BROAD-WINGED HAWK NESTING AND ECOLOGY

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THE Broad-winged Hawk (*Buteo platypterus*) breeds primarily in the mixed deciduous forests of eastern North America and migrates each winter to Central and South America (Bent 1937). Migration data indicate that, unlike many other raptors, the Broad-winged Hawk population of northeastern North America has remained relatively stable for the past 35 years (Spofford 1969).

The nesting of this raptor has never been studied in detail, although Burns (1911) compiled a general description of its taxonomy, distribution, food habits, external morphology, and development. Rusch and Doerr (1972) investigated its nesting and food habits near the northwestern limit of its range in Alberta, Canada. The present study was conducted in the central Adirondack Mountains of New York where I found it the most common breeding diurnal raptor. The objectives of this study were to describe qualitatively and quantitatively the species' nesting behavior and selected aspects of its ecology.

METHODS

The main study area was the Archer and Anna Huntington Wildlife Forest Station, a 15,000-acre property located 8 km northwest of Newcomb, New York, circa 44° N and 74° 10′ W at an elevation of from 475–820 m. It is continuously forested with 60% hardwoods composed of an overstory dominated by sugar maple (*Acer saccharum*), beech (*Fagus grandifolia*), and yellow birch (*Betula alleghaniensis*), and 20% coniferous and mixed growth dominated by varying amounts of red spruce (*Picea rubens*), eastern hemlock (*Tsuga canadensis*), and yellow birch. The remaining 20% is divided about equally between open water, marshes, swamps, and other forest types. Logging for softwoods was conducted intermittently from 1850 through 1928 and since 1943 both hardwoods and softwoods have been cut.

The study was conducted from January 1971 to September 1972, including the 1971 and 1972 breeding seasons. Nests were searched for during the late winter and early spring, and places where Broad-wings were seen frequently were searched during the summer. Of the 61 raptor nests located on the study area and 8 outside it, Broad-wings used 4 in 1971 and 6 in 1972.

I used live traps to capture 52 free-ranging birds. The automatic bow-net traps (Tordoff 1954) caught 40 birds and Bal-chatri traps (Berger and Mueller 1959) took 8 individuals. I baited both these traps with live black and white mice (*Mus musculus*). Bow-net traps were set in areas of high activity during the arrival period and near active nests after hatching. Bal-chatri traps were dropped from vehicles when birds were seen perching near roads. I used a dho-gazza trap (Hamerstrom 1963) baited with a live Great Horned Owl (*Bubo virginianus*) near active nests, primarily to capture previously trapped birds, or those I was unable to catch with the bow-net trap.

All birds handled were weighed, measured, and banded. Weights were taken with

a pull-type spring scale. (An estimate of food present in the crop was subtracted from the total weight.) Wing chord and tail measurements were made with a metal ruler (see Mueller and Berger 1968). I also took molt and brood patch data.

The larger bird of a mated pair and/or the one having a brood patch was considered the female. Both members of the pair were captured at five nest sites, one member at two nest sites, and neither member at three nest sites.

I placed Standard U.S. Fish. Wildl. Serv. numbered metal bands and colored (orange, white, blue, green, and yellow) vinyl-coated nylon bands on the legs of all birds handled. One or two of these colors placed on each leg let me identify individual birds at a distance. I placed falconer's bells on one adult and two fledglings in 1971 to help follow their movements.

Prior to hatching, the nest was watched from ground blinds placed 20–30 m from the tree. Tree blinds were used only after the eggs had hatched. Tree blinds were not built during the incubation period for fear of causing abandonment or keeping an incubating bird off the eggs too long. In 1972 the parents deserted a nest when I built a tree blind near it during incubation.

I placed blinds at six nest sites; three nests were studied intensively (1–71, 2–71, and 6–72). A 20–45× zoom spotting scope gave me a clear view of the nest. I made use of two or three different observers on 23 days in order to obtain a complete daily record. A total of 759 hours was spent observing from blinds during the 2 years.

Vocalizations were recorded with a Nagra Tape Recorder and a Fennheiser Model 804 microphone. A Kay-Electric Sona-Graph 6061–B was used to produce sound spectrograms.

BREEDING CYCLE

Broad-winged Hawks arrive in the Adirondacks before the snow disappears and the deciduous trees leaf out. Egg-laying coincides approximately with the trees' leafing out in mid-May. The eggs at all four known nests in 1971 and the five nests in 1972 hatched during a 1–2 week interval (23–28 June 1971 and 10–22 June 1972), indicating a close synchrony within this population. Burns (1911: 252) notes that "the normal egg producing period in a given locality is confined within about two weeks time."

The mean hatching date in 1971 was 23 June and in 1972 was 13 June. The time of the birds' arrival on the breeding grounds might account for the difference. In 1971 the first birds were seen 10 days later than in 1972. The pair known to have nested on the area in both years was 7–10 days ahead of their 1971 chronology in 1972. It is further known that Broad-wings farther south lay earlier than those in the north (Burns 1911: 252; Rusch and Doerr 1972).

For a long range migrant with a relatively long breeding cycle, it is imperative that nesting activities start as soon as the birds reach the breeding grounds. Any delay only reduces the time available for the young to develop their hunting and flying skills before the autumnal migration and thus lessens their chances of survival.

