

PREY BROUGHT TO RED-SHOULDERED HAWK NESTS IN THE GEORGIA PIEDMONT

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The Red-shouldered Hawk (*Buteo lineatus*) is a common breeding species throughout the southeastern U.S. Despite its wide distribution, information on its food habits in the Southeast is largely anecdotal (Burleigh 1958, Janik and Mosher 1982). Although food habit studies in several geographic regions have documented the breadth the Red-shouldered Hawk's diet (Craighead and Craighead 1956, Snyder and Wiley 1976, Bednarz and Dinsmore 1985, Parker 1986), they differ with respect to the importance of certain prey classes in the diet. While this could represent variation within and between regions, it may be an artifact of the methods used to quantify prey (Marti 1987), or due to the failure to report results in terms of biomass (Steenhof 1983). Our objectives were to quantify the prey brought to nests of the Red-shouldered Hawk in Georgia and to compare food habits in Georgia with those reported elsewhere.

STUDY AREA AND METHODS

The study was conducted on the 5718-ha Bishop F. Grant Memorial Forest (BGF), located in Putnam and Morgan counties, approximately 14 km north of Eatonton (83°28'N, 33°25'W), in east-central Georgia. The area lies within the Piedmont physiographic province, a peneplain dissected by numerous streams to form a rolling topography (Brender 1973). Elevation ranges from 120–220 m above sea level. Average annual rainfall is approximately 120 cm, with peak precipitation occurring in winter (USDA-SCS 1965, 1976).

Over 60% of BGF consists of natural or planted stands of loblolly pine (*Pinus taeda*). Bottomland hardwood forests (7%) exist along the area's major drainages. These include Big Indian Creek, Gladly Creek, and Little River. Dominant vegetation includes green ash (*Fraxinus pennsylvanicus*), sweetgum (*Liquidambar styraciflua*), box elder (*Acer negundo*), sycamore (*Platanus occidentalis*), overcup oak (*Quercus lyrata*), water oak (*Q. nigra*), and willow oak (*Q. phellos*). Upland hardwood stands (23%) consisting of mixed oaks (*Quercus* spp.) and hickories (*Carya* spp.), blackgum (*Nyssa sylvatica*), sweetgum, and winged elm (*Ulmus alata*) lie adjacent to bottomland corridors, or are associated with major drainage basins. The remainder of BGF is maintained as pasture for cattle grazing and hay production, or is planted as wildlife food plots. Several

small reservoirs provide irrigation, public fishing, and waterfowl habitat.

We monitored prey deliveries to eight occupied Red-shouldered Hawk nests within ($N = 6$) and around ($N = 2$) BGF from 3 April–14 July 1994. Old nests were located prior to leaf-out, and then rechecked for signs of occupancy. Observations totaling 103 hr were made with a 20–45× spotting scope and 8× binoculars from a ground blind placed within 20 m the base of the nest tree. Observation periods were normally 4–6 hr and were allocated randomly to cover all daylight hours (0600–1800 H). Most nests were observed over one time interval at least once each week from early in incubation until the young had fledged. Nest sites were checked periodically for remains of prey beneath the nest. We compared the observational data with those of prey remains to insure that we counted only those prey remains that could not have been seen during observations from blinds. Regurgitated pellets normally contained only hair or feathers, and were excluded from the analysis. Prey items were identified to species or the lowest possible taxonomic category.

We calculated the percent frequency of each prey item from the total number of items delivered to nests and collected from prey remains. The percent biomass contribution of each prey item was calculated by multiplying the frequency of occurrence of each prey item by its mean body mass. When possible, we derived biomass directly from prey collected on the study area. Otherwise, we estimated prey biomass (Marti 1987) from the literature (Golley 1962, Steenhof 1983, Dunning 1984). Large insects were assumed to weigh 1 g, the average mass obtained from representative samples collected on the study area. The masses of unidentified prey were assumed to be similar to the mean mass of the most closely related, identified taxa.

RESULTS AND DISCUSSION

All Red-shouldered Hawk nests were located in bottomland forests, or in upland hardwood stands adjacent to the bottomland corridor (Moorman and Chapman 1996). Mean nest height was 17.6 m (range = 12.2–21.3 m, $N = 8$). Six of eight nests fledged at least one young (range = 1–2) for an average of 1.8 young per successful nest.

A total of 181 prey items (Table 1) was identified by observations made from blinds ($N = 144$) and remains collected beneath nests ($N = 37$). Prey delivered to nests averaged 36.1 g (range = 1–487 g). Vertebrates represented 76.2% of the prey by numbers and 97.2% of prey biomass. Vertebrate prey included nine species of mammals, nine species of birds, eight species of reptiles, and four species of amphibians. Invertebrates represented 23.8% of the prey by numbers, but were insignificant in

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Table 1. Food habits of Red-shouldered Hawks (*Buteo lineatus*) in the Bishop F. Grant Memorial Forest, Putnam and Morgan counties, Georgia in 1994. Prey items from eight nests identified from visual observations in blinds ($N = 144$) and prey remains beneath nests ($N = 37$). Prey listed taxonomically by class. N = number of individuals, $\%N$ = percent occurrence of prey, Mass = mean prey biomass in grams, and $\%B$ = percent of total biomass.

