REPRODUCTIVE BEHAVIOR OF WHITE-BREASTED NUTHATCHES

II. COURTSHIP

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WHITE-BREASTED Nuthatches (*Sitta carolinensis*) are unusual among northern hemisphere birds in their close pair bonds held over most of the year as well as in their varied forms of courtship, which can reach a crescendo in midwinter. The present report on their behavior includes field observations begun in Bethesda, Maryland in 1952 but carried on for the most part in Lyme, New Hampshire between 1963 and 1970, as well as studies of hand-raised individuals. I have been studying Red-breasted Nuthatches (*S. canadensis*) similarly with an aim of eventually comparing the behavior of the two species.

General accounts of White-breasted Nuthatches are given by Tyler (1916) and Bent (1948), among others. While these authors describe some displays excellently, they omit others and fail to account fully for all that happens in courtship, which Thomson (1964) describes as covering "a wide range of activities of which the function seems to lie in attracting a mate, maintaining the pair bond, and in facilitating copulation and parental activities."

METHODS OF STUDY

Aviary studies.—I removed young in the pinfeather stage from several nests and raised them by hand. One pair of these carried out breeding behavior, going as far as laying and incubating eggs in 2 successive years. This hand-raised pair enabled me to see repeatedly and at close range much that helped interpret field observations. The birds were maintained in an aviary 2 m square, 3 m high, and built inside a greenhouse.

Field studies.—I observed courtship behavior to best advantage by going into woods before dawn in winter months, often at temperatures close to 0°F, and watching the roost holes (Kilham, 1971) in order to follow the activities of males in the first half hour of the day when, as Tyler (1916) notes, courtship activities may reach a peak. White-breasted Nuthatches become recognizable individually when followed through most of the year. One male held the same territory for 2 and two others for 3 years. All retained the same mates throughout this time as could be checked by head patterns (Figure 1) in which the distribution of gray and black differs between one individual and another. Retention of the same mates over successive years is also described by Brackbill (1969) for *S. carolinensis* and by Lack (1945) for the European Nuthatch (*S. europaea*); both authors used color bands for identification.

I operated a woodland feeding station over two successive winters. Although this enabled me to watch nuthatches at close range, the artificial abundance of food had a markedly disruptive effect on their behavior. Hence essentially all of the present studies were made in woodlands away from houses and feeding stations.

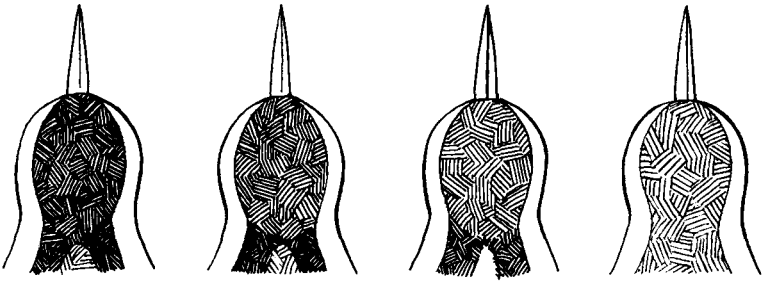

Figure 1. Head patterns of individual female White-breasted Nuthatches, ranging from dull black to light gray with mixed types in between.

White-breasted Nuthatches have a variety of vocalizations associated with courtship (Table 1), and each of these can vary in the way it sounds with distance, as Tyler (1916) noted. Main displays associated with courtship were the following:

INTIMATE NOTES

The most frequent vocalizations of White-breasted Nuthatches are the low "hit-tuck" notes members of pairs exchange as they travel through woods in fall and winter months. The vocalizations are seldom monotonous, for each bird makes a slightly different note from the other, as Thoreau (1962) noted, "Nuthatches are faintly answering each other, tit for tat, on different keys," his account indicating their occasional antiphonal nature. Much of the answering by the two birds is irregular, for one may be feeding while the other continues calling alone. A fast rate of exchanges is 30 a minute, but this rate is seldom maintained. The term "intimate" is appropriate, as these notes reflect the close pair bond of a well-established pair. They doubtless serve a number of functions. One of these seems to be location, for the two nuthatches are frequently out of sight of each other as they spiral about the trunks and branches of large trees; another is expression of moods as they change from minute to minute in relation to circumstances. The European Nuthatch (*S. europaea*) has equivalent "sie, sie" notes which Löhrl (1958) describes as *Stimmfuhlungslaut*. Such notes may also have additional functions. Equilibrium is not always present between members of a pair, and the "kun," or "kun-uns" and "tchups" that may replace the usual notes may be a way in which a male asserts his dominance.