Spring Arrival and Return of Banded Birds

Broad-wings are the last of the three common hawks of the region to start nesting. Red-tailed Hawks (*Buteo jamaicensis*) are seen 4–6 weeks before the first Broad-wings arrive, and Goshawks (*Accipiter gentilis*) have already laid by mid-April. I saw the first Broad-wings on the study area on 29 April 1971 and 19 April 1972.

Trapping was extremely successful during the arrival period, probably because of the scarcity of suitable prey (amphibians, reptiles, and nestling birds) at that time. Luttich et al. (1971) noted that Red-tailed Hawks were captured more effectively shortly after their spring arrival, and also attributed this to the apparent scarcity of prey.

All birds trapped (15 in 1971 and 12 in 1972) and seen during the spring arrival period were adults. I noted the first subadults on 3 June 1971 and 17 May 1972. Wood (*in* Burns 1911: 225) and Haugh (1970: 44) pointed out that the early (mid-April to early May) migrant Broad-winged Hawks are mainly adults while later (mid-May to June) migrants are largely second-year birds. Mueller and Berger (1965) record a late movement of 95% subadults on 26 June and hypothesize that "many subadults, non-breeding Broad-winged Hawks migrate considerably later than the adults or possibly these individuals spend the summer doing a certain amount of wandering."

Experienced breeders probably do not wander, but return directly to their breeding grounds. Of the 18 Broad-wings banded on the study area in 1971, I recaptured four there in 1972. The first bird seen and the first captured in 1972 were within 100 m of their 1971 capture site. I caught the other two birds in July at nest sites within 400 m of their 1971 capture site.

I banded both members of two pairs in 1971, one pair of which I recaptured in 1972 (nest 1–71). These birds remained paired in 1972 and nested about 400 m southeast of their 1971 nest site (nest 1–72). Burns (1911: 242) contended that Broad-wings "frequently if not always mate for life," but cited no direct evidence.

None of the eight juveniles banded in 1971 was captured or seen in 1972.

Nests and Nesting Sites

I found 14 Broad-wing nests on or near the study area. Yellow birches supported 12 of these nests, one was in a sugar maple, the other in a black cherry (*Prunus serotina*). The mean height of the nests was 13.3 m (range 11.0–15.5 m; SD = ± 1.36 m) and the mean diameter at breast height (DBH) of the nest trees was 54.1 cm (range 42.1–74.2

cm; SD = ± 8.28 cm). The first main crotch supported 12 of the 14 nests; the other two were in other crotches.

Burns (1911: 245) records an average height of 10.1 m for 167 nests in the Canadian and Transition zones. Nests on the study area averaged a greater height primarily because yellow birches under these forest conditions normally form their first main crotch at a height of 12.2–14.0 m (Fowells 1965: 107).

Burns (1911: 243) stated that the most abundant or characteristic tree species of a locality is apt to be the one most frequently chosen for nesting, but yellow birch was not the most abundant species on the study area, where they constituted only 20% of the trees 42 cm DBH and larger (the size most often used for nesting here). The sugar maple comprises 41.7%, beech 10.7%, other hardwoods 4.2%, and softwoods 23.4%.

The clear preference for yellow birch on the study area and in other parts of New England (Burns 1911: 243) can probably be related to their life form and/or the site on which they are most abundant. Orians and Kuhlman (1956) found that elms (*Ulmus americana*), although outnumbered by both sugar maples and white oaks (*Quercus alba*), were the preferred nest trees of Red-tailed Hawks in Wisconsin. They thought that this preference might be the result of the elms growing along streams and fence rows, and because their large spreading branches provide many suitable nest sites. The main branching of the yellow birch has somewhat the same vase-shaped appearance as the elm, and the main crotches provide an excellent supportive structure in which a stick nest can be built. Neither sugar maple nor beech provide such suitable crotches so consistently as yellow birch.

Yellow birch trees tend to be more concentrated in moist, poorly drained sites. Frequently they are found close to small streams, lakes, or swampy areas and it is this type of site that Broad-wings seem to prefer throughout their range (Burns 1911: 238–242). On the study area most nests were located on these poorly drained sites, which most closely resemble the hemlock-yellow birch type (Type 24, Soc. Amer. Foresters 1964), a type accounting for less than 10% of the study area. On the drier, better drained upland sites, the sugar maple-beech-yellow birch type (Type 25, Soc. Amer. Foresters 1964) predominates (60% of the forest), but Broad-wings usually do not nest on these sites.

NEST CONSTRUCTION AND MAINTENANCE

In 1971 I noticed the first signs of nest building on 13 May at nest 2–71 and on 17 May at nest 1–71. Adult birds were present in the immediate vicinity of each nest, and the nest rims showed fresh sprigs of