PREY SPECIES	N	$\%N$	MASS	$\%B$
Oligochaeta				
Unidentified earthworms	8	4.4	6	0.7
Crustacea				
Unidentified crayfish (<i>Cambarus</i> spp.)	17	9.4	7	1.8
Insecta				
Unidentified beetles	5	2.8	1	0.1
Unidentified grasshoppers and crickets	8	4.4	1	0.1
Unidentified caterpillars	5	2.8	1	0.1
Amphibia				
Spotted salamander (<i>Ambystoma maculatum</i>)	1	0.6	12	0.2
Two-lined salamander (<i>Eurycea bislineata</i>)	5	2.9	7	0.5
Unidentified salamanders	10	5.5	9	1.4
Southern toad (<i>Bufo terrestris</i>)	3	1.7	20	0.9
Unidentified toads (<i>Bufo</i> spp.)	4	2.2	20	1.2
Southern leopard frog (<i>Rana utricularia</i>)	10	5.5	38	5.8
Unidentified frogs (<i>Rana</i> spp.)	13	7.2	38	7.7
Reptilia				
Snapping turtle (<i>Chelydra serpentina</i>)	11	6.1	24 ^a	4.0
Green anole (<i>Anolis carolinensis</i>)	3	1.7	15	0.7
Eastern fence lizard (<i>Sceloporus undulatus</i>)	3	1.7	17	0.8
Unidentified skinks (<i>Eumeces</i> spp.)	4	2.2	18	1.1
Black racer (<i>Coluber constrictor</i>)	3	1.7	77	3.5
Black rat snake (<i>Elaphe obsoleta</i>)	2	1.1	190	5.8
Eastern kingsnake (<i>Lampropeltis getulus</i>)	1	0.5	190	2.9
Rough green snake (<i>Ophedrys aestivus</i>)	1	0.5	15	0.2
Unidentified water snakes (<i>Nerodia</i> spp.)	5	2.9	125 ^a	9.7
Eastern garter snake (<i>Thamnophis sirtalis</i>)	10	5.5	64	9.8
Aves				
Mourning Dove (<i>Zenaida macroura</i>)	1	0.5	119	1.8
Carolina Wren (<i>Thryothorus ludovicianus</i>)	1	0.5	21	0.3
American Robin (<i>Turdus migratorius</i>)	1	0.5	78	1.2
Pine Warbler (<i>Dendroica pinus</i>)	1	0.5	12	0.2
Unidentified warbler (<i>Dendroica</i> sp.)	1	0.5	12	0.2
Common Yellowthroat (<i>Geothlypis trichas</i>)	1	0.5	10	0.1
Kentucky Warbler (<i>Oporonis formosus</i>)	1	0.5	14	0.2
Hooded Warbler (<i>Wilsonia citrina</i>)	2	1.1	11	0.3
Northern Cardinal (<i>Cardinalis cardinalis</i>)	3	1.7	45	2.1
Indigo Bunting (<i>Passerina cyanea</i>)	1	0.5	15	0.2
Unidentified passerines	2	1.1	17	0.5
Mammalia				
Short-tailed shrew (<i>Blarina brevicauda</i>)	2	1.1	13	0.4
Eastern mole (<i>Scalopus aquaticus</i>)	1	0.5	40	0.6
Eastern cottontail (<i>Sylvilagus floridanus</i>)	1	0.5	230 ^a	3.5
Eastern chipmunk (<i>Tamias striatus</i>)	4	2.2	110	6.7
Eastern gray squirrel (<i>Sciurus carolinensis</i>)	1	0.5	487	7.5
White-footed mouse (<i>Peromyscus leucopus</i>)	3	1.7	18	0.8
Unidentified mice (<i>Peromyscus</i> spp.)	2	1.1	18	0.6
Golden mouse (<i>Ochrotomys nuttalli</i>)	2	1.1	18	0.6
Hispid cotton rat (<i>Sigmodon hispidus</i>)	6	3.3	85	7.8
Pine vole (<i>Microtus pinetorum</i>)	4	2.2	26	1.6
Unidentified voles (<i>Microtus</i> spp.)	3	1.7	26	1.2
Unidentified rodents	5	2.9	33	2.6
TOTAL	181	100.0		100.0

^a Specimens represent subadult animals.

terms of prey biomass (2.8%; Table 1). All of the crustaceans identified were crayfish (Cambaridae), and the oligochaetes were earthworms (Lumbricidae).

Amphibians (25.6%) were the most frequently delivered prey items to Red-shouldered Hawk nests. Frogs (*Rana* spp.) were numerically important as prey and, collectively, they represented 41.4% of amphibian prey delivered to nests. Reptiles (38.5%) and mammals (33.9%) contributed most to total prey biomass (Table 1), followed by amphibians (17.7%), birds (7.1%), crustaceans (1.8%), oligochaetes (0.7%), and insects (0.3%). The species contributing most to total prey biomass were eastern garter snakes (*Thamnophis sirtalis*) and water snakes (*Nerodia* spp.).