At the approach of actual nesting or during the early nesting period, females are generally silent while males, hunting prey to feed them, may continue to make small notes that can be surprisingly varied when they are away from their mates.

TABLE 1

VOCALIZATIONS[1] COMMONLY ASSOCIATED WITH COURTSHIP IN THE WHITE-BREASTED NUTHATCH

Vocalization	Purpose	When used
"Wurp-wurp-wurp" (8–11 notes in rapid series)	Courtship song of male; associated with back presented to female and bowing display at full intensity. Numerous variations at less intensity. May serve as territorial song; location notes, etc.	January to early May, sporadic only at other seasons
"Phee-oo"	Expression of intense sexual emotion (1) by male prior to and during pursuit flights, (2) by female immediately before and after coition.	February (male only) to early May
"Hit-tuck" and "tchup"	Serves (1) to maintain pair bond, (2) as location notes. "Tchup" conveys a mild degree of excitement.	Winter and early spring primarily
"Kun," "ka-un," "kaan," etc. ("quank")	Expresses excitement, the degree depending on whether the notes are single or given in a rapid series and whether loud or soft.	All months

[1] A rapid "hn, hn, hn" or trill, commonly heard in late breeding season, is considered more related to agonistic than to courtship behavior and will be dealt with elsewhere.

COURTSHIP SONG

The song the male nuthatch sings in winter and spring has at least four variations, and while all may serve to advertise territory, their main function appears to be courtship.

Early morning rendezvous song.—The finest and most prolonged singing of male White-breasted Nuthatches may begin in January and last until early March, often at temperatures below freezing when woods are deep in snow, and always in the first half hour after leaving the roost hole. The male is essentially a lone bird at this time, for males and females roost at a distance from each other and may emerge from their holes at different times. Within minutes of leaving his roost hole in late winter, for example, Male B (MB), who had recently acquired his mate, would fly to the topmost branch of one of the tallest oaks or maples growing in an exposed position at the edge of a swamp. Resting at right angles to his perch 20 to 35 m above the ground, he sang flat-sounding "what, whats" in a rapid series of 8 to 11 notes lasting 2 seconds, followed by a rest period of 3 seconds in which his body swayed slowly in an arc of 45 degrees. His head and neck would then suddenly shoot up (Figure 2) so that his body was almost vertical as he began again. In full performance his body bowed down with each note, but at lesser intensities only his bill appeared to move from an upward

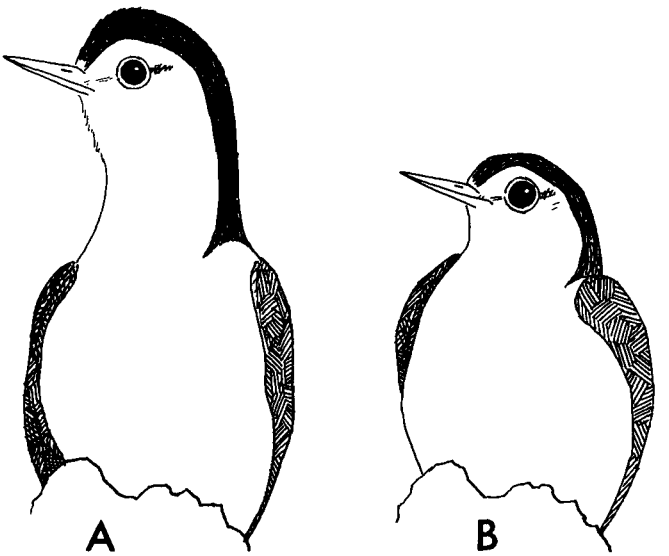

Figure 2. A male White-breasted Nuthatch (A) shoots head and neck upward at start of courtship song, (B) then relapses at end to resting position.

position of 45° at the start to a position slightly below the horizontal at the end. After 2 to 3 minutes of facing in one direction, MB would hop around to face the opposite way.