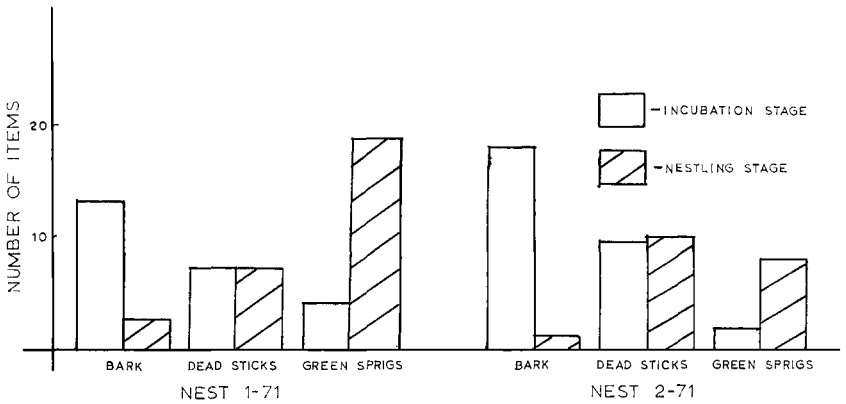

Figure 1. Comparison of nesting materials delivered by female Broad-winged Hawks at two nests on the Huntington Forest during the incubation and nestling stages. (215 hours of observation at nest 1–71 and 173 hours at nest 2–71.)

balsam fir (*Abies balsamea*) and/or hemlock. Construction probably began before 17 May at nest 1–71, as the male was trapped within 100 m of the nest on 6 May and the female just below the nest on 13 May.

Two of the 10 active nests were known to have been renovated rather than newly built. The eight other nests were not found until after birds were occupying them, and all were well along in construction when discovered. Detailed observations began after laying and consequently include nest maintenance activities rather than original construction or renovation.

Both parents collected nesting material during the incubation and nestling stages, but the females brought most of it. Particularly interesting was the female's apparently unique role in bringing bark (sugar maple, beech, and yellow birch) to the nest, which is probably related to her being primarily responsible for incubation (see following section). This conclusion is supported by my observation that during incubation the females brought all the bark chips and placed them directly into the nest cup (Figure 1).

Birds usually carried sprigs and bark in the beak, whereas dead sticks they brought in the talons. They usually tried, either immediately upon arrival or later, to incorporate this material into the nest structure. Sugar maple was the commonest sprig brought in 1971, but they also used yellow birch, hemlock, balsam fir, and northern white cedar (*Thuja occidentalis*). In 1972 I counted the sprigs from two nests on 9 July (4 weeks post-hatch). Nest 5–72 contained 61 hemlock and 4 balsam fir sprigs, whereas nest 1–72 had 27 sugar maple, 16 hemlock, 9 quaking

TABLE 1
COMPARISON OF ATTENTIVENESS AND INATTENTIVENESS DURING INCUBATION FOR TWO PAIRS OF BROAD-WINGED HAWKS ON THE HUNTINGTON FOREST

Nest	Observation time (minutes)[1]	% Attentiveness		% Inattentiveness
		Female	Male	
1–71	3703	89.4%	5.3%	5.3%
2–71	4545	94.1%	4.3%	1.6%
Mean		91.9%	4.8%	3.3%

[1] Observation periods ranged from 120–814 minutes per day on 12 different days at each nest.

aspen (*Populus tremuloides*), 1 black cherry, and 1 ash sprig (*Fraxinus* sp.). These data contradict Burns (1911: 248) who states that "seldom is more than one kind of leaf used in the individual nest."

The parents brought sprigs more frequently after than before hatching (Figure 1), possibly because of the greater availability of deciduous sprigs later in the growing season. The freshness of the sprigs indicated that the birds probably broke them from living stems. Although I never saw the birds do so, Burns (1911: 248) states that Broad-winged Hawks break sprigs from the tops of trees and Schnell (1958) describes how a female Goshawk tore living sprigs from lodgepole pines.

The selection of sprigs may not only be associated with individual preference, but also with availability and the ease with which sprigs can be broken from the tree. The difficulty experienced in breaking twigs from red spruce and beech might account for their absence in the nests, although both species are common on the study tract.

A great many species of raptors deposit living sprigs in their nests, but no satisfactory explanation has been given although several have been proposed (Olendorff 1971: 70–73).

INCUBATION STAGE

Roles of the sexes.—There was a clear division of labor during the incubation stage: females incubated and males hunted. Males covered the eggs only when females left the nest to consume food the males brought (Table 1).

Females were at the nest for periods ranging from a few seconds to over 8 hours (Table 2). They remained continuously alert during these periods and occasionally stood on the nest rim to preen or stretch (see Schnell 1958). Before resettling on the eggs, they occasionally placed their beaks down into the nest cup and apparently turned the eggs. Longer attentive periods were often associated with inclement weather conditions, i.e. rain and cool temperatures. Females probably did most, if not all, of the nocturnal incubating. On several occasions they were

seen incubating at dusk and were again present at dawn the following day.

Males usually visited nests only after transferring food to the females and these visits were infrequent and short (Table 2). Females usually intercepted the males before they reached the nest. Moments after the females' departure, a whining (transfer) call was heard (see vocalizations below). Males often arrived at the nest moments after the transfer and assumed an incubating pose. The food transfer took place at the nest on only two occasions, when the female whined, took the prey item in her beak and flew from the nest with it. Males generally remained at the nests until relieved, but occasionally left and returned within a few minutes with a stick or sprig. Females usually returned to the nest within 15 minutes, and the males departed either before or just after the females arrived. The females' calling frequently preceded the males' departure (see vocalizations below).

Female inattentive periods were frequently associated with one or all of the following activities: feeding (transfer call heard), collecting nesting material, and/or defecating. The adults never defecated from the nest and consequently must have done so away from the nest.

