REPRODUCTIVE BEHAVIOR OF WHITE-BREASTED NUTHATCHES

I. Distraction Display, Bill-sweeping, and Nest Hole Defense

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This report describes two forms of behavior related to defense of nest-holes among White-breasted Nuthatches (*Sitta carolinensis*) which, as these birds nest in comparatively large natural cavities in trees, are particularly exposed to competition from tree-living squirrels. Observations have involved 20 breeding pairs of nuthatches, of which 7 were observed in Bethesda, Maryland between 1952 and 1960 and 13 in Tamworth and Lyme, New Hampshire, between 1963 and 1967. They are preliminary in nature; more definitive data are being sought in attempts to breed hand-reared White-breasted Nuthatches in captivity. The problems involved have not been described elsewhere in print, so far as I am aware.

Sweeping and Nesting Period

The habit of bill-sweeping is confined to the nesting season. It is similar to wiping the bill as many birds may do after feeding, except that a White-breasted Nuthatch of either sex usually holds some object such as an insect in its bill, and swings its whole body in an arc (Figure 1) as it sweeps back and forth over areas of bark by the nest entrance for many minutes at a time. It will occasionally sweep with the bill alone and at other times poke into an object, such as the body of an insect, then dab at the bark as if applying whatever adheres to its bill. An overall view of bill-sweeping and objects used is given in Table 1.

Period of nest building.—A pair of nuthatches began inspecting a squirrel box in Bethesda, Maryland on 10 April 1959. The female was carrying in bits of bark and other nest material, but she interrupted these

TABLE 1

Summarizing View of the Bill-sweeping Habit of White-breasted Nuthatches in Terms of General and Specific Times Involved and Objects Used

Times involved	*Intensity*	*Objects used*	*Extent*
A. General			
Nest-building	++++	Insect	++++
Incubation	+	Fur	++
Nestling period	+	Plant material	+
B. Specific and occasional		Feather	(single observation)
Capture special insect	+++	Bill alone	+++
Threat of squirrel	+++		

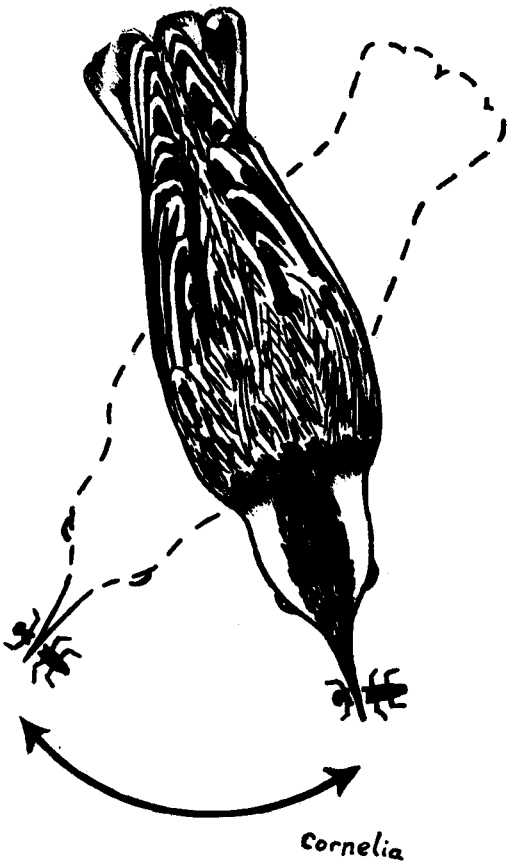

Figure 1. White-breasted Nuthatch sweeping with insect.

activities occasionally to sweep the roof of the box and adjacent tree trunk for 5 or more minutes at a time. She paid no attention when the male offered her food. He arrived shortly afterward with an insect in his bill. Using it in the manner of a broom, he swept inside, then outside the entrance until almost nothing of the insect remained.

The actual building of a nest may occupy female nuthatches in an almost exclusive fashion, but sweeping before or after this activity is often a prominent feature of the prenesting period, as became apparent in the course of observations made in New Hampshire. Sweeping of female FB in Lyme, for example, led to the discovery of her nest cavity at 0600 hours on 29 April 1967. She was sweeping when visited at 1300 and again at 1800 when her mate, MB, was also sweeping. Areas swept included the inside of the nest cavity, the space around the nest entrance with particular attention to the base of a small branch just below the hole, and the upper

slope of the leaning maple trunk in which the cavity was located. A fork formed with a large branch 6 meters below the hole also received special attention. FB continued to sweep for the next few weeks and did so at most times of day except when it rained. I sometimes found MB sweeping at the same time, but he was nearly always the first to stop and fly off. An impression one had from watching the nuthatches was that they were somehow preparing or adapting the maple stub by sweeping the bark again and again as one might paint a house prior to moving in.

