OBSERVATIONS OF NORTHERN GOSHAWK PREY DELIVERY BEHAVIOR IN SOUTHCENTRAL WYOMING

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ABSTRACT

We observed prey deliveries by northern goshawks *(Accipiter gentilis)* in southcentral Wyoming during the breeding seasons of 1996 and 1997. Female goshawks brooded and fed young, delivered prey, defended young, and maintained nest structures while males delivered prey and defended young. Females tended to be aggressive toward males after prey deliveries. Males delivered prey directly to nests during the nestling stage when females were absent. Males and females continued to deliver prey to nests during the fledgling stage, often being intercepted by the young on their way to nests. Males and females made 71 and 29 percent of deliveries to nests, respectively. Red squirrels *(Tamiasciurus hudsonicus)* were the prey item delivered most often.

Key Words: *Accipiter gentilis,* nest behavior, northern goshawk, prey delivery rates, transfers.

INTRODUCTION

The northern goshawk (*Accipiter gentilis*) is considered a sensitive species by the USDA Forest Service in the Rocky Mountain Region. Northern goshawks prefer to nest in mature forests (Reynolds et al. 1982, Speiser and Bosakowski 1987, Squires and Ruggerio 1996).

Food habits of northern goshawks have been well studied (Schnell 1958, Gryzbowski and Eaton 1976, Reynolds et al. 1982, Zachel 1985, Kennedy 1991, Boal and Mannan 1994, Bull and Hohman 1994, Doyle and Smith 1994, Reynolds et al. 1994, Watson et al. 1998). Fewer studies have documented behavior at nests. Previous studies of goshawk nest behavior have typically ended about 7 days after fledging and were conducted without the use of radio telemetry (Zirrer 1947, Schnell 1958, Allen 1978, Lee 1981, Boal 1994,

Boal et al. 1994). Although fledging occurs between 36-42 days post-hatch (Boal 1994a), fledglings remain within 300 m of the nest area for approximately 25 days, during which time they are still provisioned by adults (Kenward et al. 1993). Aspects of goshawk ecology, such as male and female provisioning rates, may change after fledging occurs.

Previous work on goshawk nesting behavior assumed the male captured and delivered prey when: 1) the male delivered prey directly to the nest; and 2) vocalizations associated with prey transfers were heard away from nests. The female was assumed to capture and deliver prey only when: 1) the male was not observed or heard during the prey delivery; and 2) the observer did not believe the delivery to be a cache retrieval. In most cases observers had no knowledge of goshawk activities or locations away from nests prior to deliveries.

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Only Lee (1981) conducted a nest behavior study in the Central Rocky Mountains. As part of a habitat study of kill areas in southcentral Wyoming (Good 1998), we monitored male and female goshawks by telemetry and direct observation to confirm prey deliveries by adults through the nestling and fledgling stages, i.e., up to 62 days post hatch, in south-central Wyoming. We describe prey delivery rates and adult and juvenile behavior at the nest and after fledging.

STUDY AREA

The study was conducted on the Medicine Bow National Forest in the Sierra Madre and Medicine Bow ranges in south-central Wyoming. The USDA Forest Service manages forested lands, whereas the surrounding rangelands are a mosaic of state and private land and land administered by USDI Bureau of Land Management (BLM). Elevation in the Sierra Madre and Medicine Bow ranges varies from about 1828 to 3749 m (Alexander et al. 1986). Temperatures from May through August vary from 15-20 °C during the day, and 0-10 °C at night. Mean annual precipitation varies from 38 cm at 1830 m to 64 cm at 3050 m elevation (Alexander et al. 1986).

Lodgepole pine (*Pinus contorta*) and aspen (*Populus tremuloides*) dominate lower elevation forests between 2590-3050 m, whereas sub-alpine fir (*Abies lasiocarpa*) and Englemann spruce (*Picea engelmanni*) are dominant from 2740 m to timberline. The prevalence of lodgepole pine and sub-alpine fir between 2740 to 3050 m depends upon aspect, soils and other factors (Alexander et al. 1986). Lodgepole pine and aspen stands are interspersed with natural meadows, clearcuts, and roads. We monitored goshawk nests in low-elevation lodgepole pine and aspen forests. Goshawk hunting areas also occurred in low-elevation lodgepole pine and aspen forests (Good 1998).

METHODS AND MATERIALS

We conducted nest observations from June to mid-August 1996 and 1997. We fitted male and female goshawks with radio transmitters and followed them using three manually operated tracking towers during this same period.