A sudden change, often noted after 5 to 10 minutes, was a shift from the dull "what" notes to musical "wurp, wurp, wurps." On nearly all such occasions I soon heard the first "kun" or "kun-un" notes of the female. She was usually at a distance and in no hurry to arrive. When she did come to branches below her mate, he would soon stop singing and join her, the two then foraging together and exchanging "hit-tuck" notes.

Direct display to mate song.—Another pattern of singing the rendezvous song was exemplified by Pair L in February 1966, when FL, on arriving to join her mate, took a perch below the level of his and about 3 m away. After swaying slowly from side to side for a time, she then became motionless, as if held by his song. This latter began when ML, stretching upward into a vertical position, began bowing down with each "wurp" of his song, thus displaying in succession, as well described by Bent (1948), first "the black of his crown and his rough raised mane, then the blue gray of his back, then the variegated pattern of his expanded tail, then perhaps at the end of his bow, a flash of ruddy brown." This ruddy brown in the vent region, although present

in both sexes, appears to be brighter in males than females. The complete attention that a female can give to such a performance over a period of 6 to 8 minutes is extraordinary. After this time FL would become restless and leave to forage; ML, like other males, would then stop singing.

One does not encounter this full intensity performance with all males. In the winter of 1969, for example, I heard it quite regularly with MB who had acquired a mate the fall before, whereas in the following year, when I likewise followed his activities from January to March, I never witnessed a full performance. It seems possible therefore that males mated for a year and having well-established pair bonds sing in a less prolonged fashion.

During the first few hours of a winter morning when two nuthatches move through woods, there are pauses when the pair may become motionless, each facing the same direction. The male now gives a performance at lesser intensity, delivering his pleasant-sounding "wurps" from a branch well below tree top level and with little or no bowing, although he keeps his back turned toward his mate.

Keeping in touch with mate song.—The members of a pair of nuthatches are not together continuously. Males are generally more wide-ranging than their mates, leaving them from time to time to make a circuit of one part or another of their territories. Thus MB, after leaving his mate on 9 March 1969, spiraled around one tree trunk after another singing continually; each of his leisurely songs consisting of six to eight "wurps" given at a rate of six series a minute. These vocalizations doubtless kept his mate informed not only of where he was, but also conveyed that all was well and thus, in serving to maintain the pair bond at a distance, had a homeostatic function.

Nest building and incubation.—After a quiet period in late March, males may sing in April when their mates, increasingly involved with the prospective nest hole, pay less attention to them. Their singing now may well be a release for sexual energy. Thus one male did an extraordinary amount of singing in May 1966, and this led me to where the female was trying to establish a nest in a cavity in an old maple that, with two large entrances, seemed a poor choice. She persisted in uncertain efforts for several weeks before abandoning the site.

Displays accompanying the singing of such lone males can be bizarre. Tyler (1916) described this situation particularly well: "If perched on a small branch, he may turn almost upside down. He straightens up to the erect position in silence, then tilts slowly forward while he repeats his song. He continues the deliberate tilting over and over again; always singing as he lowers his head and shoulders."

