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FEEDING ECOLOGY OF SHARP-SHINNED HAWKS NESTING IN DECIDUOUS AND CONIFEROUS FORESTS IN COLORADO[1]

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Abstract. Feeding ecology of 11 Sharp-skinned Hawk (*Accipiter striatus*) pairs nesting in aspen (*Populus tremuloides*), conifer (*Abies, Picea* spp.), and mixed aspen-conifer habitats in southwest Colorado was investigated during 1988–1989. Small birds ($\bar{x}$ = 20.9 g, SE = 0.8 g) and mammals ($\bar{x}$ = 41.1 g, SE = 3.3 g) comprised 91 and 9% of 513 prey identified at nests that fledged at least one young, respectively. Sixty percent of the birds eaten during the hawks' nestling and fledgling stages were nestlings or fledglings. Accordingly, median mass of birds eaten decreased from 17.4 g during incubation to 12.1 g during the nestling stage. Although more birds were consumed than mammals during all nesting stages (birds = 91.1%; mammals = 8.9%), the proportion of birds relative to mammals in diets progressively decreased from incubation through fledging. Taxa of birds in the diet were consumed in proportion to their occurrence in the most abundant of three different habitats surrounding nests, whereas some mammalian taxa were consumed in greater proportion than their relative "availability" in these habitats. This suggested that Sharp-shinned Hawks foraged opportunistically for birds, but may have selectively foraged for mammals. Differences in the habits of mammals (e.g., fossorial vs. terrestrial behavior), and hence their relative availability, may explain the apparent selection for certain species of mammals by Sharp-shinned Hawks.

Key Words: Accipiter striatus; *Sharp-shinned Hawk; diet; food habits; feeding ecology; aspen forest; conifer forest; Colorado.*

INTRODUCTION

Sharp-shinned Hawks (*Accipiter striatus*) are small, forest-dwelling raptors that feed primarily on small birds (10–30 g) associated with forest canopies (Craighead and Craighead 1956, Storer 1966, Reynolds and Meslow 1984). In Colorado, Sharp-shinned Hawks breed in quaking aspen (*Populus tremuloides*) and conifer (*Abies, Picea, Pseudotsuga*) forests. Forests in which hunting Sharp-shinned Hawks have been observed include mature aspen, conifer, and mixed aspen-conifer. Within mature aspen forests, however, these hawks nest only in patches of conifers (S. M. Joy and R. T. Reynolds, pers. observ.).

Smith and MacMahon (1981) demonstrated that avian species diversity and community composition differed among aspen, spruce, and fir forests in Utah and Idaho. If bird and mammal numbers differ among these forests in Colorado and if Sharp-shinned Hawks forage opportunistically, then diets of the hawks might reflect the relative abundance or availability of prey in forest types surrounding nests. Foraging opportunism would allow Sharp-shinned Hawks to use a variety of forest types in spite of different faunal communities, provided that sufficient food and nest sites were available.

We examined the diets of nesting Sharp-shinned Hawks in mature forests of aspen, conifer, and mixed aspen-conifer in Colorado during 1988–1989. We tested for differences in prey

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sizes and prey numbers among nesting pairs, among nesting stages, and between avian and mammalian prey. To evaluate the hypothesis that Sharp-shinned Hawks are opportunistic foragers, taxonomic composition and the size-frequency distribution of birds and mammals in Sharp-shinned Hawk diets were compared with estimates of relative abundances of birds and mammals in each of the three forest types.

STUDY AREA

The study was conducted on 28,750 ha of the Gunnison and Grand Mesa National Forests in west-central Colorado and included portions of Gunnison, Delta, and Mesa counties. Elevations ranged from 2,750–3,200 m. In western Colorado, aspen forests comprise as much as 25% of forested lands (Green and Van Hooser 1983). Within our study area, aspen existed as both seral and stable (contained no conifers) communities in small (<10 ha) patches and extensive (>500 ha) forests. In the study area, seral aspen patches and forests (often with emergent conifers in the aspen canopies) are successional to Englemann spruce (*P. engelmannii*) and subalpine fir (*A. lasiocarpa*), and at lower elevations blue spruce (*P. pungens*) (Langenheim 1962, Morgan 1969). Situated within these aspen forests were small to large areas of pure, or nearly pure, conifer forests. As a result, forests on the study area were composed of a mosaic of large (>500 ha), medium (200–500 ha), and small (<200 ha) patches of aspen, conifer, and mixed aspen-conifer forests. Throughout the study area, the majority (>70%) of aspen forests were in mature (70–120 year) and old-growth (120+ year) age classes (Shepperd 1990).

Vegetative composition of the understory in these forests varied with elevation, slope, aspect, and type of forest. Aspen and, to a lesser extent, mixed aspen-conifer had tall (>1 m), well-developed, herbaceous understories with a minor shrub component. Dominant forbs included butterweed groundsel (*Senecio serra*), white geranium (*Geranium richardsonii*), Barbey larkspur (*Delphinium barbeyi*), white-flowered peavine (*Lathyrus leucanthus*), and monkshood (*Aconitum columbianum*). Prominent low-growing plants included elk sedge (*Carex geyeri*), wild strawberry (*Fragaria ovalis*), yellow prairie violet (*Viola nuttallii*), and fringed brome (*Bromus ciliatus*). The shrub component consisted of snowberry (*Symphoricarpos* spp.), chokecherry (*Prunus virginiana*), and mountain-mahogany (*Cercocarpus montanus*).

