

THE ADVANTAGE OF CROSSED MANDIBLES: A NOTE
ON THE AMERICAN RED CROSSBILL.

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PROBABLY many who have watched Crossbills feeding on the fruit of our coniferous trees, straining and prying at the cones in order to reach the seeds, have wondered at the peculiarly formed beak which proves so fitted for the work it is called upon to do. Clearly, the crossed bill must possess some advantage over the common type, else it is difficult to understand its persistence. But how does it perform its work and what advantage has it?

Most writers, in dealing with these birds, confine the account to their habits; some describe, more or less fully, the construction of the bill, but have little or nothing to say as to how it is used; still others, manifestly reasoning from structure to function, plunge boldly into speculations which seem plausible enough until the facts are known.

Thus Audubon (*Orn. Biol.*, Vol. 2), writing of the "Common Crossbill," says: "Nothing can exceed the dexterity with which they extricate the seeds from the cones with their bill, the point of the upper mandible of which they employ as a hook, placing it at the base of the seed, and drawing it up with a sudden jerk of the head." Langille (*Our Birds in Their Haunts*) goes farther and attributes this action to both mandibles! Even so painstaking and trustworthy a writer as Coues (*Key*, ed. 4, p. 348), appears, in this instance, to have arrived at his conclusions in the same way; for whether or not the bill constitutes a "handy tool for cracking nuts of some kinds and shelling out their kernels" and aside from the rather dubious statement that it "acts like a pair of cutting pliers,—pincers and scissors in one" it certainly is not used (unaided, at any rate) to "skilfully husk" pine seeds out of their cones.

Two years after Audubon advanced his ingenious explanation and over fifty years before Coues published his 'Key,' an edition¹

¹ White, Rev. Gilbert, M.A. *The Natural History and Antiquities of Selborne. A New Edition; with Notes, by Edward Turner Bennett.* London. 1836.

of Gilbert White's 'Selborne' was published containing a footnote in which is given a detailed account of the functions of the Crossbill's singular equipment written by William Yarrell (a friend of the editor) and previously published "in the fourth volume of the Zoological Journal." Although the account has reference to the European bird, it applies equally well to our species. It seems surprising that so interesting an observation applicable to one of our common birds should have been so completely overlooked.

In April, 1917, an exceptional opportunity was afforded Dr. Windsor M. Tyler and me to observe one of our birds at work, and although the experience did not permit us to see all the minute details described by Yarrell, it made plain the chief part which the bill plays in securing the seeds. I have ventured to outline the process, as it was illustrated to us, not only because, by so doing, an obviously obscure subject is cleared up, but also because, —our experience being mainly corroborative,—the credit for the really important discovery will thus be given, after all these years, where it belongs.

Our bird, a male American Crossbill (*Loxia curvirostra minor*) was brought me by a neighbor, who had found him lying dazed in the street, the result, possibly, of having struck against overhead wires, or perhaps more likely still, against an automobile, since he proved to be unhurt and in a few hours had recovered sufficiently from his bewildered condition to fly about and help himself to food.

We kept him four days, giving him the freedom of a small, unused back-room and feeding him chiefly on suet. On the second day branches of pitch pine (*Pinus rigida*), bearing unopened cones, were gathered. These were placed over the stove until the heat had caused the cones to open. The branches were then nailed to the side of a "dry-sink" which stood in a corner of his new quarters. His attention was immediately attracted and almost as soon as the last nail was driven he had become busy with the cones, prying their scales apart and extracting the seeds which lay between. Like many of his kind, he was surprisingly fearless; indeed, so little did our presence disturb him that we were able to watch him, whenever he fed, as closely as we wished,

often from a distance no greater than is required to read ordinary print.