Incubation period.—More extensive observations on sweeping were on a pair of nuthatches that nested in a squirrel box in Bethesda between 28 April and 11 June 1957. On 2 May the male swept so vigorously at 1300 hours that I could hear the *swish, swish* 60 feet away. The swishes heard in the next 7 minutes were too rapid to count, but they were obviously in the hundreds. The female also swept for part of this period. I believe she laid her first egg on this day for there were 5 eggs in the nest when I looked in 5 days later.

On 6 May both nuthatches swept continuously from 1908 to 1918 hours. They swept particularly on the roof and corners of the nest box as well as on knob-like growths on the tree trunk, paying little attention to each other and making no vocalizations. At 1925 they both returned to sweep for another 5 minutes even more vigorously than before. The female then entered the box for the night and her mate, after sweeping with almost frantic vigor for an additional 2 minutes, flew off to roost elsewhere.

Nestling period.—The eggs of this pair hatched on 23 May. On the evening of 31 May the female swept the roof and tree trunk in seemingly frantic fashion for 13 minutes, then entered the nest box for the night at 2021. Both nuthatches were sweeping on the evening of 8 June but independently of each other. At one time, for example, he was 8 feet above the nest box while she was sweeping 5 feet below it. I noted bill-sweeping in this pair for the last time on 10 June, which was the day the young left their nest. The intensive sweeping of this pair prior to roosting has been noted in other pairs during incubation and nesting when little other bill-sweeping was manifest.

Situations Precipitating Bill-sweeping

The following observations made in Lyme between 1965 and 1967 illustrate more specific situations leading to bill-sweeping:

Bill-sweeping as reaction to squirrels.—Bill-sweeping can have a special relation to the proximity of squirrels. While the majority of nest trees observed had no squirrels living particularly close to them, a few of the nest trees were in favorable squirrel habitats. It was at these that most of the sweeping episodes, such as the following, took place:

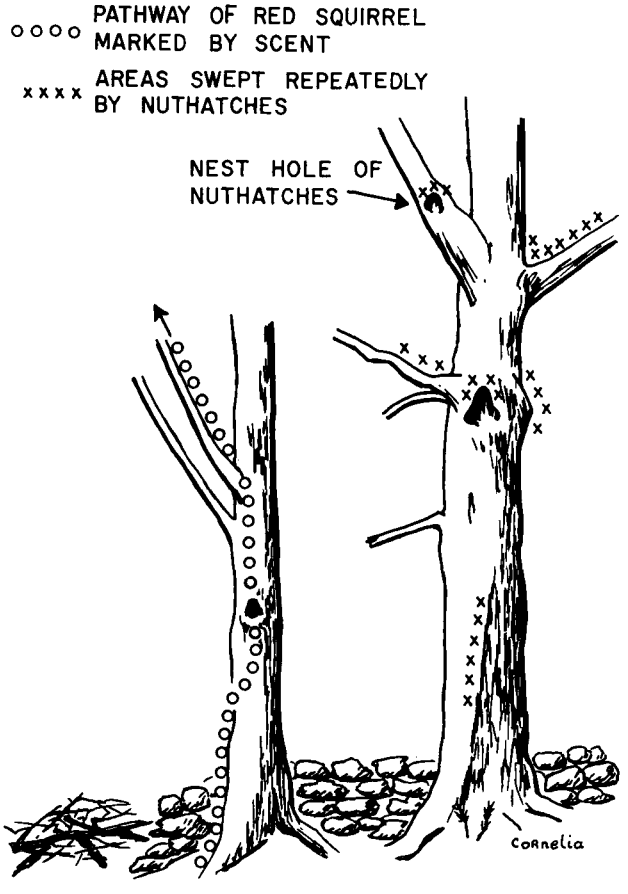

Figure 2. Diagramatic representation of interrelations of White-breasted Nuthatch and red squirrel. Squirrel has pathways up adjacent trunks and branches, used routinely and presumably marked by scent. No such odor trails became established on the nest maple of pair W because of the repeated sweeping of protuberances and branch junctions by the nuthatches (for concepts involved see Text).

