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Foraging Behavior and Success of Golden Eagles

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Quantitative data on the predatory behavior and capture success of free-living birds of prey are difficult to obtain. Consequently, most studies have assessed predation indirectly from prey remains found on nests (e.g. Craighead and Craighead 1956, Smith and Murphy 1973) or by observing prey delivery rates to nests (e.g. Snyder and Wiley 1976, Newton 1978, Collopy 1983). For most species, however, available information remains qualitative (Bent 1937, Brown and Amadon 1968, Brown 1977). The purpose of this paper is to describe the hunting behavior and capture success of Golden Eagles (*Aquila chrysaetos*).

The study area, known as the Snake River Birds of Prey Area (BPA), is located along the Snake River Canyon in the cold desert plateaus south of Boise, Idaho. Vegetation and topography of the area are described by USDI (1979) and Collopy (1980).

Each of four pairs of nesting Golden Eagles was observed approximately once every 6th day during incubation, brood-rearing, and post-fledging periods at four sites in 1978 and 1979 (Collopy 1980). I directly observed adults away from the nest by means of focal animal sampling (Altmann 1974). In 1978, 961.6 h of daylight observations were made at study sites during 72 24-h sampling periods; in 1979, 1,107.7 h of daylight observation were made at sites during 78 24-h sampling periods. The amount of time individual eagles were observed varied, depending on their behavior and on the local topography. A second observer simultaneously observed nests during the brood-rearing period from blinds located 15–40 m away, which allowed the identification of the prey and the sex of the adult. Individual recognition of adults at the nest was facilitated by photographs showing unique plumage characteristics. I readily distinguished one male by the radio-telemetry transmitter that had been attached to it by an earlier researcher (Dunstan et al. 1977). When both eagles hunted together or in the same vicinity, sex was assigned based on relative body size (females are larger than males). All capture attempts by eagles of unknown sex were excluded from consideration.

Golden Eagles were observed to hunt and capture prey while foraging alone (solo-hunt) and in pairs (tandem-hunt). Each predatory attack (e.g. pounce or stoop) directed at potential prey was considered a capture attempt. The percentage of success was calculated as the proportion of capture attempts with known outcomes that were successful. All capture attempts with undetermined outcomes were excluded from analysis. Overall, 10 of 92 (10.9%) attempts by males and 3 of 36 (8.3%) attempts by females were of unknown capture success due to distance from observer and/or local topography.

Chi-square contingency tests (Remington and Schork 1970) were used to detect significant differences ($P < 0.05$) in capture success due to mode of hunting and sex.

Male Golden Eagles attempted significantly more prey captures when solo-hunting than when tandem-hunting ($\chi^2 = 19.2$, $P < 0.0005$); females used both foraging methods equally ($\chi^2 = 1.0$, $P > 0.30$) (Table 1). This difference in hunting mode between the sexes was due to the fact that males had fewer opportunities to tandem-hunt early during the nesting season when females were brooding young and not hunting. The eagles tandem-hunted primarily late in brood-rearing when nestlings were left unattended for most of the day (Collopy 1980). Fisher (1893), Willard (1916), and Gordon (1955) have also reported tandem-hunting in Golden Eagles.

Overall, 26 tandem-hunts were recorded. Pairs frequently were observed systematically quartering the ground below cliffs along talus slopes. The eagles typically were oriented into the wind, which enabled them to course slowly over vegetation and attack any potential prey from relatively close quarters. During tandem-hunts the male was always in front of the female and appeared to lead the direction of the hunt. Males also flew at greater heights than females on 23 (88%) of the hunts. Frequently during a hunt, the male circled back, with the female following, to revisit a particular area on the slope. Solo-hunting eagles foraged in the same areas, searching with the same low coursing flight.

Twenty (77%) of the tandem-hunts resulted in cap-

TABLE 1. Foraging success of male and female Golden Eagles in the Snake River Birds of Prey Area.

Sex and hunting technique	Capture attempts			Percentage success[a]
	Number successful	Number unsuccessful	Total	
Male				
Solo	18	41	59	30.5
Tandem	1	22	23	4.3
Total	19	63	82	23.2
Female				
Solo	3	10	13	23.1
Tandem	1	19	20	5.0
Total	4	29	33	12.1
Total, combined	23	92	115	20.0

[a] Capture attempts are expressed on a per pounce basis.

ture attempts by both sexes; on six occasions (23%) only one of the eagles made an attempt to capture prey. During tandem-hunts in which both sexes made capture attempts, males initiated 18 (90%) of the attacks. By flying above and in front of females, male eagles apparently were first to locate and attack potential prey. Female eagles attacked prey whenever the male's attempt was unsuccessful. Only two successful tandem-hunts were observed during this study; both captures occurred on the second attempt, one by a male and one by a female.

