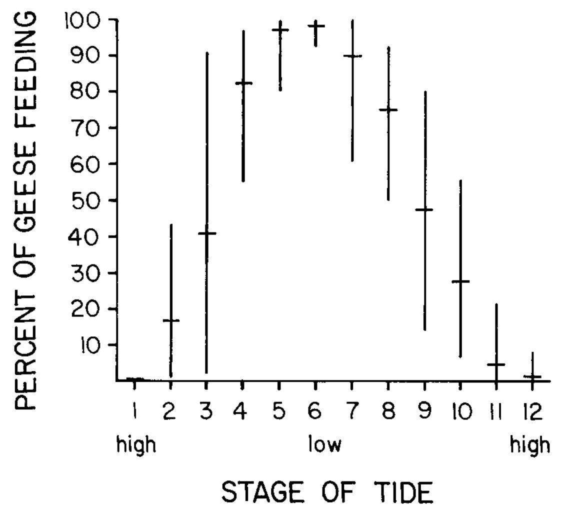

FIGURE 1. Percent of Emperor Geese feeding during each hourly stage of the tide as determined from 194 counts of birds. Horizontal bars show means, and vertical bars represent 95% confidence limits.

Raveling 1979), probably use those fat reserves during the nesting period. Therefore, factors affecting food resources in estuaries along the north side of the Alaska Peninsula in spring may directly influence the reproductive success of geese in summer.

I thank J. C. Bartonek, C. J. Lensink, and D. G. Raveling for reviewing this manuscript. This study was supported in 1977 by the Bureau of Land Management under contract to the National Oceanic and Atmospheric Administration as part of the Outer Continental Shelf Environment Assessment Program, and in 1979 by the U.S. Fish and Wildlife Service, Division of Wildlife Ecology and Research.

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Condor 85:368–369

AERIAL INSECT-CATCHING BY AMERICAN KESTRELS

SERI G. RUDOLPH

Capture of flying insects by American Kestrels (*Falco sparverius*) has been reported by several authors (Locke 1961, Balgooyen 1976, Suring and Ault 1981). They describe a type of flycatching behavior in which birds sally out from a perch to capture individual insects at ground or perch height and return directly to the perch. Although I have seen such behavior four times, I describe here another aerial hunting technique that I have observed more frequently, and that apparently has not been reported previously in this species. Similar foraging behavior, variously described as "hawking," "swift-like," or "swallow-like," has been noted in several Old World falcons, including the Lesser Kestrel (*F. naumanni*; Chasen 1920, Sage 1967), Red-footed Falcon (*F. vespertinus*; Congreve 1929, Ticehurst and Whistler 1929), Eleonora's Falcon (*F. eleonorae*; Walter 1979), and European Hobby (*F. subbuteo*; Everett 1976).

While studying foraging behavior (Rudolph 1982), I watched kestrels with binoculars or telescope for 775 half-hour periods distributed evenly between 19 February and 8 July 1979. My study area, near Davis, Yolo Co., California (elevation 14 m), consisted mainly of flat, open agricultural fields divided by narrow strips of riparian vegetation. Most of my observations (89%) were on 10 individual birds, 8 of which (5 male, 3 female) showed what I call "aerial insect-catching behavior" ["flight-hunting" of Collopy and Koplin 1983—ed.]. Each of the 49 episodes I saw began when a bird flew directly out or upward from a perch, and then circled upward using a combination of soaring and flapping flight. This behavior, which is typical of raptors rising in thermal updrafts, contrasted sharply with the direct lateral flight seen in sallying flycatching episodes (e.g., Suring and Ault 1981).

To capture flying insects, birds banked, stalled, or dove abruptly and grasped the prey in the bill. Although kestrels and other raptors commonly use the feet as their capture "tools" (e.g., Everett 1976), Suring and Ault (1981) have also reported insect capture using the bill, and Balgooyen (1976) reported kestrels securing prey with the bill while foraging on the ground. Usually birds ate the insects while soaring, bringing the head down and one foot forward to manipulate the prey as described by Ellison (1946). On 15 occasions, birds descended to a perch with insects caught in this manner, and 13 of these were fed to nestlings or fledglings. The type of insect taken was not evident, although the two that I saw most clearly were 1.5–2.5 cm long.