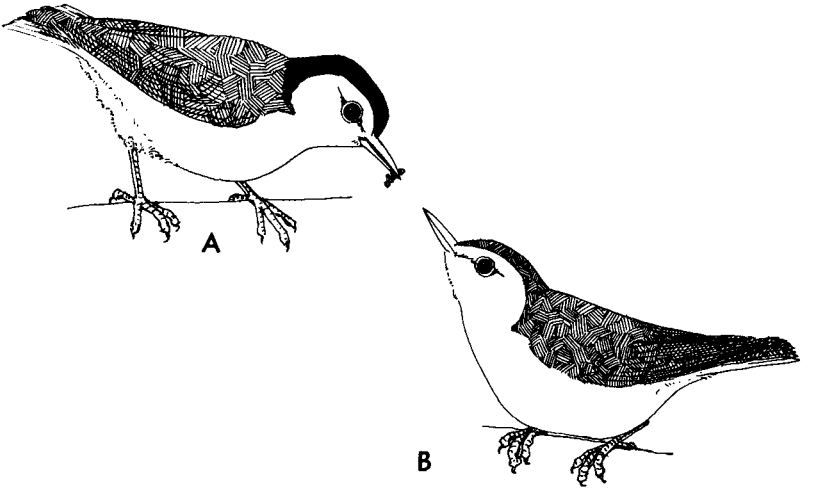

Figure 3. Courtship feeding with female White-breasted Nuthatch (B) in motionless, fixed pose which forces male (A) to line his bill up exactly with hers in presenting well-prepared mealworm.

While it is impossible to cover all variations of the courtship song, it should be noted that White-breasted Nuthatches occasionally sing their courtship song in the air while flying from one tree to another, and that a male may sing in late afternoons especially in April.

Aviary nuthatches.—My hand-raised nuthatches were limited in some respects, for the male could not sing his early morning song from a tree top, nor was he ever alone and at a distance from his mate. He did, however, face a rival male in a similar aviary 2 m away. Both males would start singing the "what, what" song, often while clinging to the top wire of the cage after I had turned on the aviary lights at 5:30. When the mated male's female emerged from her roost box, he would immediately take a back-to-her pose and start his pleasanter sounding "wurp" song. These aviary "wurp" songs never sounded quite the same as those in the wild, and whether this was due to the acoustics of the enclosing greenhouse or to other causes I was never sure.

COURTSHIP FEEDING

MB had been singing his early morning song for a month when, on 23 February 1967, he fed his mate three times in 10 minutes on bits of stored food. Such feeding can take place rapidly without perceptible display. On 2 March, however, his mate FB crouched low and motionless on a limb, bill pointed upward, as MB ran straight along the limb at her with food. She remained motionless, refusing to take the food until

he held his head high and pointed his bill in line with hers, whereat she seized the food in a flash. I followed these details, for I had witnessed them many times in the aviary (Figure 3). The bill of the White-breasted Nuthatch is long and slender and food is held better if not taken from the side. Hence the need, it would seem, of a direct approach. This behavior by the female was as if she were training her mate for his job of feeding young nestlings later on.

The straight run of MB along the limb on 2 March was also of interest. Nuthatches normally progress obliquely, pointing to one side, then swinging to the other as they hitch along. The straight run, on the other hand, is the way parent nuthatches sometimes approach a nest hole, possibly because it is faster, more mouselike, and hence attracts less attention than the usual side to side method. Why did MB adopt the mouse run on 2 March? The tree involved was an aged, gnarled oak with a hole such as nuthatches use for nesting. FB had entered the cavity several times, trying it out, and even driving MB away as she would do later on in actual nesting. It seems therefore that the tree stimulated MB to adopt the mouse run, an approach he had not used in other trees and would not use consistently until actual nesting was in progress.

I saw other details of courtship feeding to close advantage in the aviary. My hand-raised male, for example, tried to feed his mate bits of peanut early in the winter, but she took no interest in his feeding efforts until I supplied mealworms (*Tenebrio*). The female could seize these herself, swallowing them swiftly and more or less whole. After a few worms, however, she crouched motionless as if waiting to be fed, and persistently refused any worm offered to her intact. After being rebuffed in this manner several times, the male wedged the worm into a crevice, worked it over carefully until it was limp and well-punctured by his bill, and then brought it to her. When his bill was held in just the right position (Figure 3), she seized the worm in a flash as I had observed in the field. One can only speculate why the female was particular about how the worm was presented. By one interpretation she was teaching her mate, or more exactly awakening his latent parental instincts, by playing the role of a nestling so young that it could manage only prey well-prepared ahead of time and placed directly into its throat.