When a red squirrel (*Tamiasciurus hudsonicus*) ran up an adjacent maple at 0800 on 5 May 1966, female nuthatch FW emerged from her nest hole immediately. She first made a distraction display (see Figure 3), then began to sweep as the squirrel moved away. FW had nothing in her bill initially, but after her mate arrived to feed her, she swept hard for 15 minutes on special parts of the sugar maple using fragments of an insect. Areas swept included protruding knobs and ridges, junctions of larger branches and the main trunk, as well as the vicinity of the nest hole as shown in Figure 2.

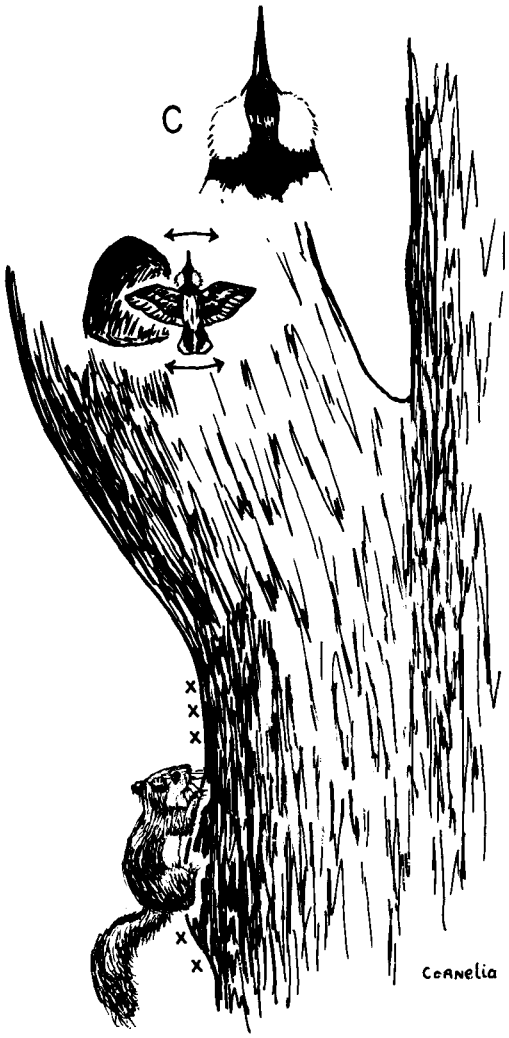

FIGURE 3. Diagram of events observed on nest maple of nuthatch pair W on 20 June 1966. Red squirrel ascending trunk paused, then made detour of nuthatch's nest, seemingly deterred by distraction display of female W at nest rim and possibly, as an additive effect, by confusing odors laid down by sweeping activities of the nuthatches. Detail at C shows how raising of auricular feathers gives appearance of large, false eyes, to nuthatch as viewed from behind.

I observed no further sweeping at the sugar maple until 14 May when a gray squirrel suddenly began a loud scolding, "*chuck, chuck, c-w-aan*" 30 meters from the nest. FW emerged from her nest hole and swept for 4 minutes while the squirrel continued to scold.

Female W was incubating within the nest hole a week later when a juvenile red squirrel ran up the adjacent maple. This time FW remained inside, but her mate reacted almost immediately with 2 minutes of sweeping, centered largely around the nest entrance. This was the first and only time I saw MW sweeping.

I noted no further sweeping nor any close approaches of squirrels to nest W until 20 June, when a red squirrel whose territory was close by ran up the trunk of the nuthatches' nest tree. FW disappeared within her hole immediately. It was as if her immediate concern was to guard the entrance and her nestlings from within. By the time FW emerged 5 minutes later the red squirrel had passed, but she now caught sight of a chipmunk (*Tamia striatus*) directly below on the ground. FW remained motionless while eyeing it intently. Then, when the chipmunk came no closer, she took a piece of unidentified material from storage and swept for several minutes. This reaction to chipmunks was not unusual, for I saw it at two other nests.

Capture of special insects and sweeping.—Aside from the approach of a squirrel, the only other situation I noted that served to precipitate immediate sweeping was capture of some special insect. Examples at two nests may be illustrated by events at Nest F:

Female FF flew to her nest at 1219 on 11 June 1967 with a single insect, larger and hence more recognizable than what she had been in the habit of carrying to feed her young. The insect was a blue-black beetle with a prominent abdomen, and was about 2 cm in length. FF exhibited an intense drive to sweep the walls of the nest cavity in an almost frantic manner for 9 minutes. She emerged a few times to sweep briefly about the entrance. After her last bit of sweeping on the outside she stored the remnants of the beetle in a crevice. She now appeared as if exhausted by her efforts and rested motionless for 6 minutes just below the nest hole.