Before going further it may be needful to explain that the seeds of all conifers are borne at the base of rigid, woody scales which are attached to a central axis and arranged in alternating, overlapping rows, forming the cone. Until mature, they are protected by the tightly closed scales, but when fully ripened, the scales, sooner or later, separate and allow them, as they loosen from their seats, to drop out or be shaken out and distributed by the wind. In this section of southern Massachusetts, the pitch pine is one of the most common trees; groves of it cover extensive tracts, and it is also plentifully mixed with other growth. Its seeds, often produced very abundantly, are sought after by many birds. Besides the Crossbills,—who come to us irregularly and in varying numbers and who feed largely, if not entirely, upon them,—Chickadees are especially fond of them; so are Red-breasted Nuthatches and Goldfinches. Pine Siskins and Redpolls also take them commonly; Juncos not infrequently, and Tree Sparrows occasionally.¹ There are thus many birds who feed, more or less, upon these seeds and who are, unquestionably, able to obtain them easily, without the specialized organs which the Crossbill possesses. Nevertheless, there is this difference; all these other birds pick the seeds out *with the bill* and as the act requires considerable room between the scales, it is possible only with such cones as happen to be widely open.

The Crossbill, on the other hand, is not thus restricted; nor is his manner of securing them the same. Briefly, his method, plainly shown us by our bird, involves the use of *two* appliances; *the bill*, which forces and holds apart the scales; and *the tongue*, which lifts the seeds out.

So far as this essential fact is concerned, our experience, is in perfect accord with the testimony of Yarrell. If we try, however, to apply to our birds and cones his description of the minor actions employed in the operation, we meet with difficulties. According to Yarrell's account, after the birds have fixed themselves across

¹ The importance of these trees in contributing to the food supply of our wintering birds is often underestimated. Observers who live in localities where this, or other cone-bearers are common, would find it interesting to list the various species of birds which depend, in any degree, upon them.

the cones "they bring the points of the maxillae from their crossed or lateral position to be immediately over each other. In this reduced compass they insinuate their beaks between the scales; and then opening them not in the usual manner, but by drawing the inferior maxilla sideways, force open the scales."

Now, in respect to our birds, at least, it is not easy to see how the compass of the bill would be greatly reduced by bringing the crossed tips together; but assuming this to be the case, and assuming further, that in this condition it is insinuated between the scales, it is evident that the insinuation must be sidewise; that is, the sides of the bill must, necessarily, lie against the opposite scales; hence (applying the action to one of our pine-cones) one or the other mandible, according to the position of the bird, can hardly fail to rest upon the wings of the very seeds he is after. To add to this difficulty, he now (according to the description) exerts, with the lower mandible, a lateral pressure sufficient to force the scales apart, thus, it would seem, pinning the seeds down beyond any possible chance of securing them. But even if this last assumption is wrong, and the seeds are actually left free to be extracted, one might be rather skeptical of the bird's ability to separate, in the manner described, the scales of a great many cones, some of which are attached to their axes with almost unyielding rigidity.

In the case of our bird this part of the process,—these rapidly made adjustments of the beak to the scales,—was more or less obscure; necessarily so, from the fact of their half-hidden position. This much, however, is a matter of observation; in dealing with the cones which have begun to separate the head is turned so that the bill is inserted sidewise;—another agreement with the 'Selborne' account. Then follow the actions so characteristic of the feeding bird; a straining, twisting, prying movement, obviously requiring the outlay of considerable strength, not only of the muscles of the neck and shoulder, but, if need be, those of the body as well, and which results in bringing the head back into line with the body, at the same time forcing the scales apart far enough to allow the seeds to be secured.

This, of course, is the end to be achieved; now let us see if the motions themselves do not give us a clew as to how they aid in

making the achievement possible. Before I go farther, however,—lest I be accused of the same speculative fault which is apparent in the accounts of the writers quoted,—let me say frankly that the following is offered for no more than what seems a reasonable interpretation of the actions employed.