Red-shouldered Hawks in the Georgia Piedmont preyed upon a variety of food items. Although their food habits were similar to those reported in previous studies in which the majority of prey taken were amphibians, reptiles, mammals, and crayfish (Craighead and Craighead 1956, Snyder and Wiley 1976, Bednarz and Dinsmore 1985, Parker 1986), the importance of certain prey classes such as amphibians and reptiles differed. Craighead and Craighead (1956) and Bednarz (1979), for instance, reported food habits based largely on percentages of prey occurring in pellets and found that small mammals were the preferred food of nesting Red-shouldered Hawks in Michigan and Iowa, respectively. Snyder and Wiley (1976) reported that invertebrates were the dominant foods found in Red-shouldered Hawk stomachs. Parker (1986) used visual observations to identify food items delivered to nests in Missouri, and found that amphibians were the most frequently delivered prey. Overall, frogs (*Rana* spp.) were the most frequently delivered prey to Red-shouldered Hawk nests in our study, and contributed most to total prey biomass. Craighead and Craighead (1956), Bednarz (1979), and Parker (1986) all found frogs to be important foods of Red-shouldered Hawks. However, studies relying on pellet analysis alone may underestimate the proportions of amphibians in the diet because amphibians are often completely digested and leave little osseous remains in pellets (Errington 1932). Snyder and Wiley (1976) and Portnoy (1974) both reported a higher incidence of frogs in the diet than suggested by pellet analysis.

Eastern garter snakes, unidentified water snakes and hispid cotton rats (*Sigmodon hispidus*) also were important prey, in terms of both numbers and biomass. Garter snakes were reported in Red-shouldered Hawk diets in Michigan (Craighead and Craighead 1956) and Iowa (Bednarz 1979). Cotton rats have never been reported as important prey, but distribution of cotton rats does not extend into the northern portion of the Red-shouldered Hawk's range, where voles (*Microtus* spp.) and mice (*Peromyscus* spp.) are taken more frequently (Craighead and Craighead 1956, Bednarz 1979). Snapping turtles (*Chelydra serpentina*) were numerically important prey items,

but contributed little to overall prey biomass because individuals taken by the hawks were small.

Red-shouldered Hawks in our study rarely brought birds to nests and birds contributed little to total prey biomass (7.1%). Only Craighead and Craighead (1956) found that birds were important prey items based on the frequency of occurrence of avian species within pellets.

Although invertebrates, particularly crayfish, were frequently delivered to Red-shouldered Hawk nests in our study, they contributed little to total prey biomass (2.8%). Snyder and Wiley (1976) found that 55.6% of a Red-shouldered Hawk's diet included invertebrates. The invertebrate component of their study probably was overestimated because they did not examine their data in terms of biomass. In addition, their study was based largely on analysis of stomach contents, which could contain items of secondary origin, particularly insects, ingested incidentally as stomach contents of prey.

Of the prey delivered to Red-shouldered Hawk nests in this study, 60% (108 of 181) were those frequently associated with bottomland forests, marshes, or wet meadows. Red-shouldered Hawks we equipped with radio transmitters (Howell and Chapman 1997) were located most often foraging within bottomland forests close to water, small beaver (*Castor canadensis*) ponds, wet meadows, or areas containing many seasonally or permanently flooded pools. Other researchers also have demonstrated the importance of these habitats as foraging sites for Red-shouldered Hawks (Henny et al. 1973, Portnoy 1974, Bednarz 1979, Parker 1986, Bloom et al. 1993). Red-shouldered Hawks in our study foraged in the bottomland forest habitat and used the variety of foods within it, rather than specializing on particular prey species, a result consistent with Bednarz and Dinsmore (1985). The most important foods of Red-shouldered Hawks during the nesting season were reptiles and amphibians, particularly snakes and frogs, associated with the bottomland forest. Small mammals may become more important during the winter months, given the seasonality of the preferred prey (Craighead and Craighead 1956) and also may increase in importance as buffer foods during extremely dry conditions (Bednarz and Dinsmore 1985).

RESUMEN.—Las presas de *Buteo lineatus* fueron estudiadas durante la estación reproductiva en un área de pinos de manejo intensivo en la región fisiogeográfica del piedemonte de Georgia. Un total de 1881 items fueron entregados a los pichones ($N = 144$) y, colectados como restos de presas debajo de los nidos ($N = 37$). Los vertebrados representaron el 76.2% de las presas en números y el 97.2% de la biomasa, incluyendo nueve especies de aves, ocho especies de reptiles y cuatro especies de anfibios. Los invertebrados representaron el 23.8 % de las presas en números pero fueron insignificantes en términos de biomasa (2.8%). Serpientes, ranas y roedores fueron las presas mas frecuentemente entregadas y de mayor contribución a la biomasa total de presas. Sesenta por ciento

de las presas entregadas en los nidos fueron aquellas asociadas a habitats del sotobosque, lo cual sugiere que *Buteo lineatus* forrajea extensivamente en este habitat.

[Traducción de César Márquez]

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