I saw no further sweeping at this nest until 1045 on 16 June, when FF flew to the nest tree carrying the same type of blue-black beetle as the one used 11 June. My immediate thought was, she is going to sweep, which proved correct. FF began to sweep immediately on alighting, concentrating her activities on the inside of the nest cavity as before. It was only when she came outside for brief periods that I could see additional aspects of her sweeping behavior. Once she stopped sweeping to deposit the insect in a crevice, then poked her bill into it repeatedly prior to sweeping for a few moments without it. It appeared as though she were applying something, as one might dip a brush into a can of paint. FF stored the remnants after 5 minutes. I had noticed that she ate the viscera when these had protruded during her activities. When through with her sweeping she went back over her course, devouring a few small bits of material that had clung to the bark here and there.

A number of points regarding these episodes are worthy of comment. First is the fact that FF gave no signs, physical or vocal, that she was excited by the threat of any immediate danger. To an observer therefore, the stimulus to sweep appeared to come from the nature of the insect itself, which possibly had some irritating property. A second point of interest is the special attention given to the inside of the nest cavity. As this sweeping was done at a time when the young were halfway through the nestling period it may have served some imprinting function, either by letting the nestlings see the parent perform in an intensive fashion within the nest itself, or chemically by giving them a chance to pick up some of the taste of the insect as they poked about the nest cavity. One might note here that the mother nuthatch had picked off and eaten bits of insect adhering to bark, a fact supporting this idea that the nestlings might do the same.

Objects Used in Sweeping

Insects.—Usually the nuthatches sweep with a mere fragment of material which might not be recognizable even at close range and is much less so to an observer on the ground and many meters distant. Insects are more readily recognized by their chitenous outerparts than most other object. While nuthatches usually take them from storage prior to sweeping, in several examples above insects, possibly of a special nature, were used immediately after capture.

Plant materials.—As plant materials generally lack the hard parts characteristic of insects, it does not take much manipulating to render them amorphous and unrecognizable. Two types of examples suggested that nuthatches use them in sweeping. First of these were direct observations, such as one made on female FB on 12 May 1967 as she swept about her nest hole for 8 minutes with a wad of bright green, exceedingly moist-looking fibrous material a full centimeter or more in diameter. She lodged the material several times in crevices, then poked her bill into its mass before sweeping for a time with her bill alone.

A second line of evidence for use of plant materials was purely circumstantial. This was the collection and storage of buds from sugar maples, a phenomenon observed in three nesting pairs. Male C, for example, attacked six such buds on 8 and 9 May 1965, usually clinging to them upside down to hammer at the attachment of bud to twig from below. I never saw a nuthatch eat such buds; in each case the buds were simply stored in some other part of the nest tree and left there. Bussman (1946) has described a similar type of behavior in the European Nuthatch (*Sitta europaea*). In his case, however, gum from the bud was incorporated in the nest entrance.

Fur.—Fur is, after insects, the most frequently recognizable of the materials the nuthatches use. The various ways they may store and/or

sweep with it was illustrated by the activities of pair B in 1967. At 1730 hours on 13 May FB took a wad of gray fur from storage close to the nest entrance and swept with it for 5 minutes, bits of the fur coming loose and clinging to the bark here and there as she did so. The fur might well have come from a gray squirrel. On 18 May her mate, MB, took from a crevice a small wad of red fur such as might have come from a red squirrel, then re-stored it closer to the entrance hole without sweeping. I then noticed that FB was sweeping with a feather, the only time I ever saw a nuthatch do so. This feather was curved and about 2.5 cm in length. I suspected that it might have come from a Ruffed Grouse (*Bonasa umbellus*).

Sweeping with bill alone.—Nuthatches appear to store a considerable supply of objects both inside and outside of nest holes. They can thus start sweeping without loss of time whenever seized by the impulse to do so. When incited to sweep abruptly by some special stimulus, they may start sweeping with nothing but their bills alone.

BIOLOGICAL SIGNIFICANCE OF BILL-SWEEPING

At least several answers are conceivable to the question of whether the habit of bill-sweeping has survival value for White-breasted Nuthatches. One is that the habit serves to strengthen the pair bond as well as attachment to the nest site. Yet it appears doubtful for a number of reasons that the habit could be for such purposes alone. First is the fact that courtship activities are usually at a low level during actual nesting and would not be expected to rise to an intense level when an intruder threatened the nest. A further reason is that female nuthatches sweeping alone seemingly pay no attention to their mates. If both members of a pair sweep at the same time, they may be many feet apart and even out of sight of one another in seeming indifference, all of which is unlike behavior primarily associated with a pair bond.