We attached transmitters with tip switches to the adult male and female goshawk at each nest using a backpack harness (weight = 25.5 g). Foraging movements of male goshawks were monitored using three manually operated null-peak antennas. Tracking towers were placed on tall knobs surrounding the nest and/or foraging areas. Eight male goshawks were monitored during the summers 1996 and 1997. At 2-week intervals during the breeding season we monitored goshawk movements and observed behavior at each nest. Male foraging movements were monitored from the time goshawk nestlings were 8-20 days to 50-62 days.

We recorded locations of male goshawks during tracking sessions at two-minute intervals until the male returned to the nest with prey. Tracking sessions lasted 24 hours, and locations were taken during daylight hours. One to three foraging bouts were recorded/session, mostly during morning and evening. Locations were determined at 10-min intervals when foraging bouts were not being recorded. Locations also were determined from females every 10 minutes. We confirmed prey deliveries to nests using an observer in a ground blind near each nest. Observers maintained radio contact with telemetry personnel to confirm the presence of adult males in nest stands.

We assessed the accuracy of kill-site locations by comparing calculated locations of test transmitters with actual locations of those transmitters differentially corrected with Global Positioning Systems (GPS). Technicians on the ground with a transmitter on a 7.9-m (26-ft) pole walked randomly configured transects that were straight-line, half-circle, or sigmoid in shape. Test locations were taken at two-

minute intervals. Test locations determined while the observer was stationary were an average of 100.2 m (SD = 76.25 m, $n = 64$) from GPS locations. We used only stationary test locations to estimate our accuracy of locating kills because goshawk kill-sites were stationary locations. Stationary telemetry locations were located an average of 155.6 m (SD = 119.6 m, $n = 171$) from GPS locations.

In Sweden male goshawks usually returned directly to the nest to deliver prey after making a kill during the breeding season (R. Kenward, personal communication.). We identified a kill-site by determining where a goshawk began a direct flight path toward his nest (see Fig. 1). Widén (1982) noted that radio signals of goshawks often were variable in strength while it was chasing prey and were faint when it was on the ground with prey. We observed similar signal patterns that helped us determine the exact point of kill, which

preceded the goshawk's return to the nest. We assumed a goshawk's last stationary location before a direct return to the nest marked the kill site.

Goshawks are considered short duration, sit-and-wait predators (Squires and Reynolds 1997). When hunting, goshawks fly to a perch for a short period of time, scanning for prey. The goshawk will then fly to another perch. Inter-perch flight times range from 24 sec (Widén 1984) to 3.5 min (Kennedy 1991). Foraging males remain perched for a median time of 3 min, an average of 8 min, 36 sec (Kennedy 1991). Thus, we believed that we could identify hunting behavior with radio telemetry by noting when a goshawk changed stationary locations every 2–10 min.

We identified male prey deliveries by monitoring their movements at two-minute intervals (Good 1998); we determined if he had exhibited hunting behavior and visited
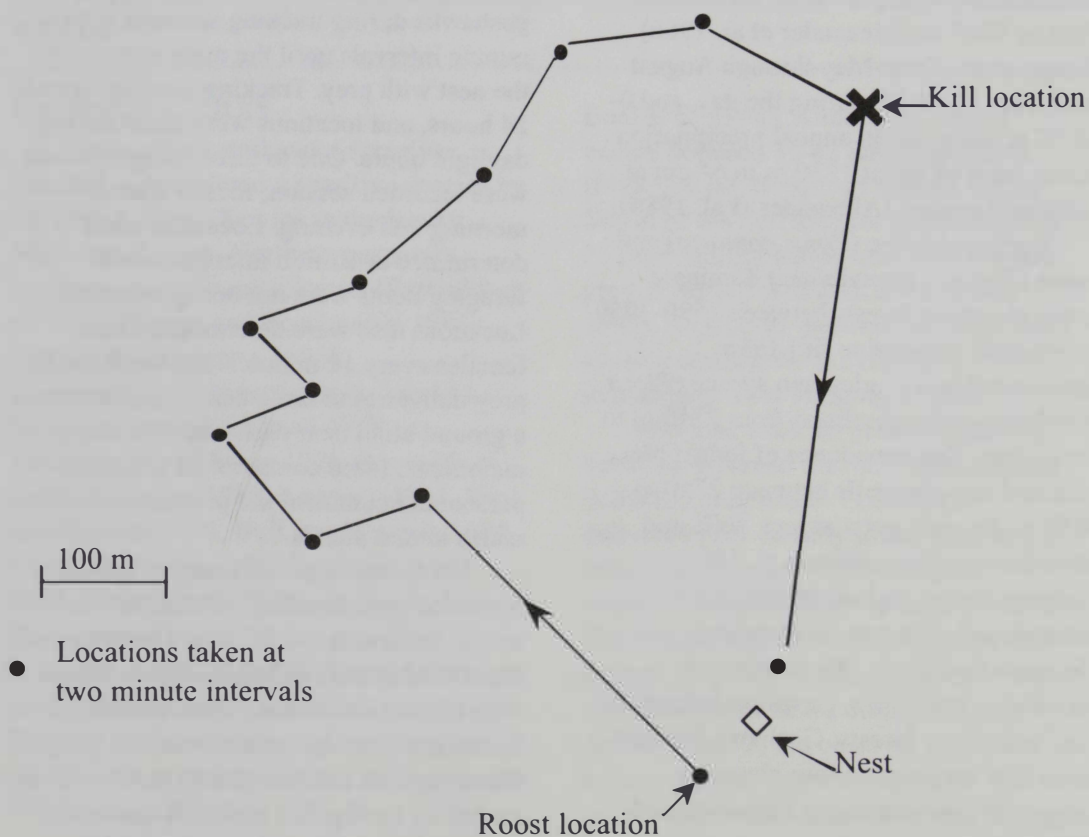
Figure 1. An example of a male goshawk foraging tract.