Another phenomenon noted in the aviary as well as in the wild was that female nuthatches have two distinct types of behavior in courtship feeding, one being the crouching-motionless pose just discussed (Figure 3). In the other, seen as the season advances, she crouches with wings shivering loosely, bill held wide open at an angle of 45°, and gives the "chrr" or "k-duck, k-duck" notes of an older nestling. Here a curious

feature noted repeatedly and at close range in the aviary was that the female made sideways motions with her mandible reminiscent of a "smacking of the lips" while waiting for her mate to feed her. She made these motions both before and after being fed by the male, but never when she fed alone. It is conceivable that female nuthatches salivate in this later-developing type of courtship feeding. The possibility of active salivation in White-breasted Nuthatches and its relation to bill-sweeping are discussed in a previous report (Kilham, 1968).

Observations on *S. carolinensis* in late April and early May suggest that the food passed by the male may be important to the breeding economy of the female nuthatch. Thus on 1 May 1969 for example, I followed the members of Pair C as they moved in a circuit through woods 250 m from their nest between 17:30 and 17:45 at a time when FC was laying or starting to incubate eggs. As with other females at this stage, she moved slowly over stubs and branches, appearing lethargic and taking little interest in feeding herself. Her mate MC meanwhile was highly active in search of prey. He appeared driven by the kind of energy parent birds have when feeding young, and as fast as he could find an insect he flew to feed it to her. She did no begging and assumed no special postures in taking the food. I had previously noted much the same behavior in the aviary. I offered a tray of six mealworms to my hand-raised female, then laying eggs, she took one worm; then, resting without further efforts to feed herself, she took four more fed to her by her mate. He meanwhile consumed one.

The amount of food fed by the male in this type of courtship feeding could be important when one considers that a female may lay as many as eight eggs and then do all the incubating. These successive activities could be a drain on her physical reserves, and here expenditure of energy by the male would save hers for other purposes. So a possible further advantage she may attain a greater depth of broodiness when not driven to seek her own food. This would explain her seeming lethargy when she leaves the nest hole to move about in company with her mate.

Courtship feeding, in summary, appears to serve a complex of functions. The whole process may consist, especially early in the season, of what Lorenz (1965) has termed intercalated elements of innate response and learning and, seen from this point of view, the behavior of the female may be the "school marm" who teaches the male to prepare food in just the right way, as well as giving the two birds experience in cooperating effectively against the time of nesting later on. At time of egg-laying the actual amount of food passed may serve the economy of the female in a variety of ways. This latter idea has also been ex-

pressed by Krebs (1970) for courtship feeding in the Blue Tit (*Parus caeruleus*).

"Phee-oo" and Pursuit Flights

I heard the first "phee-oo" notes of the year from MB on 2 February 1969 at 07:20, 25 minutes after he had left his roost hole and joined his mate. The notes were twice followed by swift pursuit flights, which often happen with such speed that one fails to perceive details. On 2 March, however, MB was resting well up in a tree when he suddenly bristled into an agonistic pose with tail cocked up, wings drooping, and back feathers ruffed. He then flew almost straight down at his mate in what became a fast, wild chase in, up, and around trees, and ending in possibly 20 seconds about where it had begun. MB made "phee-oos" continuously while twisting and turning within a meter or less of FB. The two birds then settled down to usual foraging behavior, FB making "tchup" notes, MB answering with low "phee-oos." Ten minutes later MB precipitated another pursuit flight by floating down to his mate with outstretched wings.

This "phee-oo" note is expressive of especially ardent states of sexual excitement in either sex. A male reaching such a state in early morning hours in midwinter doubtless finds outlet for his emotional energy in the flight chase, which may serve to arouse his mate as well. I never observed copulatory behavior following these chases, but it is possible that it might occur later on in the season, if one can judge from the similar chases of *S. canadensis*.

Males give "phee-oo" notes again toward the end of nesting in what may be a mild revival of courtship. On 15 June 1968 for example, I found MP resting with head down on a tree trunk 5 m from his nest. Here he gave a few "phee-oos," then a low "wurp" song. The young left the nest on the following day.