An alternate explanation of bill-sweeping is that the habit serves chiefly as a first line of defense of the nest hole against squirrels. This hypothesis has been suggested by field observations. Findings presented below are thus regarded as being only suggestive in nature and are being followed up by a long term study involving attempts to breed hand-raised White-breasted Nuthatches in captivity, then to test various interactions between them and hand-raised gray squirrels. These projects are already underway.

Meanwhile the biological significance of the bill-sweeping habit as it appears at present is outlined by means of the following concepts: first that red as well as gray squirrels use the same type of nest cavity in old sugar maples and other trees as White-breasted Nuthatches and are thus nest hole competitors; second that these squirrels leave scent trails on branches and trunks of trees which they customarily use in traveling about;

and third that the bill-sweeping of nuthatches with various objects is primarily a means of defense of their nest holes against mammalian competitors.

Types of holes for which squirrels and nuthatches compete.—The range of cavities nuthatches use in old sugar maples have roughly two sizes of entrance holes; those of 3 to 4 cm in diameter attracting red squirrels and those of 7 to 10 cm, the larger gray squirrels. In 1964 I found two nuthatch nests with the smaller entrances. On returning a year later to find out if the birds might be reusing the same cavities for nesting, I found red squirrels occupying both of them. On other occasions it has taken many visits to reveal whether a squirrel was actually occupying a hole. While making observations on nuthatch pair D in two successive seasons with repeated visits in April, May, and June, I noted what appeared to be an ideal, but apparently vacant cavity in an old sugar maple near where I usually stood. On only a single day in each year did I discover that it was occupied by nesting gray squirrels. Thus in 1966 the mother squirrel rested some moments before entering and in 1967, three half-grown squirrels suddenly emerged from the hole, then reentered it a few moments later.

Scents trails of squirrels.—In a discussion of intraspecific signals used by mammals in general, Wynne-Edwards (1962) points out that there are "no instruments by which odors can be detected, amplified, analyzed or defined." I have not found much specific information on scent trails in published accounts of squirrels. The following observations suggested that squirrels may lay down such trails on old sugar maples, among other trees, in the breeding season of nuthatches:

A female red squirrel with a center of activities in a brush pile 8 meters from the nest maple of nuthatch pair W in the spring of 1966 (see Figure 2) had young moving about neighboring trees by 7 June. On 18 June the squirrel rubbed her chin a number of times on a main log of the brush pile. She then made a circular tour of adjacent trees and branches giving what I have interpreted as a territorial song (Kilham, 1954) about every 3 minutes. The squirrel stayed away from the nuthatch maple on this as on previous occasions. On 20 June, however, the mother red squirrel started up the maple and was halfway to the nest hole before the female nuthatch looked out, then spread wings and tail in distraction display (Figure 3). The squirrel moved on up the maple, without coming close. She then returned, paying attention to various ridges of bark and protuberances on the way down, all of which were places I had noticed the nuthatches sweeping on previous occasions (Figure 2).

At 0645 on 7 June 1967 I watched an adult male gray squirrel as it walked slowly across branches to an old sugar maple where it sniffed the bark, particularly where large branches formed the main trunk (Figure 4).

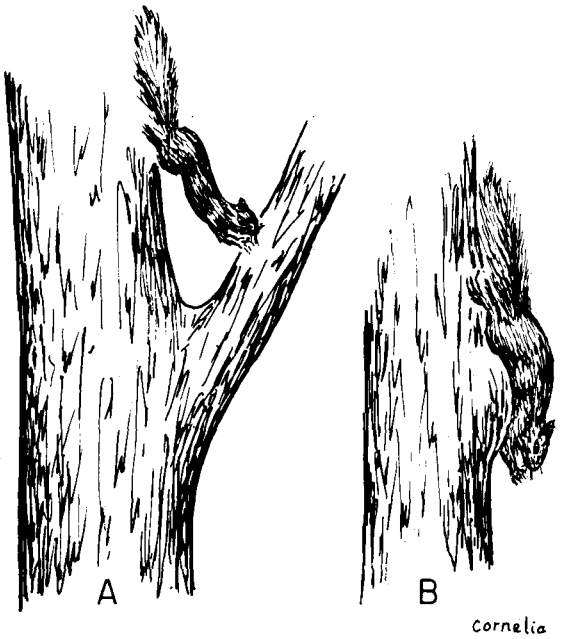

Figure 4. Types of gray squirrel activities involving parts of old sugar maples such as are swept with particular intensity by nesting White-breasted Nuthatches. Male squirrel sniffs at place where large branch joins trunk on tree where female gray squirrel, resting on protuberance, had young.