Incubation period.—I did not climb nest trees in 1971, and therefore the females' attentiveness and behavior alone indicated the presence of eggs. During the first period of observation at nest 1–71 in 1971 (25 May), the female was present at the nest 501 minutes, the male 94 minutes, and both were absent for 93 minutes. The female nestled down in the nest as if incubating and appeared to be turning the eggs on several occasions. At nest 2–71, 400 minutes of observation on 27 May similarly indicated the presence of eggs. I saw the females at each nest feeding a nestling on 23 June. Prior to this date there was no indication that the eggs had hatched. I climbed to nest 4–72 on 21 May 1972 and 2 eggs were present. The eggs were pipped on 20 and 22 June, but failed to hatch. My continued presence may have made the parents desert the nest.

The above data suggest an incubation period of no less than 28 days, indicating that the Broad-winged Hawk probably has an incubation period within the 30–38 day interval typical of most congenerics (Olendorff 1971: 86). This is in contrast to Burns' (1911: 267) frequently quoted incubation period of 21–25 days.

Molt and brood patch formation.—None of the 18 birds trapped before 21 May in 1971 and none of the 12 birds trapped before 4 May in 1972 showed a brood patch or had begun molting remiges or rectrices. An adult in flight on 27 May 1971 was missing a primary in each wing and at least one rectrix. On 1 June 1971 the male at nest 1–71 was missing

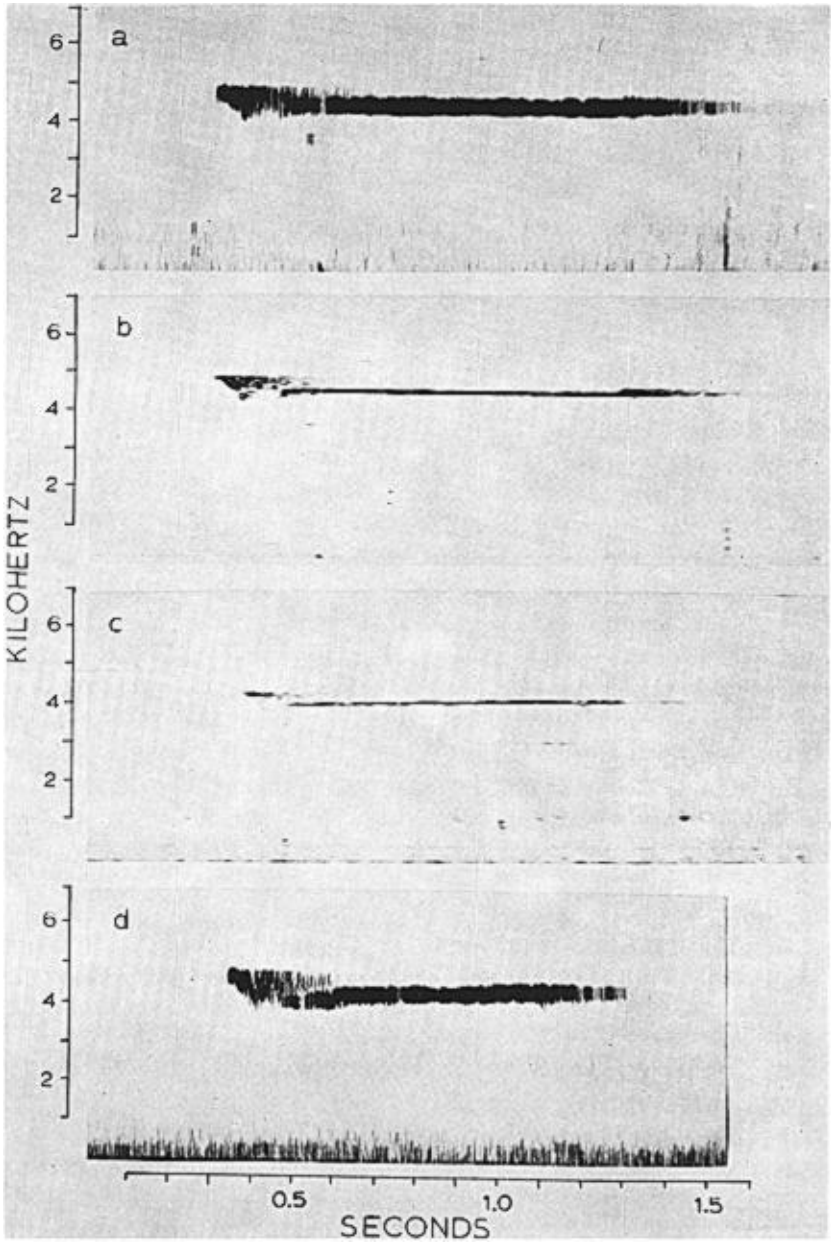

Figure 2. Spectrograms of Broad-winged Hawk vocalizations on or near the Huntington Forest: a and b, call given by adult when I approached nest tree; c, dismissal call (female); d, call given by 44-day-old fledgling. The analyzing filter bandwidth is 300 Hz for a and d and 45 Hz for b and c.

a primary and the following day the central rectrices were absent. This bird had a complete complement of flight feathers when captured on 6 May. I noticed the male at nest 2–71 missing his central rectrices for the first time on 14 June 1971. All adults trapped after mid-June in both years had begun molting remiges and rectrices.