Conifer understories were sparsely vegetated and dominated by low-growing (<1 m) herbs and shrubs including heart-leafed arnica (*Arnica cordifolia*), field horsetail (*Equisetum arvense*), elk sedge, myrtle blueberry (*Vaccinium myrtillus*) and kinnikinnik (*Arctostaphylos uva-ursi*). Plant names follow Weber (1976). Sheep and cattle foraged freely in the study area during July and August.

METHODS

DIET DETERMINATION

Areas intensively searched for nests within the study area were identified from aerial photographs (1:24,000) and topographic maps (7.5-min series) following Joy (1990) and included patches, as well as extensive areas, of aspen, conifer, and mixed aspen-conifer. Nest searches began in May in both 1988 and 1989 and were conducted throughout the nesting season. Prey remains (feathers, bills, feet, fur, skull fragments, and regurgitated pellets) were collected from nest sites as least once every seven days, and as often as every two days. Four days prior to changes in nesting stage (incubation to nestling, nestling to fledgling), prey remains were collected every two days. Activities of pairs (food exchanges between males and females, prey handling, feeding at nests, and roosting behavior) were recorded from blinds near all nests. Areas of approximately 5 ha, centered on nest trees, that contained prey-handling sites were thoroughly searched for prey remains during each visit to nests. Searches for prey remains often required 1–3 hr/visit. Prey remains were collected from nest sites until fledged young dispersed or nests failed.

Prey remains were sorted by nest and collection date. Avian remains (remiges, contour feathers, rectrices, feet, bills, and bones) were reconstructed and compared with National Museum of Natural History (Washington, D.C.) specimens for identification and a minimum count of individuals was determined as described by Reynolds and Meslow (1984). Single feathers of a species were excluded. Mammalian remains (fur, feet, tails, skull fragments, and teeth) were identified in a similar manner at the U.S. Fish and Wildlife Service museum in Fort Collins, Colorado.

Diet determinations based on the collection of prey remains may not include all prey consumed

viduals in 8-min circular variable plot censuses (Reynolds et al. 1980) at 15 stations (100-m spacing) in each plot. Stations in each of the 15 census plots were censused five times during June of each year (1988–1989). All censuses occurred between 05:30–12:30 MDT (D. M. Finch and R. T. Reynolds, pers. comm.).

Relative abundances of small mammals in each forest type were estimated by totaling the number of individuals per species captured once (excluding recaptures) during late-July to mid-September, 1988–1989, in the 15 plots (R. T. Reynolds and D. M. Finch, pers. comm.). Mammal trapping grids (10 × 10 at 15-m spacing) were nested within the larger bird census grids and had one Sherman trap (7.6 cm × 8.9 cm × 23.0 cm) at each of 100-grid points per plot (100 Sherman traps/plot) and one circular pit-fall trap (160 cm depth, 130 cm dia.) at every-other grid point (25 pitfall traps/plot). Small mammal plots were live-trapped for one session of six consecutive nights per year (750 trap nights/plot^{-1} year^{-1} × 2 year = 22,500 total trap nights) (R. T. Reynolds and D. M. Finch, unpubl. data). We assumed that these abundance estimates approximated the relative "availability" of birds and mammals to Sharp-shinned Hawks in the three forest types within our study area.

Forests within 2-km radii of each Sharp-shinned Hawk nest were classified as aspen (≥90% aspen trees in overstory), conifer (≥90% conifer trees in overstory), or mixed aspen-conifer (mixed stands with <90% aspen and <90% conifer trees in overstory) from aerial photographs (1:24,000) taken in October 1978 when the color contrast between aspen and conifers was at a maximum. The 2-km radius was selected because 2 km is about half the nearest-neighbor distance between nests of this hawk (Reynolds and Wight 1978, Clarke 1984) and circles with this radius encompass all estimates of home-range size in this species (see review in Reynolds 1983). Around each nest, the three forest types were assigned to one of three habitat-dominance categories (dominant, secondary, or limited) based on the proportion of the 2-km radius circle each forest type occupied. Forest types comprising ≥50% of the area around nests were considered "dominant". "Secondary" habitats were defined as forest types occupying >5% and <50% of the area. Forest types comprising ≤5% of the area were termed "limited".