It even retraced its steps to do so twice. While the squirrel was thus engaged, three half-grown gray squirrels emerged from a cavity in the hole below, then quickly reentered. The tree was thus occupied by a family of squirrels. The mother squirrel might, expectedly, be coming into a breeding condition again as her young reached the juvenile stage. Both Flyger (1955) and Taylor (1966) observed that male gray squirrels may not only sniff but also eat the bark where females in estrus have rested.

While I have encountered no extensive accounts of squirrels laying scent trails, my own observations have received support in personal communication from Peter Weigl, who is studying squirrels of various species at Duke University, in the following personal communication: "The tree and flying squirrels which I have hand-reared habitually marked their trails over new surfaces with minute drops of urine. The positions of animals at such times with their stomach close to the ground would facilitate the spreading of glandular and other substances from the urogenital region." Weigl has also noted that rubbing of the chin on a log is "a common form of marking behavior."

Transfer of young squirrels and night movements.—Squirrels have some

ability to move about at night. As red and gray squirrels both have pure-cone retinae (Tansley *et al.*, 1961) they are unable to see well at such times, and one can presume that they possibly follow scent trails laid down during the day. At 2300 on 6 September 1952 I located an adult female gray squirrel by a peculiar whine as she moved back and forth between a hickory and a tulip poplar which had a leafy nest at the top in our yard in Bethesda. Hearing the same whine at 0630 the following morning, I was able to watch the mother as she transferred four one-third-grown young, one at a time, from the leaf nest to a squirrel box up on a pole. Gray squirrels may have a close familiarity with all potential holes within their home range. Intrusion by such a mother squirrel in the night might represent a special hazard to a pair of nesting nuthatches and may explain why the birds sweep with special intensity just before dark.

I have had no observations that flying squirrels (*Glaucomys*) are also a hazard. They seem to prefer to occupy woodpecker holes in straighter trees rather than the types of cavities White-breasted Nuthatches use, which may explain why they were not encountered in present studies.

Sweeping as chemical defense against squirrels.—Chemical defense of nest holes is not unknown among birds. Nestling Hoopoes (*Upupa epops epops*) produce a foul-smelling secretion from special glands (Sutter, 1946). It is conceivable that White-breasted Nuthatches accomplish a similar type of defense by using the special and analogous glands of insects as brooms in bill-sweeping. The crushed bodies of various arthropods can be very potent in this regard. Eisner and Meinwald (1966), among others, have recently described how many species of insects produce defensive secretions which are not only odorous, irritating, or otherwise repellent in nature, but are also persistent in effects, and are produced in relatively large amounts and in a highly concentrated form within integumental glands. It is often difficult for man to appreciate the sensitivity of other mammals to odors in even trace amounts.

One may ask, if this is true in regard to insects, why should nuthatches use plant materials on occasion as well? The related Red-breasted Nuthatch (*S. canadensis*) applies plant materials in the form of resinous sap from coniferous trees to the bark surrounding nest holes. The usefulness of these resins in defense is probably in their stickiness. Plant materials have a wide variety of other properties and the fact that the various alkaloids, essential oils, and other so-called "secondary substances" are primarily defensive in serving to ward off attacks of phytophagus insects and herbivores has only been appreciated in recent years (see Fraenkel, 1959). Eisner (1964) has pointed out, furthermore, that defensive substances of plants and arthropods may even be identical in chemical structure in some instances. Thus White-breasted Nuthatches could, conceivably, sweep with bits of plants or of insects interchangeably.

An important question still remaining is why do these birds sweep, and not infrequently with no more than a few whisps of weathered fur, a feather, or even with the bill alone? One presumes that this latter habit also has survival value. A possible explanation is that White-breasted Nuthatches use saliva as well as juices of plants and insects in sweeping. The concept of saliva with special properties is not new among birds. Welty (1964: 89) gives a good summary of such species as the European Green Woodpecker (*Picus viridis*) with salivary glands 7 cm in length that supply an insect-holding film for its protrusible tongue and of the European House Martin (*Delichon urbica*) which builds a nest of mud mixed with saliva. The salivary glands of this latter species are especially enlarged during the breeding season. One wonders whether similar conditions may not obtain among some species of nuthatches. The European Nuthatch (*S. europaea*), for example, builds a nest entrance of mud while the Rock Nuthatch (*S. neumayer*) builds an all mud nest much like that associated with some species of swallows but embeds the bodies of insects within it (see Löhrl, 1967). Löhrl (1958) raises the issue of whether *S. europaea* uses saliva in nest construction, but leaves it unanswered. One can do the same with as much reason for *S. carolinensis*.