the nest within approximately 30-minutes of the prey delivery to the nest, or if he was heard, observed, or located by radio signal near the nest, female or fledglings around the time of a prey delivery. We attributed deliveries to females if the male did not appear to be hunting prior to a prey delivery, had not visited the nest area within approximately 30 minutes of a prey delivery, or the delivery did not appear to be a cache retrieval. When prey transfers between male and female goshawks occurred away from nests, we used telemetry to confirm that male and female goshawks were in the same area.

We observed each nest once every two weeks from before dawn until the first prey delivery by the male. If a prey delivery occurred early in the morning (0600-0900 hrs) we continued to observe nests until the male delivered prey a second time or until 1200 hrs, whichever occurred first. We used this approach to accommodate aspects of an ongoing adult habitat use study. We also conducted nest observations from 1700 hrs until the male delivered prey in the evening. To increase the number of deliveries observed we occasionally conducted observations between 1200–1700 hrs. Observation periods averaged 6 hrs, for a total of 295 observation hours (range 11.75–67 hrs/nest, $\bar{x} = 36.8$ hrs/nest, $n = 8$ nests) over two years.

RESULTS

Male and female prey deliveries

We observed a total of 69 deliveries during 1996 and 1997. Males made 42 deliveries (71%), females made 17 deliveries (29%), and we were unable to determine which adult made the delivery for 10 deliveries. Females delivered prey more frequently than males at two nests. At one of these two nests, the male made no deliveries, whereas the female made at least five deliveries during six days of observation (39 hrs). At the other nest, the male made two deliveries and the female made three deliveries during seven days of observation (40.5 hrs).

Prey transfers and intraspecific behavior

Females tended to be aggressive toward males during food deliveries at nests, giving dismissal calls (Schnell 1958) and alarm calls (Squires and Reynolds 1997). On one occasion a female gave an alarm call and taloned a male when he tried to land on the nest with prey.

During the nestling stage, we identified, through direct observation, the location (at nest vs. away from nest) where males delivered prey on 10 (24 %) of 42 occasions. We observed prey items being transferred from the male to the female away from the nest on three of those 10 occasions. Other deliveries by the male most likely occurred away from the nest, and thus, were not directly observed by us. The male delivered prey directly to the nest on seven occasions during the nestling stage. In all seven cases, the female was not at the nest during the delivery although they were nearby on those occasions and visited the nest within a few minutes of the prey delivery. Males left immediately after delivering prey, except one instance in which a male stood on the nest rim for 30 sec until the female returned to the nest.

Prey were generally delivered to fledglings away from nests ($n = 8$) after fledging (range, 25–400 m) between the ages 39 and 62 days, whereas four deliveries on four different days (fledgling ages 45-55 days) occurred directly at nests. Juveniles were present at the nest prior to the delivery during two of these direct deliveries to the nest.

Only adult females were observed feeding nestlings. Nestlings fed themselves as they matured. We observed the earliest self-feeding at 20 days. The female did the majority of feeding until 26-27 days after which the nestlings increasingly fed themselves. Adults provisioned juveniles up to 62 days post-hatch.

Prey delivery rates

Male and female goshawks delivered 0.23 items/hr/pair ($n = 8$ goshawk pairs, includes deliveries for which the sex of the delivering adult was not determined).