Program PREFER (Johnson 1980) was used to examine whether birds or mammals in diets (n = 11 nests) reflected the relative abundance—by taxa (bird and mammal families) and size-class categories (after Storer 1966)—in the (1) dominant, (2) secondary, and (3) limited habitat-dominance categories surrounding nests. Null-hypotheses tested were that: 1) avian and 2) mammalian taxa were eaten in proportion to their abundance in each of the three habitat-dominance categories (dominant, secondary, and limited); and that 3) avian and 4) mammalian size-classes were eaten in proportion to their abundance in each of the three habitat-dominance categories. PREFER requires that the number of "preference components" (i.e., taxa and size-class categories) not exceed the number of "individuals" (i.e., nests) in tests (Johnson 1980). Thus, taxonomic categories of prey containing fewer than 2 individuals at all nests combined (families Scolopacidae, Trochilidae, Mimidae, and Mustelidae) were omitted from analyses. Mammalian prey in size-class categories nine (166–216 g), eight (125–166 g), six (64–91.1 g), and two (8–15.6 g) (Storer 1966) were also omitted because they were not tallied in prey remains or during census counts. Diet and relative-abundance data were paired by year to eliminate differences in prey abundance between years. Waller and Duncan's (1969) multiple comparison procedure was used in PREFER to assess relative "preferences".

Finally, we examined the overall pattern of food-resource use of nesting Sharp-shinned Hawks by comparing the hawks' diets to the entire range of bird and mammal sizes that occurred in the study area.

RESULTS

Diets of 11 Sharp-shinned Hawk nesting pairs were determined, four nests during 1988 and seven nests during 1989. Ten (91%) nests were in small (1–14 ha), insular conifer patches surrounded primarily by aspen (n = 8) or mixed aspen-conifer (n = 2) forests, and one nest was within a large, contiguous conifer forest. Prey were collected from all nest sites during all nesting stages in 1988. In 1989, five of seven nests failed prior to fledging. Prey remains were collected from all seven nest sites during incubation, from four nest sites during the nestling stage, and two nest sites during the fledgling stage. A total of 686 prey items was identified (Appendix 1), including 53 species (39 genera, 14 families) of

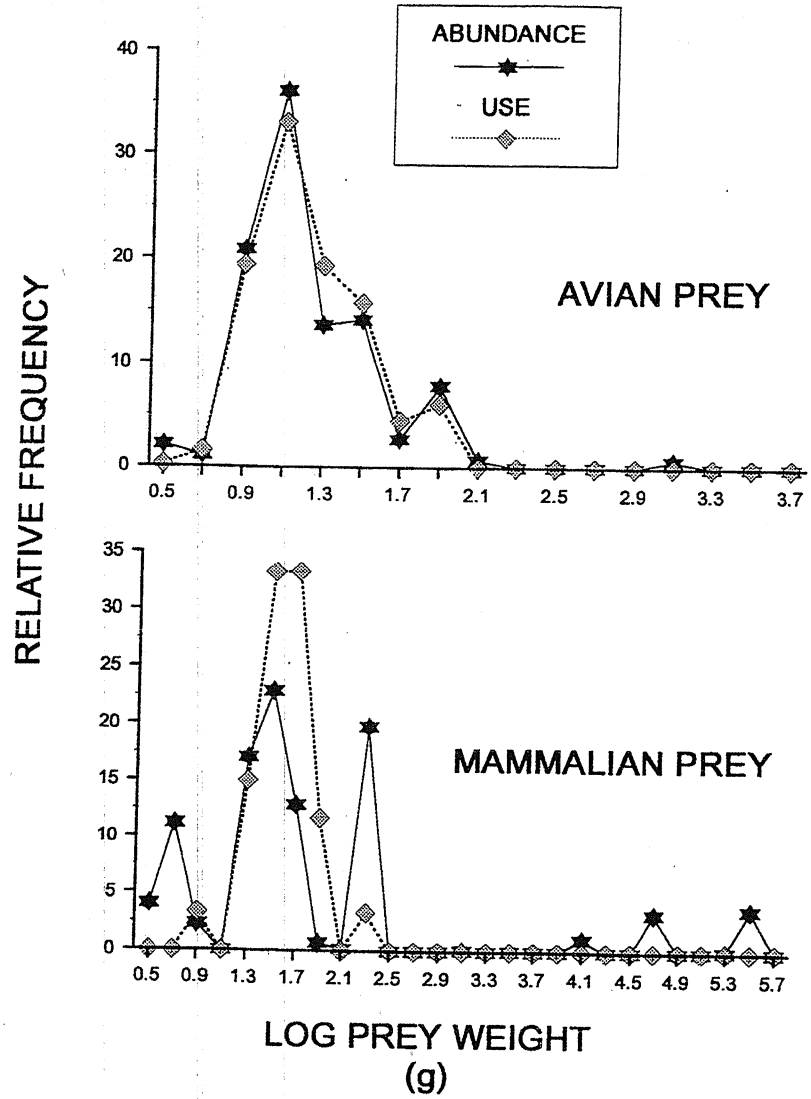

FIGURE 5. Relative abundance of birds and mammals by size class and their relative frequency in diets of Sharp-shinned Hawks in aspen and conifer forests in Colorado, 1988–1989.

ing fossorial vs. terrestrial behavior of Geomyidae and Muridae).

Although aspen and mixed aspen-conifer habitats comprised the majority of dominant and secondary habitats surrounding nests, all Sharp-shinned Hawks nested in conifer trees. The singular use of conifers, which have long and dense crowns, for nesting is probably related to a need for this small hawk to hide its nest from predators (Reynolds 1989).

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