Löhrl (1958) describes a note for *S. europaea* that appears comparable to the "phee-oo" of *S. carolinensis* in being an expression of intense sexual drive. The "phee-oo" note as used by female White-breasted Nuthatches in copulatory displays is described below.

Copulatory Behavior

My hand-raised nuthatches came into breeding condition earlier than wild pairs, possibly because of my turning on aviary lights at 5:30 in winter. The minutes following were especially favorable for courtship, and I witnessed copulations and displays accompanying them between 23 March and 30 April 1967 as well as between 12 March and 2 May 1968, the birds having attempted to establish a nest in each period.

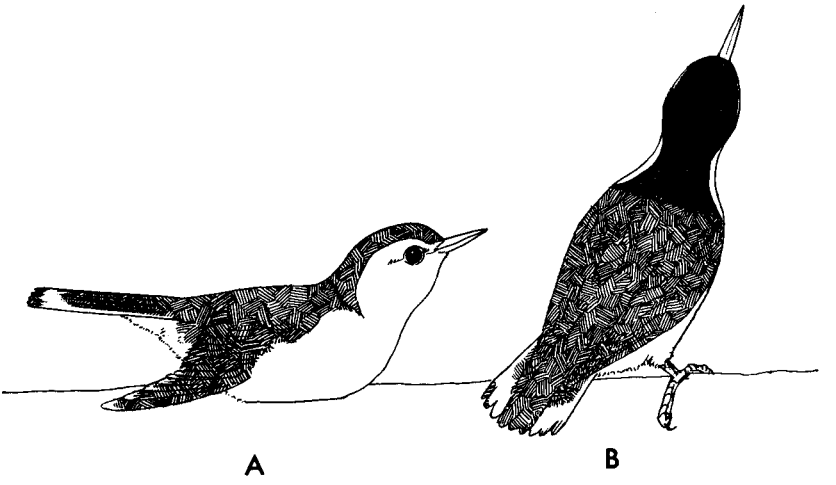

Figure 4. Female White-breasted Nuthatch (A) giving "phee-oo" invites coition in squatting pose. Male (B) presents back of head as he moves over and around her in a precopulatory dance.

In a usual performance the female emerged from her roost box, which became the subsequent nest box, making plaintive "phee-oo" notes. Then reaching a log, she squatted low with tail straight or slightly elevated, wings drooping and quivering, and head held upward (Figure 4a). A fluffing out of flank feathers as seen from in front made her appear larger than usual. The behavior of the male now became most bizarre. He danced with tail cocked up, head stretched upward to the limit, and neck twisted in an awkward pose at an angle of 45° as if trying to present a view of his black head and neck to his mate the whole time (Figure 4b). Moving about on her right side, he then passed under her bill and even hopped on and off her back to reach her left side in the same continuing dance, which ended in perhaps 10 seconds when he mounted, fluttered to hold his position as he bent his tail under hers, fell off to the left as he did so, and then moved away. She remained in the same position, continuing to give "phee-oo" notes and swaying her bill from side to side for some moments after he left.

The copulation pose of the female (Figure 4a) is similar to one of her begging poses. Pendulum movements of head and bill, and particularly the "phee-oo" notes, appear to alert her mate that her readiness is for copulation rather than for courtship feeding. I witnessed this same behavior in the wild on 10 May 1965. A male had been catching insects and feeding them to his relatively inactive mate at noontime when she crouched in her precopulatory display. He then danced about

her in the manner described for the aviary male. In a similar incident on 9 May 1970, I noted that the tail of the male was well-fanned showing the white patches when in coition.

Löhrl's (1968) description of the copulatory behavior of the European Nuthatch is much the same as what I have described for *S. carolinensis*. He states, however, that the tail of the female remains closed, showing no white, whereas in my aviary female the tail was slightly fanned.

The precopulatory display of White-breasted Nuthatches, and probably other species of *Sitta* as well, is a unique performance, as copulation in many avian species is attended with little display. A feature of the display of the male White-breasted Nuthatch is the close resemblance of the bizarre dance, with head held high to present the back of it to the crouching female, to the direct-to-mate courtship singing in mid-winter when the male sings with head high in a similar pose to the female who, while not crouching, remains motionless as if the display had a marked effect upon her. The display may actually have a double function, one being signal in nature, arousing the female to a pitch of readiness for copulation, and the other doing the same for the male himself in a kind of autostimulation.