Burns (1911: 266) notes that the presence of down feathers adhering to the nest invariably indicates that incubation is progressing. I first noticed down feathers at nest 1–71 on 1 June, at 2–71 on 31 May, and at 4–72 on 21 May. The development of the female's brood patch accounts partially, if not completely, for the down in these nests. Nesting females trapped after the first of June (24 June, 22 and 23 July 1971, 20 and 25 July 1972) had extensive brood patches covering the ventral abdominal and thoracic regions. Nesting males trapped during this same interval (13, 20, 27, and 31 July 1972) had no brood patch.

Vocalizations.—The Broad-winged Hawk's characteristic call is a shrill whistle described variously as "kill-e-e-e," "sigee," "tig-e-e-e," and "peeo-we-e-e-e" (Burns 1911: 206–209; Bent 1937: 248). This call was given when I approached the nest tree and frequently after a trapped bird was released (Figure 2a, 2b). The fledglings were able to produce this whistle when 30–36 days old (Figure 2d). I also heard previously undocumented calls and named them transfer call and dismissal call, according to probable function. Schnell (1958) noted what he termed a transfer scream and dismissal scream in the Goshawk. These vocalizations, although audibly different from those of the Broad-wing, probably function in a similar fashion.

The transfer call is a series of whining sounds heard when the male gives food to the female (Figure 3a, 3b, 3c). This call was given at the nest twice when the transfer took place there. On all other occasions the female left the nest and the call was given away from the nest. Fledglings (5–8 weeks old) gave a similar whining, almost frenzied call when the parents brought food to the nest (Figure 3d).

The female voiced the dismissal call (Figure 2c) prior to and/or after the male left the nest. This call is similar to the typical whistle (Figure 2a, 2b), but somewhat more plaintive. The female persisted in whistling when the male was reluctant to leave the nest and continued to call as long as he remained at the nest or in the immediate vicinity.

Nestling Stage

Parental care.—The females at two nests brooded the nestlings almost continuously (88.8% attentive) during the first week (49 hours of observations). The following week the females' attentiveness dropped off, but rain brought them back to the nest. Males never brooded, and their

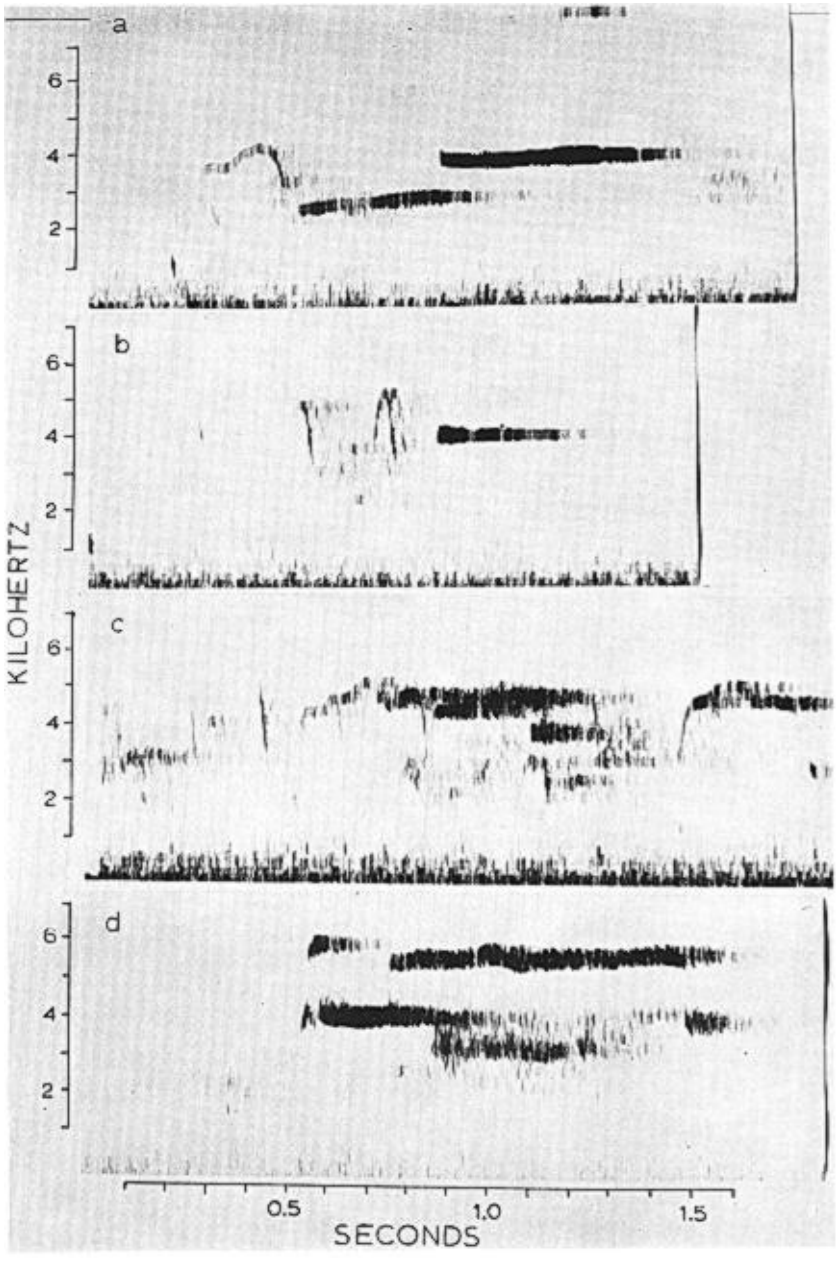

Figure 3. Spectrograms of Broad-winged Hawk vocalizations associated with the transfer of food on or near the Huntington Forest: a, b, and c, sequence of calls associated with the transfer of food from the male to the female; d, call associated with transfer of food from parent to fledgling. The analyzing filter bandwidth is 300 Hz for all spectrograms.