Overall, Golden Eagles captured 23 prey items from 115 attempts for which the outcomes were known (Table 1). These prey included 6 black-tailed jackrabbits (*Lepus californicus*), 7 mountain cottontails (*Sylvilagus nuttalii*), 5 Townsend ground squirrels (*Spermophilus townsendi*), 1 kangaroo rat (*Dipodomys* sp.), 3 unidentified small mammals, and 1 gopher snake (*Pituophis melanoleucus*).

Based on all prey delivered to nests ($n = 154$), not just observed captures, I found that male and female eagles did not capture significantly different-sized prey ($t = 1.4$, $P > 0.10$; Collopy 1980). Although overall capture success of males was nearly twice that of females (23% vs. 12%), the difference was not statistically significant ($\chi^2 = 1.8$, $P > 0.10$). I attributed this lack of statistical significance to small sample size. If, however, this difference holds when larger sample sizes are obtained, it may provide some additional perspectives on the ecological significance of reversed sexual size dimorphism.

On a per attempt basis, solo-hunting Golden Eagles were significantly more successful at prey capture (29%) than those tandem-hunting (5%) ($\chi^2 = 10.1$, $P < 0.005$). Furthermore, eagles were more successful when they hunted alone than when they hunted in tandem (29% vs. 8%), even if each tandem-hunt and its outcome were considered one joint effort ($\chi^2 = 4.3$, $P < 0.05$).

These differences appear counter-intuitive, because the selective advantage of cooperative hunting behavior is assumed to be increased capture success. If tandem-hunting eagles search for larger, more elusive prey, however, they would be expected to have lower success rates than more opportunistic solo-hunting eagles. Unfortunately, no distinction between the species pursued by Golden Eagles using the two hunting techniques was possible. Evidence supporting this interpretation was presented recently for another species by Hector (1981), who correlated the lower capture success of tandem-hunting Aplomado Falcons (*Falco femoralis*) with a higher proportion of bird attacks.

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Flocking in the Hook-billed Kite

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Hawks are not generally thought of as gregarious birds, but they regularly occur in flocks in two situations: (1) when migrating (for example, *Buteo platypterus, B. swainsoni, Ictinia mississippiensis,* and *Cathartes aura*), and (2) when feeding on resources that are patchy in time and space (for example, *Falco naumanni, F. eleonorae* and other falcons that feed on insects for at least part of the year, and most vultures and other carrion-eaters). Some species typify both situations (for example, *Falco naumanni* and *Cathartes aura*). Of course, neither all migrating hawks nor all hawks utilizing patchy resources are gregarious.

The accipitrids loosely grouped together as "kites" (Brown and Amadon 1968) include a number of genera the species of which feed on insects and/or rodents and are often social even when not in migration (for example, *Elanoides, Elanus, Chelictinia,* and *Ictinia*). Flocking is an appropriate response to patchy resources but contrasts with the rather aggressively maintained territoriality of many hawk species that feed on more dispersed prey (Newton 1979). The kites mentioned above are less aggressive, in general, than many raptors that feed on birds and larger mammals. Most tropical woodland hawks are usually encountered singly or in pairs, and it was with considerable surprise that I observed members of one of these species aggregated into a soaring flock.

On 2 September 1978 Susan Hills and I watched a flock of 25 Hook-billed Kites (*Chondrohierax uncinatus*) soar up in an early-afternoon thermal from semi-wooded country southeast of San Francisco de Apure, Apure, Venezuela and disappear to the northeast. The day was typically tropical—sunny, hot, humid, and still. At first we were confused, because the flock obviously contained three different kinds of birds, but with further study we realized they were all identically shaped, with the long tail and narrowed wing base typical of *Chondrohierax*. Most of them had the vivid primary barring also characteristic of this species. Two of the birds looked black at a distance, with a single wide white bar on the tail slightly proximal to midlength. Twenty of the birds were gray beneath, the fine ventral barring obscured by distance but visible in the 20-power spotting scope through which I watched them. The gray birds had prominently barred dark and white primaries and four equally prominent tail bars, black-white-black-white from tip to base. Finally, three of the birds were distinctly brown beneath, with prominent reddish brown on the less conspicuously barred primaries and dark tail bars slightly narrower than those of the gray birds. A photograph taken with a 450-mm lens shows eight of these birds, including all three plumage types.

Although the literature does not completely clarify the plumage variation in this species, it appears that the gray birds were males and the brown ones females. All references that I examined stated that most