Courtship-related Activities

The various activities described below are not peculiar to nuthatches but are, for example, observable among Hairy Woodpeckers (*Dendrocopos villosus*) as well, the first two conveying a calm mood of harmony between the members of a pair in the breeding season.

Resting motionless.—A pair of nuthatches moving through woods together may come to rest as if on signal and remain silent and motionless for 5 or 10 minutes. This absence of activity can be a striking phenomenon when it comes between periods of active courtship.

Leisurely preening.—A female listening to the "wurp" song of her mate late in breeding season may preen in a leisurely and thorough manner. Her mood appears to be one of contentedness. Such preening by either sex may be accompanied by scratching and stretching. Although birds need periods of body maintenance at all times of year, these periods become exaggerated in both woodpeckers and nuthatches in April as the period of actual nesting approaches.

Floating flight.—Nuthatches of either sex may suddenly launch into a floating flight with wings fully outstretched and held in a V. The occasion appears to be sheer exuberance in association with a variety of other activities. I have seen a male float down to his mate giving "phee-oos" prior to a pursuit flight, another male float the last 16 m to his nest hole when feeding his mate in the incubation period, and a

female come to the nest hole in long floating flights when carrying in nest material.

COMPARISONS WITH OTHER SPECIES

The main breeding song of the White-breasted Nuthatch differs in a number of ways from those of more classically described species, such as the British Robin (Lack, 1943), in being sung in most sustained fashion in midwinter when males have already formed pairs and established territories, and again in the male nuthatch addressing his song to his mate rather than to rival males. This latter situation is seen clearly on winter mornings when a male first sings with the intensity of a lone male. When his mate arrives the tone of his song changes and he displays with back to her, singing while she perches almost motionless as if hypnotized by his display. This potential of female White-breasted Nuthatches for hypnoticlike states is discussed elsewhere (Kilham, 1968). A feature of this midwinter singing is that the male sings from high up in trees where the gleaming white of his breast may show to special advantage in the first rays of the morning sun. It is of interest that the male European Nuthatch, which has a dull breast and lacks the sharply contrasting sexual dimorphism in plumage of the male White-breasted Nuthatch, is not described (Löhrl, 1958) as singing either from a special perch or to his mate while displaying his plumage at the same time.

From Löhrl's (idem) description it seems that, while the European Nuthatch bears a number of similarities to *S. carolinensis* in (1) the types of patterns of its various vocalizations and (2) in singing its main song in midwinter after establishment of territory and pair formation, a fact that Löhrl regards as astonishing. *S. europaea* differs in being a far more aggressive species that devotes far less of its time and energies to courtship than does its American counterpart. For this several reasons are conceivable. One is that *S. europaea* can be readily induced to nest in bird boxes, hence may attain far greater population densities than are observable for *S. carolinensis*. Accompanying this are small territories of 2.5 ha or less, which apparently lead to far more contact with neighboring and rival males. Regardless of what factors may be actually involved, Löhrl (pers. comm.) has found *S. europaea* an innately aggressive species in comparative observations made with various species of *Sitta* in captivity.

White-breasted Nuthatches in New Hampshire are, in contrast, thinly distributed in territories of approximately 15 ha, an estimate of size agreeing closely with one Brackbill (1969) made in Maryland. Encounters with rival males are infrequent and, in the case of established pairs,

relatively mild affairs as will be described in a later report. One gets the impression that males, freed of marked demands to defend territories, devote their energies to courtship activities.

The intimate "hit-tuck" notes of *S. carolinensis*, exchanged thousands of times daily in winter months, fit descriptions Armstrong (1963) gives for duetting as serving the functions of "contact, rapport, and maintenance of the social bond." He further notes of tropical species that, "Duetting does not seem to be recorded of any species with a brief pair-bond—another indication of its significance in pair-maintenance." Here White-breasted Nuthatches are unusual among birds in north temperate regions in maintaining pairbonds the year around.