If we keep in mind the shape of the bill together with its position in respect to the adjacent scales, it is quite safe to assume that as the head is being turned back, the crossed tips will be brought to bear on the opposing scales, thus forcing them further and further apart as the movement continues. In this action there is indicated a perfect adjustment of the beak to the cone. A round-pointed bill, under the circumstances, would simply revolve between the scales without affecting them. The crossed bill possesses the unique advantage of *distance between the closed tips*; instead of tapering to a point, it is terminated by what is practically a wedge. This can be seen if it is diagrammed and a straight line drawn from tip to tip and from each tip back towards its base. Hence, its action might be compared with that of a knife-blade inserted horizontally between the two scales and then turned until it was perpendicular to them. It is peculiarly fitted to perform this function of a wedging instrument, for, as it is turned, the crossing mandibles support one another and give to it a strength and stability no other type would have. Moreover, an action of this kind would call for an unusual development of the muscles at the base of the bill, and this is just what we find to be the case.

Further, as the rotary movement progresses, the upper mandible would ultimately be forced into position so as to act much like a lever,—its tip resting on the lower scale, the broad curve above its tip against the under side of the upper scale,—thus, a lifting of the shoulders, exerting a pressure outward or away from the body (analogous to raising the handle of the knife) as the movement is being brought to a close would allow the upper mandible, alone, to hold the scales separated. This is precisely what actually happens, for now the lower mandible, automatically relieved from pressure, can open (while the scales are being held apart) and thus give free action to the prehensile tongue. That the tongue has been developed into a really prehensile organ is also shown by the manner

in which it is used to pick up small pieces of suet, broken off by the bill.

So far the performance has to do only with seeds that are more or less easily obtained. But it happens that some cones contain them in a thoroughly ripened condition, yet remain closed, often tightly, for some time. On our white pines (*Pinus strobus*) the process of separation commences in September and the period through which the seeds are being shed is short. The pitch pines, though a trifle later in beginning, prolong the period so that many of the cones remain partly and many others entirely closed throughout the winter and even into the spring. There are species which hold their seed much longer; the scrub pine (*P. contorta*), growing from northern California to Alaska, keeps them firmly locked within the cones for years.

With all cones, therefore, some time must elapse between the maturing of the seeds and the separation of their scales. Obviously, during this time, the seeds are completely protected from the common-billed birds. The Crossbill, however, who depends almost wholly upon them must, of necessity, be able to take them as he finds them, although it may be doubted if even he could do much with the cones of the last mentioned species. Nevertheless, in dealing with the general run of cones that are partly open or entirely closed, that is, with those in which the process of separation has just begun, or with those in which it is just about to begin,—his superior equipment is again indicated; for if the fact is kept in mind that his position, in relation to the cone upon which he is at work, will be (except in rare instances) such that its base is toward him, and that, consequently, the scales will open in the same direction, it is apparent that leverage can be applied to any scale by wedging the tip of the upper mandible under its edge. The application of leverage would be exactly the same as in the previous illustration, only at this stage, instead of being deep down between the scales, it would be at their surface. After an opening sufficient to admit the tip of the bill is made, the rest is easy.

When it is considered, moreover, that upwards of twenty-five species of pines alone (to say nothing of the various species of hemlocks, spruces and the rest of the family), inhabit the North American continent; that these coniferous trees are distributed

over the greater part of this vast area; that different species, in different regions, ripen their seeds at different times; that local conditions may cause them to yield abundantly, now in this section, now in that; and conversely, that localities where the seeds are plentiful at one time may have few or none at another;— it is not difficult to see how the Crossbill might have acquired his erratic and wide-ranging habits.

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[Note.—Upon referring to *The Zoological Journal*, IV, pp. 459–465, where Yarrell's account appears, we find that the paragraph quoted from Yarrell (p. 162 *supra*) is in turn quoted by him from "Townson's 'Observations in Natural History and Physiology,'" in which, he says, a chapter is devoted to this subject. We have not been able to consult the latter work but it would appear that the "discovery belongs" to Townson [Robert?] rather than to Yarrell.—ED.]