DISTRACTION DISPLAYS

A White-breasted Nuthatch of either sex can transform itself in what to a human observer is a moth-like object when, holding itself in a rigid pose with wings and tail outspread and bill pointed upward, it sways slowly from side to side in the face of an intruder approaching its nest hole (Figure 5). Each sway may take 10 to 20 seconds, and such displays are much alike when produced at full intensity. The ability of nuthatches to cling to tree trunks in odd positions makes them look somewhat different at different times. Examples illustrating the range of this performance and the contexts in which it may be performed are as follows:

Bethesda 1957.—Pair A. Male A was sweeping near his nest box in our yard at 0730 on 7 May, when he suddenly went into a distraction display in which he pointed straight out from the tree trunk as he faced a gray squirrel approaching from the ground. The squirrel came to within a meter of the displaying nuthatch, paused, then turned and left. MA then continued sweeping. The nest box contained 5 eggs at the time.

I observed similar episodes on 17 May and 7 and 11 June. In each case the nuthatches exhibited the same interplay of sweeping and distraction displays. They had to contend with a relatively concentrated gray squirrel population in the suburban area in which they lived.

Experience with aviary pair, Lyme 1967.—An opportunity for close observation of nest hole defense among White-breasted Nuthatches was afforded by a hand-raised pair that went through much of their breeding

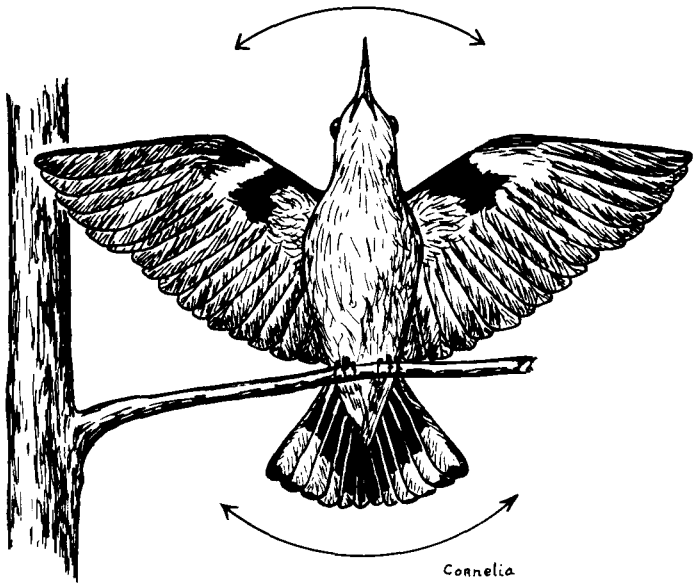

Figure 5. White-breasted Nuthatch in distraction display.

behavior in captivity. A chipmunk began entering their cage in early April. On 7 April the male nuthatch was resting by his nest box watching the ground intently, occasionally fanning his tail and partly raising his wings as he did so. The chipmunk had entered the cage from the ground. It suddenly ran up the side of the cage and over onto the roof of the nest box, where the male nuthatch met it in full distraction display. The chipmunk, possibly from daily close exposure to the nuthatches, was not deterred. As it came even closer the nuthatch swung backward, still in display, until its body, with belly upward, projected outward from the edge of the nest box at an angle of 90 degrees. After a momentary pause it dropped away. The chipmunk now came over the edge of the box and looked into the entrance. Here it faced the female nuthatch. She drove at the intruder head on and, from the rapid departure of the chipmunk, her sharp bill must have delivered an effective blow. This episode clarified one point—that a nuthatch in distraction display may hold its rigid pose, without evidence of either fear or of making of any motion of threat to attack, right up to the moment of being almost touched by an intruder.

Discussion

Distraction displays.—Armstrong (1964) has described injury-feigning and mammal simulation as the only types of distraction displays among birds. Both, however, apply to ground-nesting species and thus appear