The Hairy Woodpecker (*Dendrocopos villosus*) is another temperate zone species maintaining year-round pair bonds, having intimate notes, and carrying on active courtship, even to the extent of precopulatory behavior in midwinter (Kilham, 1966). Such courtship, as with that of White-breasted Nuthatches, takes time, sometimes several hours a day in severely cold weather. If both species, woodpecker and nuthatch, had a narrow survival margin of winter food supply, they would probably be without the margin of leisure needed for active winter courtship, as discussed elsewhere in relation to the Downy Woodpecker (Kilham, 1970).

There are some marked differences as well as points of comparison between Hairy Woodpeckers and the sympatric White-breasted Nuthatches. Unlike nuthatches and passerine birds in general, it is the male woodpecker that spends the night on the nest, and with *D. villosus* the female may take the lead in courtship in the early breeding season (Kilham, 1966). With some pairs she may even do the most drumming, an activity comparable to the song of nuthatches and done in *S. carolinensis* exclusively by the male. A further point of difference is that with the Hairy as with possibly all other species of woodpeckers there is no courtship feeding, a form of courtship that establishes male dominance away from the nest in such birds as the White-breasted Nuthatches. The evolution of courtship patterns among birds, and why some species should have close and enduring pair bonds and others not, is probably related to their total ways of life, including such aspects as how much leisure their food economy provides and how much time is taken up in agonistic and other types of behavior (Kilham, 1968, 1969). From these points of view, the sympatric Hairy Woodpecker and White-breasted Nuthatch offer much as a continuing study in evolution and comparative ethology.

The overall goal of current investigations is to compare the White- and Red-breasted Nuthatches with special attention to their agonistic,

courtship, and nesting behavior by means of fieldwork, supplemented by aviary studies. So far my hand-raised birds have either bred successfully (*S. canadensis*) or have exhibited a large range of their natural behavior in attempting to do so (*S. carolinensis*). A fascinating feature of both species is not only that they communicate with each other with such a variety of visual and auditory displays, but also with an emotional intensity and persistence that to say the least is impressive.

SUMMARY

The courtship behavior of White-breasted Nuthatches has been followed by year-round field and aviary studies, the latter on hand-raised individuals that exhibited a spectrum of activities culminating in egg-laying in 2 successive years.

Main forms of courtship observed were the following:

A courtship or main breeding song that reaches peak performance in the first half hour of winter mornings. After attracting his mate to him, a male may continue singing, displaying the plumage of back of head and body to her while she remains attentive for minutes at a time. Less intense variants of this "wurp-wurp-wurp" song take place at other times of day and phases of the breeding cycle.

Intimate "hit-tuck" notes may be exchanged between members of a pair thousands of times daily in winter and early spring.

A "phee-oo" note conveying a high pitch of sexual emotion given, for example, (1) by a male when he attacks his mate and thus precipitates a fast pursuit flight of short duration, and (2) by the female when inviting coition.

Courtship feeding, beginning in winter, can be of three types: (1) the female assuming a motionless pose with bill raised in a fixed position that forces the male to approach in a precise way with food well prepared. This is the blind nestling type. (2) Another imitative performance is where the female gives the begging notes of older nestlings while holding bill open and quivering her wings; and finally (3) at time of egg-laying, the female may simply take repeated feedings from her mate without displays, possibly because these feedings serve primarily to build up her energy reserves.

Copulatory behavior is initiated by the female squatting low on a perch, slow pendulum motions of her bill and "phee-oo" notes conveying that she is not begging for food. The male, in coming to her, dances in a bizarre manner, keeping head high with the back of it turned toward her.

Forms of behavior indicative of emotional harmony between members of a pair near the time of egg-laying are when both rest motion-

less for minutes at a time, or one or both birds preen in prolonged leisurely fashion. Floating flights are observable in a variety of contexts.

White-breasted Nuthatches in New Hampshire are thinly distributed, occupy large territories the year around, spend relatively little time contending with neighboring pairs once established and, with an economy built around a widespread storage of food, appear to have ample time for courtship throughout the winter.

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