TABLE 2

SUMMARY OF ATTENTIVE AND INATTENTIVE PERIODS DURING THE INCUBATION AND NESTING STAGES FOR TWO PAIRS OF BROAD-WINGED HAWKS ON THE HUNTINGTON FOREST[1]

		Attentive periods				Inattentive periods	
		Number/day		Total time (min.)[2]		Number/ day	Total time (min.)[2]
Nest	Date	Female	Male[3]	Female	Male		
1–71[4]	1 June	6	1	810 (24–351)	13 (———)	5	17 (1– 9)
	2 June	6	2	793 (7–222)	25 (9–16)	7	41 (1– 15)
	1 July[5]	17	0	554 (1–134)	0 (———)	17	333 (2– 51)
	10 July	13	6	224 (1– 89)	6 (———)	18	730 (2–143)
	13 July[5]	11	4	356 (1–223)	4 (———)	13	550 (5–131)
	21 July	3	9	15 (1– 13)	9 (———)	13	792 (9–152)
	22 July	6	7	24 (1– 15)	7 (———)	14	929 (2–256)
2–71[4]	3 June	4	2	735 (63–410)	55 (21–34)	3	10 (1– 7)
	4 June	12	4	793 (1–261)	16 (1– 9)	11	27 (1– 5)
	15 June	4	3	814 (16–496)	59 (6–45)	4	4 (———)
	29 June	10	1	784 (26–161)	2 (———)	9	84 (2– 21)
	6 July[5]	6	1	775 (30–369)	1 (———)	4	100 (10– 55)
	9 July	14	5	380 (2–102)	5 (———)	17	481 (1– 95)
	15 July	18	6	75 (1– 23)	6 (———)	26	834 (1–225)

[1] Observations made during the entire daylight period.
[2] Range of individual periods in parentheses.
[3] If male arrived at nest while female was in attendance, it was *not* counted as an attentive period for him.
[4] At least one egg hatched on 23 June.
[5] Rained at least 50% of the observation time.

visits were always of short duration (Table 2). The females' presence at the nest at dawn and dusk indicated that the young were brooded through the night until 21–24 days old.

The males continued in their role of food provider throughout this stage (Table 3) and frequently gave the prey to the females away from the nest during the first week. Later the males brought food directly to the nest. When females were absent, males left the prey on the nest rim. On four occasions American toads (*Bufo americanus*) were still alive and jumped out of the nest before the female returned to feed the young. Only females tore up food and fed it to the young. If the young dropped pieces of food offered, the females picked them up and offered them again. While feeding the young, the females intermittently fed themselves. Once the young were capable of feeding themselves (24–28 days of age), the parents remained at the nest only long enough to deposit a prey item.

Females began hunting after the nestlings were 1–2 weeks old. I heard or saw them making kills on several occasions. Rain seemed to limit the number of deliveries (see Table 3).

Females at two nests fed the young for periods ranging from 2–50 minutes, averaging about 9 minutes (94 periods). Duration depended

TABLE 3

DAILY FOOD DELIVERIES TO THE NEST BY THREE PAIRS OF BROAD-WINGED HAWKS ON OR NEAR THE HUNTINGTON FOREST[1]

Nest[2]	Date	Minutes of observation	Number of items		Number of items delivered between		
			Female	Male	05:00–10:00	10:00–15:00	15:00–20:00
1–71	1 July[3]	868	2	2	1	2	1
	10 July	961	3	5	3	2	3
	13 July[3]	962	1	6	3	3	1
	21 July	817	0	10	1	5	4
	22 July	961	2	8	3	3	4
	29 July[3]	780	2	3	2	2	1
Totals			10	34	13	17	14
2–71	29 June	869	1	6	2	1	4
	6 July[3]	876	2	4	2	2	2
	9 July	860	0	8	3	1	4
	15 July	947	5	8	0	6	7
	28 July	872	4	12	3	6	7
Totals			12	38	10	16	24
6–72	27 June	845	3	6	3	3	3
	1 July	928	6	6	3	7	2
	3 July[3]	870	2	4	0	4	2
	5 July	780	3	11	5	6	3
	6 July	895	5	6	4	5	2
	11 July	810	3	5	2	6	0
Totals			22	38	17	31	12
GRAND TOTALS			44	110	40	64	50

[1] Observations made during entire daylight period.
[2] Nest 1–71 had two nestlings with a hatching date of 23–24 June; nest 2–71 had three nestlings with a hatching date of 23–24 June; nest 6–72 had three nestlings with a hatching date of 10–11 June.
[3] Rained at least 50% of the observation time.

on three factors: size and species of the prey item, number of items, and hunger of the young. Frogs, toads, small birds and small mammals were torn apart quickly and easily, while chipmunks (*Tamias striatus*), red squirrels (*Tamiasciurus hudsonicus*), and larger birds took longer to dismember. Females occasionally fed the young more than one item per period, and these periods were longer. The males left these additional items during the females' absence. When the young had empty crops, they ate excitedly and grabbed pieces as quickly as the females offered them. When crops were fully distended, the young were unresponsive to the offered food. The females continued to offer pieces for several minutes, but finally flew off with the unconsumed portion in their talons or beak.