Frequently birds soared very high and I was unable to follow their captures. During 23 episodes where all movements were clearly discernable for at least 1 min, I counted 51 captures in 57 min, giving a capture rate of 0.89/min. This compares favorably with the capture rates for perch- and hover-hunting (0.19 and 0.43 captures/min, respectively) during my study (Rudolph 1982).

Aerial insect-catching was strongly seasonal, and apparently associated with the period when flying insects became abundant. I never observed aerial hunting before 10 May, and 85% of the episodes occurred between 8 June and 8 July, when my study ended [but see Collopy and Koplin 1983—ed.]. To determine whether other factors affected the use of aerial hunting independently of this seasonal effect, I made further comparisons considering only data from the period from 8 June to 8 July, when aerial hunting was occurring and the same potential range of environmental conditions was available for all activities. Temperatures (at 2 m) and wind velocities (at 10 m) for half-hour periods when aerial insect-catching was observed were compared with temperatures and wind velocities for half-hour periods with at least 5 min of hunting behavior of any type. Aerial hunting occurred at warmer temperatures and lower wind speeds than did hunting in general (for temperature, $\bar{x} = 29.9°C$ compared to 27.7°C, $P < 0.05$; for wind speed, $\bar{x} = 2.4$ m/s compared to 3.2 m/s, $P < 0.01$; *t*-tests with unequal variances, Snedecor and Cochran 1967). Temperature and wind speed might affect the kestrels' behavior directly, by influencing formation of thermals and the feasibility of soaring flight, or indirectly by altering the abundance of aerial insects.

I thank P. D. Boersma, A. J. Hansen, G. J. Kenagy, J. R. Koplin, C. H. Stinson and an anonymous reviewer for their comments on various drafts of this manuscript, and G. B. Van Vliet for bringing the aerial foraging of European falcons to my attention.

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Condor 85:369–371

DIET, CAPTURE SUCCESS, AND MODE OF HUNTING BY FEMALE AMERICAN KESTRELS IN WINTER

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The hunting behavior and capture success of American Kestrels (*Falco sparverius*) are relatively well known (Jenkins 1970, Sparrowe 1972, Balgooyen 1976, Berdan 1976, Cruz 1976, Bildstein 1978, Rudolph 1983); however, the relationships between diet, foraging mode, and capture success have been addressed only for breeding kestrels (Rudolph 1982). We investigated whether wintering kestrels forage in particular ways in order to capture certain kinds of prey, and whether energetically costlier modes of hunting procure proportionately more of large prey items.

STUDY AREA AND METHODS

Our study was conducted in the Arcata Bottoms, west of Arcata, Humboldt Co., California. This 984-ha area is bordered on the south by Humboldt Bay, on the west by the Pacific Ocean, on the north by the Mad River, and on the east by the city of Arcata and surrounding redwood (*Sequoia sempervirens*) forest. Wheeler and Harris (1970) identified the four major types of land-use in the Arcata Bottoms: permanent pastures (712 ha), hay fields (207 ha), sloughs and remnant tide channels (53 ha), and dikes and roads (12 ha).

We monitored the hunting behavior of seven kestrels on winter feeding territories, four during October 1972–March 1973 and three during September 1973–March 1974. Observations of wintering male kestrels were difficult to obtain since the male:female sex ratio in the Arcata Bottoms was 1:9 (Koplin 1973); therefore, data presented here are restricted to females. Birds were not marked, so some individuals may have been studied in both years. Focal-animal sampling (Altmann 1974) was used to monitor kestrels during dawn-to-dusk observations. Three types of hunting were recognized:

Perch-hunting. Searching for prey from a perch; characterized by frequent turning and bobbing of the head.