Delivery rates varied between nests. Male and female delivery rates averaged 0.14 items/hr and 0.06 items/hr, respectively.

Food habits

Thirty-eight of 69 items delivered to nests were identified to class (Table 1). Birds comprised 21.1 percent and mammals 78.9 percent of identified deliveries ($n = 38$ deliveries).

DISCUSSION

Feeding behavior at nests was similar to the behaviors described by Schnell (1958) and Boal (1994). Our total delivery rates of 0.23 items/hour were less than 0.25 items/hour reported by Boal and Mannan (1994), and 0.31 items/hour reported by Younk and Bechard (1994). Because we often observed nests until a prey delivery was made, our determination of delivery rates probably overestimated actual delivery rates. Thus, the difference in delivery rates between our study and Boal and Mannan (1994) and Younk and Bechard (1994) probably was even greater than shown above. Younk and Bechard (1994) found goshawks in Nevada to be very productive during one year of their study (2.8 young/ breeding pair) and hypothesized that an increase in prey populations may have resulted in a large number of yearling females breeding. Although we did not measure productivity, goshawks in southcentral Wyoming may have had smaller broods than those in Nevada. Younk and Bechard (1994) also found female goshawks to remain at the nest almost continuously, which may have resulted from a large or readily available prey population (Ward and Kennedy 1996). Prey abundance or availability may have been lower in our study area in Wyoming than in Nevada, thus accounting for our higher rates of female prey deliveries.

Schnell (1958) described females as hostile to males during prey deliveries, but provided no specific examples. Few documented instances of female goshawk aggression toward males exist. Boal et al. (1994) documented males leaving the nest after delivering prey when the female approached and gave dismissal calls. However, Boal et al. (1994) also documented a male goshawk brooding young when a female was giving dismissal calls. We documented a female being physically aggressive toward a male. We know of no other published account of such aggressive behavior.

Male goshawks provided the majority of prey deliveries to the young (71%), which is consistent with other studies (Schnell 1958, Zachel 1985, Younk and Bechard 1994, Boal and Mannan 1996). However, females provided a larger

Table 1. Prey items observed during 69 deliveries to eight goshawk nests in southcentral Wyoming, 1996 - 1997.

Prey item	Number Delivered (%)	Percent of Identified Deliveries ($\underline{n} = 38$)
Unknown Bird	5 (7.2)	13.1
American Robin (*Turdus migratorius*)	2 (2.9)	5.2
Northern Flicker (*Colaptes auratus*)	1 (1.4)	2.6
Red Squirrel (*Tamiasciurus hudsonicus*)	12 (17.3)	31.5
Ground Squirrel or Chipmunk	4 (5.8)	10.5
Least Chipmunk (*Tamias minimus*)	1 (1.4)	2.6
Lagomorph	1 (1.4)	2.6
Unknown Mammal	12 (17.3)	31.5
Unknown	31 (44.9)	N/A
Total	69 (100.0)	100.0
Total Birds	8 (11.6)	21.1
Total Mammals	30 (46.3)	78.9

proportion of prey deliveries (29%) to the young in our study than has been previously documented. Zachel (1985) reported two females providing 12.1 percent and 8.8 percent of food delivered to nests. Boal and Mannan (1996) found female goshawks to deliver 19 percent of prey. Schnell (1958) reported a female providing 15 percent of food to the nest. Younk and Bechard (1994) found females did not provide any food during the nestling stage.

Comparison of our delivery rates with other studies was difficult. We assigned deliveries to males and females based upon telemetry efforts and nest observations, whereas previous studies have relied solely upon nest observations and assumptions concerning male delivery behavior. By confirming hunting activity by male goshawks prior to a delivery through use of both motion-sensitive transmitters and direct observation, we perhaps more accurately identified sex of the adult that captured and delivered prey than did earlier researchers.

Additionally, we measured delivery rates through the majority of the fledgling stage, whereas observations were discontinued soon after fledging in earlier studies. Female goshawks may deliver prey more often after young have fledged when the risk of predation is reduced. Additionally, the amount of food needed by the young may be higher after they have fledged and are more active, yet still rely on adults for the majority of their food.

Our results indicated that females in our Wyoming study might capture and deliver prey more frequently than goshawks from other areas. Our study was the first to combine intensive telemetry efforts with nest observations. Schnell (1958), Zachel (1985), Younk and Bechard (1994), and Boal and Mannan (1996) all relied upon visual or auditory cues during nest observations to assign prey deliveries to males or females. We feel that we could more accurately attribute deliveries to either the male or the female based on a combination of telemetry data and visual and auditory cues.

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