The caching of excess food seemed likely, but no actual caching sites were ever located. The Goshawk (Schnell 1958), American Kestrel (*Falco sparverius*) (Stendell and Waian 1968), and Ferruginous Hawk (*Buteo regalis*) (Angell 1969) all cache food. On five occasions at two nests,

I noted the females returning to the nest with partially consumed prey items, similar to ones removed earlier in the day. The brevity of their absences, and the fact that I did not hear a transfer call, suggests that the females neither captured the item nor received it from the male.

Nestling development and behavior.—The nestlings were visible during the first week only when being fed. They became more active during the next week and began stretching and standing at 9–10 days of age.

Preening began soon after their juvenal plumage became noticeable at about 14 days of age (see Burns 1911: 269–273 for a complete discussion of plumage development). The female never preened the young, but apparently picked insects from them.

The nestlings depended completely upon the female for tearing up food during the first 2 weeks. By 13–14 days of age the young tried unsuccessfully to tear up food for themselves. At 18–23 days of age they grasped the prey in their talons and tore with some success, but not until 27–28 days of age could they tear up food effectively. Females continued to periodically feed the young until 29–30 days of age.

The nestlings began fighting over food during the 4th week. These squabbles were much more frequent and violent in the nests with three young than in those with only two. The most aggressive nestling, frequently the oldest, was generally able to secure a prey item from the other nestlings and fed on it until satisfied. The other nestling(s) ate the unconsumed portions after the most aggressive one finished feeding. In the nests where the young were clearly different in age, the youngest received less food during this period and was always the last to feed unless it could steal a small tidbit and swallow it whole before the other young grabbed it.

Heintzelman (1966) reports a case of possible fratricide of a 4-week-old Broad-winged Hawk and Schnell (1958) reports the death of a 42-day-old Goshawk at about the same stage of development. The chances of cannibalism seem greatest at this time. Before the young reach 3 weeks of age, the female feeds them and each has a good chance of receiving some of the food, though no apparent effort is made to divide it equally. During the 4th week the young take food away from the female before she can tear it up for them. Nestlings crouch over their food while eating it and in this way protect it from their nestmates (see Schnell 1958). During this week the youngest individual at the two nests containing three young had a hard time getting enough food.

The nestlings ventured onto the limbs supporting the nest when 29–30 days old. The older nestling at nest 1–71 was 29 days old when it first began climbing the branches of the nest tree. At 19:40 it fell from the limb on which it was exercising. I found the uninjured nestling

perched in a red spruce and after weighing, measuring, and placing bells on its legs, returned it to the same tree. I followed its activities the next day from the tree blind.

The parents visited it only once the next day, when one of them landed next to it for several seconds. Throughout the day it called frequently and became more vocal when one of the parents arrived at the nest with food. In the afternoon, while the female was feeding the younger nestling, the older young tried to get back to the nest by hopping from branch to branch, but eventually ended up on the ground. Through the remainder of the day, it worked its way back up the conifers by climbing the inner portions of the limbs and gliding over short (1–7 m) expanses from one tree to another. At 17:54 it reached the nest and 30 minutes later excitedly consumed a prey item one of the parents brought.

Nesting success.—Three of the four known nests in 1971 had two young and the other had three young. I did not climb nest trees in 1971 and thus did not know how many eggs were laid. Two nests were followed from the time the eggs were laid, while the other two were discovered only after the young were 3–4 weeks old. All nine nestlings survived to 4 weeks of age.

In 1972 I climbed to two of the six nests before the eggs hatched. All four eggs hatched at one nest, but only three young survived to 4 weeks of age. The two eggs at the other nest were pipped, but my constant activities at the nest site, climbing the tree and building a tree blind, probably made the parents desert the nest.

The other four nests all contained three nestlings, and were discovered when the young were 3–4 weeks of age. A mammal destroyed one of these nests when the nestlings were 23–26 days old—perhaps the result of my visit to the nest 3 days earlier. At that time I had spread napthalene at the base of the tree and used a ladder to climb part way up it (Hamerstrom 1970). The nestlings at the other three nests all survived to 4 weeks of age. One of these 12 birds had a deformed right wing, the primaries were missing, and the damage appeared to have occurred after hatching.

Rusch and Doerr (1972) recorded a 100% hatching rate (5 nests) and a survival of 11 of these 12 nestlings to 4 weeks of age. Nesting success in this area was also high, with all young reaching 4 weeks of age in 1971. The reduced success in 1972 can probably be attributed largely to human interference.

FLEDGLING AND POSTFLEDGLING STAGES

Fledgling behavior.—The young spent much of their time on the limbs of the nest tree and adjacent trees during the 5th week, but returned to

the nest for food. When the young reached the nest at the same time, they tussled for possession of the food, but once this was established, the other young generally left the nest.