to differ in origin and nature from what I have termed the "distraction" displays of White-breasted Nuthatches, which are delivered in one place rather than while running about. The only parallel I have encountered is that Ferguson-Lees (1964) describes for nesting bitterns (*Botaurinae* spp.), "Most striking is the concealment posture shared only with the tiger herons. In this the bird becomes completely rigid with bill and neck pointed stiffly skyward . . . the bird keeps its underside towards the source of danger, watching with unwinking yellow eyes swivelled downwards, and revolves slowly . . . if the observer or other threat moves round. . . . In a light breeze, at least some species will sway with the reeds. *Ixobrychus* may even let itself be picked up." This sudden "mental freezing" of a bittern on its nest suggests an additional parallel with White-breasted Nuthatches. Thus when I opened a nest box of this species in June 1957, I found that the female sat so close over her nestlings that I had to push her aside with my finger to see them. Grinnell and Storer (1924) describe the same phenomenon as follows: "The female was on the nest and as she refused to leave even during the hubbub incident to enlarging the entrance, the observer had to lift her from the nest in order to examine the eggs. She seemed to be in a sort of lethargy and did not struggle until actually taken in hand." It is this aspect of lethargy with its hypnotic quality, which may be a basic part of phenomena underlying the distraction display. These appear to have much in common with those Hartman (1952) describes in his chapter on the death-feigning of opossums (*Didelphis virginiana*) and other animals. In reference to the state of tonic immobility induced, Hartman speaks of "reactions to a sudden stimulus too rapid to be controlled by conscious emotions."

Bill-sweeping.—A generalization applying to most hole-nesting birds is that suitable nest holes are in short supply and competition for them is usually intense (von Haartman, 1956). The nature of the competition varies with different species. While avian competitors are of chief importance for most hole-nesting birds, tree squirrels appear to be the chief competitors for natural cavities with nesting White-breasted Nuthatches in New Hampshire woodlands. The extent of this competition is not easy to assess. Squirrels are wary about entering their nest holes, a mother squirrel can spend long hours within nursing her young, and squirrels, like mammals in general (see Wynne-Edwards, 1962), live to a large extent in a world of olfactory signals beyond direct comprehension of a human observer.

Bill-sweeping may have developed from the simple habit of wiping the bill a few times on bark to clean it of fluids or bits of tissue remaining after pounding some insect. Organic substances would then remain in trace amounts on the bark. Retention of the practice might then follow if such

bits happened, by chance, to have survival value in deterring tree squirrels by means of disrupting olfactory signals.

The habit bears some analogies to that of anting among other passerines, in which insect fluids are applied to feathers (for description see Simmons, 1964). In bill-sweeping similar defensive fluids are applied to bark of nest trees. The habits may be defensive in either case. If anting is a parallel habit, its effect could be to hide or disguise body odor by anointing contour feather with repugnatory or repellent organic substances sufficiently long-lasting in nature to protect the bird from mammalian predators during the especially vulnerable hours of roosting at night. Even a slightly confusing scent might be sufficient to deter or to deflect intruders.

Bill-sweeping habits of White-breasted Nuthatches, like their distraction displays, are possibly unique among hole-nesting birds. References to either type of behavior appear to be few. Hans Löhrl has observed the bill-sweeping of *S. carolinensis* (pers. comm.) and F. H. Allen (quoted in Bent, 1948: 3) while observing a nesting pair, noted that "the wiping was too regular and long-continued to be merely for the purpose of cleaning the bill."

Summary

This report describes two behavior patterns used by White-breasted Nuthatches in defense of their nest-holes, one a "distraction" display and the other bill-sweeping.

The unusual nature of these performances appears related to the fact that White-breasted Nuthatches nest in natural cavities in trees, a situation exposing them to competition from tree squirrels.

In bill-sweeping a nuthatch usually holds some object such as crushed insect in its bill.

The sweeping may go on inside and outside of nest cavities and intensively for many minutes at a time. Although limited to the breeding season, nothing indicates that it is primarily related to either courtship or the pair bond.

Periods when bill-sweeping can be observed with greatest regularity are at the time of nest-building, especially in a new cavity, and during the last half hour before roosting during periods of incubation and rearing of nestlings.

Two sets of circumstances may precipitate bill-sweeping at almost any time: (1) the threat posed by a possible intrusion of the nest tree by a red squirrel, a gray squirrel, or a chipmunk, and (2) capture of certain insects that appear to have special properties when crushed.

The hypothesis is proposed that White-breasted Nuthatches make use of the chemical defense secretions of insects to divert or to distract tree squirrels from approaching or entering nest cavities.

When a squirrel does come close to a nest, a parent nuthatch of either sex may spread its wings fully and hold a fixed pose, swaying slowly back and forth, in what is termed a "distraction display."

As nothing in this behavior suggests impulses to attack or escape, it is regarded here as being more related to "death feigning" phenomena observed in various animal species.

The present report, which is preliminary in nature and is based on field observation, is being used as a basis for an experimental approach with White-breasted Nuthatches hand-raised in captivity.

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