a previous hiding-place after snow had altered the appearance of the ground. Cahalane (1944) observed a similar incident concerning a Clark's Nutcracker (*Nucifraga columbiana*). He found, after flushing the bird, that it had dug a hole through 8 inches of hard-packed snow to a Douglas fir cone (*Pseudotsuga taxifolia*) which was frozen to the ground litter. Evidence of another nutcracker's ability to find food in snow-covered ground is provided by Swanberg (1951).

Swanberg spent many years studying the Thick-billed Nutcracker (*Nucifraga c. caryocatactes*) in Central Sweden. In Scandinavia, where *Pinus cembra* does not occur, the Nutcracker's diet consists almost entirely of hazel-nuts. These, however, are available for only two or three months in autumn; so from late August until the supply of nuts is exhausted the bird devotes most of its time to food storage. The nuts are carried from hazel coppices to the bird's spruce-forest haunts (sometimes a distance of as much as 6 kilometres) and are there buried in the ground in small heaps at a depth of a bill's length. The bird's ability to re-locate these stores, even when they lie beneath 18 inches of snow, is extraordinary. Swanberg counted the number of excavations in the snow with nutshells in or near them, and also those which were apparently the result of unsuccessful searching. Out of 351 excavations examined the bird had dug straight to the food in 86%. Moreover, there were indications that the bird remembers which stores it used earlier in the winter. "Thus it practically never searches for a store already emptied, even if new snow has fallen".

This performance suggests something more than memory; it suggests the Squirrel's highly-efficient methods—memory plus sense of smell. Birds are supposed to possess little or no sense of smell, though Hudson (1922) was convinced that the faculty was highly developed in certain British Corvidae and provided

reasonable evidence for his convictions. On the other hand, Swanberg does not believe that the Nutcracker is aided by a sense of smell. He informs me (*in litt.*) that he has buried nuts from October to early spring in feeding places within the territories of Nutcrackers and that the birds were quite unable to find these "stores" even though they were hidden only by a thin covering of snow or moss.

Yet, if we deny the Nutcracker an olfactory sense, how are we to account for the accuracy with which it locates food lying beneath deep snow? For a bird to remember the exact position of a buried store it must presumably (consciously or unconsciously) note minutely the appearance of the immediate environment and retain a mental image of the site. Such an image, however, could be of little assistance to the bird if there occurred a subsequent alteration in the appearance of the ground. Goodwin (1956) has suggested that prolonged searching by Jays might be a result of their being at fault owing to subsequent change in vegetation or ground. Yet it would seem that the Nutcracker is able to locate 86% of its stores after all visual guides have been obliterated by snow. The incident of the Clark's Nutcracker described by Cahalane (*loc. cit.*) is of special interest, since the bird dug straight to a fir cone which was frozen to the ground litter. Here, evidently, the cone had not been previously buried by the bird but had been lying on the surface of the ground until covered by snow. In this case memory could have played no part in the discovery of the food.

Swanberg's paper (*loc. cit.*) contains no reference to squirrels, but it seems reasonably certain that the Red Squirrel (*Sciurus vulgaris*), which occurs in Sweden, would be capable of smelling out and raiding stores made by Nutcrackers. The possibility that this might occur and cause error in computing the percentage of stores recovered by the Nutcracker was suggested by a photograph in this paper (Fig. 5, p. 550). The photograph shows an excavation dug out by a Nutcracker with the shells of six hazelnuts scattered about it. These shells had clearly been split lengthwise into clean halves, and therefore closely resembled the work of a squirrel. While I had little doubt that Swanberg had taken these facts into consideration, I wrote to ask him if it was at all possible that some of the excavations attributed to Nutcrackers could have been, in fact, the work of Red Squirrels.

Swanberg replied that he had seen no signs of Red Squirrels raiding the Nutcrackers' stores, though he had thought that mice and voles (*Clethrionomys*, *Apodemus*) might be responsible for some of the 14% "unsuccessful" excavations. This opinion was based on experience gained from artificially arranged "stores" in the forest. He added that the splitting of nuts lengthwise into clean halves is characteristic of the Nutcracker, and that the bird's hacking with slightly opened bill not uncommonly results in double scratches on the shell. These scratches are usually distinguished without much difficulty from those made by the

squirrel. With this point clarified, I can only add that we have yet to learn the precise nature of the faculty employed by Nut-crackers in locating food buried beneath deep snow.

(9) FOOD STORAGE AND SEED DISPERSAL

In Norway tits store food exclusively in the trees (Haftorn, 1954, p. 115). In this country, as I have shown, Coal Tits and Marsh Tits store not only in trees but also in the earth, in ground litter, and on banks. The Nuthatch does the same; it also conceals food in crevices on walls. Although these birds probably recover 90% of the food they hide about the trees they overlook many nuts and seeds which they bury, or conceal elsewhere. This is evident to anyone who walks about the country bearing in mind that certain trees rely almost entirely upon the food-hoarding instinct for their seed dispersal. In pine woods, beech-seedlings known to have been planted by Coal Tits are found growing 100 yards or so from the nearest beech. In Nuthatch territory young trees of beech, oak and hazel sprout from the steep sides of mossy banks; and in rough flint walls near gardens stunted seedlings of yew (*Taxus baccata*) and beech are firmly rooted in crevices where the seeds could not have dropped by chance. On moors, some distance from mature timber, oak saplings growing amongst heather show clearly that Jays also overlook a fair proportion of their buried acorns. In Czechoslovakia there is a large pine forest, half of which now has an oak undergrowth as a result of Jays' burying acorns there during the past 25 years (Goodwin, 1953, citing Turcek, 1950). It would seem that birds have a greater influence than squirrels upon the reproduction and dispersal of forest trees. Squirrels appear to be too efficient to allow many of their planted seeds to germinate.