Young birds produced the typical adult whistle for the first time when 30–36 days old (Figure 2d) and thereafter whistled frequently. Burns (1911: 276) did not hear his captive young give the "rusty hinge" whistle until 89 days old. If the juveniles imitate their parents, this might explain the delay in whistling among Burns' captives.

Fledglings became able flyers during the 6th week and on 31 July 1971 I first saw one (nest 1–71) take food from an adult away from the nest. The young whining accompanied the transfer (Figure 3d) followed by crouching over the food. As soon as the young took the food, the adult left. Occasionally feeding took place at the nest during this week, but after the 6th week, I saw no adults or juveniles at the nest.

Onset of hunting.—I trapped six fledglings below their nests when 37–46 days of age. During August other juveniles were captured in bow-net traps and several were retrapped. In addition to the trapped birds, I also saw the older fledgling of nest 1–71 capture a small prey item when 54 days old.

Angell (1969) reported a 52-day-old Ferruginous Hawk killing a snake. The Broad-wing likewise begins hunting almost immediately upon leaving the nest and before the flight feathers are completely developed. The parents assist by providing food during the learning period and by nesting in places where food is plentiful. They apparently do not serve as examples to the inexperienced young during their initial efforts, because fledglings and adults are only together for very short periods. The parents bring food to the fledglings, but after the transfer, the adults leave to hunt elsewhere.

Feather development.—Feather development was completed by mid-August in 1971 and near the first of August in 1972. On 10 August 1971 two trapped juveniles still had blood in their remiges and rectrices. On 18 August one of these birds was recaptured and its flight feathers were blood-free. In 1972 juveniles trapped after 5 August had completed their feather development. Burns (1911: 273) stated that feather development (captive birds) is complete by the 45–51st day, which is the same interval I observed.

Departure.—Belling facilitated following the movements of the two fledglings at nest 1–71. These two young were last seen receiving food from the parents on 16 August, and last recorded on the study area 23 August 1971. The female parent was last sighted 31 August 1971, about 100 m from the nest.

All three fledglings at nest 2–71 were located on 19 August 1971

when one was seen taking food from the male. Two of these fledglings were trapped near the nest on 18 and 20 August 1971 and one was recaptured on 25 August. Juveniles from the other known nest sites in 1971 were seen or captured periodically near their nests until the last week of August.

In 1972 nestlings were banded at four nest sites when 24–28 days old. I was able to locate these birds within 600 m of their respective nests until they were about 8 weeks old (2nd week of August).

The last Broad-wing was seen on the study area on 14 September in 1971 and 13 September in 1972.

ACKNOWLEDGMENTS

This study was supported by the State University of New York, College of Environmental Science and Forestry through the Archer and Anna Huntington Wildlife Station program of the Adirondack Ecological Center. I am indebted to D. F. Behrend and W. C. Tierson for their advice and critical review of the manuscript. Special thanks go to P. Carella, A. Cooperrider, J. Mosher, and J. Chapman for their many hours of nest site observation. I further wish to thank the entire staff of the Huntington Wildlife Forest Station who contributed immeasurably to this project. Among others I give thanks to are A. Eggers for recording vocalizations and to G. Waring for recording vocalizations and making the spectrograms. Above all I thank my wife, Kam, for typing, proofreading skills, and patience.

SUMMARY

The nesting behavior and ecology of the Broad-winged Hawk was studied in the central Adirondack Mountains of northern New York (44° N, 74° 10′ W) during the 1971 and 1972 breeding seasons.

Broad-wings arrived at the end of April and left by mid-September. The mean hatching date was 23 June in 1971 (four nests) and was 13 June in 1972 (five nests).

Only adults were seen and captured during the arrival period. Of the 18 adult birds captured in 1971, 4 were recaptured in 1972 within 400 m of their 1971 capture sites. Two of these marked birds were a mated pair from 1971 and remained paired in 1972, nesting 400 m from their 1971 nest site.

Broad-wings built 12 of the 14 nests in yellow birch trees. Nest tree preference is probably related to life form of the species and characteristics of the site rather than to prevalence.

Both parents collected nesting material during the incubation and nestling stages, but only the females collected the bark that formed the lining of the nest cup. Both parents collected dead sticks and green sprigs.

There was a clear division of labor during the incubation stage: the females incubated and the males hunted. The males covered the eggs

only while the females ate after a food transfer. The incubation period was probably 28 days or longer.

The adults began molting remiges and rectrices near the beginning of June. Only females displayed a brood patch, which developed after their arrival on the study area.

Only females brooded. Their attentiveness waned after the young were 1–2 weeks old and only then did the females begin hunting. Males continued to provide the majority of food throughout the nestling stage. Females tore up food and fed the young until they were 28–30 days old. An average of 9 (range 4–16) food items per day was brought to the nest when the young were 2–4 weeks old.

The young successfully tore up food for themselves when 27–28 days old. When 29–30 days old, they ventured from the nest for the first time, produced the adult whistle when 30–36 days old, and began hunting at age 37–46 days. The parents continued to provide food until the fledglings reached 50–56 days of age. Feather development was completed by 45–51 days of age. I found the young within 600 m of the nest until 7–8 weeks of age.

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