CONCLUSION

It would be interesting to know how the food-storing habit in birds originated. In the Nuthatch, which habitually fixes its food in bark crevices, it is likely that storing began with the bird's carrying off and wedging more food than it required for immediate use. But the next stage—concealing the food with moss or lichen—would appear to require something like foresight. Tits do not wedge food in crevices; they hold it firm with the foot. These birds, however, are quick to learn by imitation, and it is possible that they acquired the storing habit from the Nuthatch, with which they regularly consort. That the habit is now purely instinctive is demonstrated when a Coal Tit, storing a nut on a bare tree trunk, "covers" the food with non-existent material (Richards, 1949).

The Great Spotted Woodpecker (*Dendrocopos major*) fixes galls and nuts in bark crevices before hacking them to pieces; but at times it will insert them and leave them intact. Later they may be found by accident and utilized. Have we here the habit in its

elementary stage? Perhaps in the course of time, if the custom be advantageous to the species, this woodpecker will learn to conceal its surplus food.

ACKNOWLEDGEMENTS

My thanks are due to the editor of *The Countryman* for permission to reproduce material published as an article in that journal. I am also grateful to Mr. Derek Goodwin for the loan of certain papers and for offering helpful criticism, and to Mr. I. J. Ferguson-Lees for much encouragement and advice.

REFERENCES

- ALMOND, W. E. and E. L. (1950): "Concealment of food by Marsh Tit". *Brit. Birds*, xliii: 336-337.
- CAHALANE, V. H. (1942): "Caching and recovery of food by the Western Fox Squirrel". *Journal of Wildlife Management*, Vol. 6, No. 4.
- (1944): "A Nutcracker's search for buried food". *Auk*, 61: 643.
- CAMPBELL, W. D. (1950): "Concealment of food by Marsh-Tit". *Brit. Birds*, xliii: 336.
- CHETTLEBURGH, M. R. (1952): "Observations on the collection and burial of acorns by Jays in Hainault Forest". *Brit. Birds*, xlv: 359-364.
- GIBBARD, S. D. and BOLDERSTON, W. N. (1947): In *20th Report Devon Bird-Watch. Soc.*, p. 5.
- GOODWIN, D. (1951): "Some aspects of the behaviour of the Jay (*Garrulus glandarius*). Pt. II. *Ibis*, 93: 602-625.
- (1953): "Birds and the woods". *Bird Notes*, xxv: 312-314.
- (1956): "Further observations on the behaviour of the Jay (*Garrulus glandarius*)". *Ibis*, 98: 211-213.
- HAFTORN, S. (1944): "Hamstring hos meiser". *Naturen*, 68: 58-63.
- (1953): "Observasjoner over hamstring av naering hos lappmeis (*Parus c. cinctus*, Bodd)". *Det Kgl. Norske Vidensk. Selsk. Forh.*, 26: 76-82.
- (1954): "Contribution to the food biology of tits, especially about storing of surplus food. Pt. I. The Crested Tit (*Parus c. cristatus*, L)". *Det. Kgl. Norske Vidensk. Selsk. Skrifter*, 1953, Nr. 4.
- HART, D. (1958a): "Hoarding of food by Willow Tit". *Brit. Birds*, li: 122.
- (1958b): "Hoarding of food by Coal Tit". *Brit. Birds*, li: 122-123.
- HAYMAN, R. W. (1958): "Magpie recovering and burying food". *Brit. Birds*, li: 275.
- HINDE, R. A. (1952): "The behaviour of the Great Tit (*Parus major*) and some other related species". *Behaviour, Suppl.* II.
- HUDSON, W. H. (1922): *A Hind in Richmond Park*. (Dent, London, 1951 edition, pp. 117-121.)
- LONG, D. A. C. (1950): "Concealment of food by Coal-Tit". *Brit. Birds*, xliii: 335-336.
- OWEN, J. H. (1945): "Unusual feeding behaviour of tits". *Brit. Birds*, xxxviii: 173.
- RICHARDS, T. J. (1949): "Concealment of food by Nuthatch, Coal Tit and Marsh Tit". *Brit. Birds*, xlii: 360-361.
- ROBINSON, M. G. (1950): "Concealment of food by Marsh-Tit". *Brit. Birds*, xliii: 336.
- SOUTHERN, J. B. (1946): "Unusual feeding behaviour of tits". *Brit. Birds*, xxxix: 214.
- SWANBERG, P. O. (1951): "Food storage, territory and song in the Thick-billed Nutcracker". *Proc. 10th Int. Orn. Congr.*, Uppsala, June 1950, pp. 545-554.
- TURCEK, F. (1950): "O vztahu sojky (*Garrulus glandarius* L.) k obnově dubu (*Quercus sp.*)". *Lesnická Práce*, 29: 385-396.