

PREDATORY EFFICIENCY OF AMERICAN KESTRELS WINTERING IN NORTHWESTERN CALIFORNIA*

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ABSTRACT. A study of foraging behavior of the American Kestrel (*Falco sparverius*) wintering in Humboldt County, California was undertaken from October 1972 to February 1973. An analysis of predatory efficiency and prey selection is presented on the basis of numbers of species taken relative to the number of capture attempts, and the relative frequency with which they occur in the Kestrel's diet. A total of 498 capture attempts was observed; of these, 233 (46.8%) were successful, 221 (44.4%) were unsuccessful, and 44 (8.8%) were undetermined. Of the 233 successful captures 199 (85.4%) were invertebrates (beetles, grasshoppers, earthworms, butterflies and other insects) and 34 (14.6%) were vertebrates (mice, shrews and birds).

The American Kestrel (*Falco sparverius*) is one of the most common raptors in the New World, and has been the subject of many studies. Cade (1955) studied winter territoriality among Kestrels in southern California and suggested that territoriality serves to secure an adequate food supply through the winter. Roest (1957) described different aspects of breeding behavior, hunting methods and social interactions among Kestrels. Willoughby and Cade (1964) described the breeding behavior of captive Kestrels. Enderson (1960) reported on movements in a resident Kestrel population in east-central Illinois.

The lack of studies concerning prey selection and predatory efficiency among raptors, in general, and the American Kestrel, in particular, prompted this study of foraging behavior. Observations were made from October 1972 to February 1973 in the Arcata Bottoms east of Arcata, Humboldt County, California. The results reported here are part of a larger study to relate predatory efficiency, prey selection and activity budget, as observed in the field, to metabolic rates measured in the laboratory. The project is ongoing; more field data will be collected.

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Study Area

The Arcata Bottoms consist of extensive pasture land used for grazing cattle. It is an ecological unit 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 the surrounding Redwood (*Sequoia sempervirens*) forests. Vegetation in the Arcata Bottoms consists predominantly of grasses, forbs, shrubs and few trees.

Materials and Methods

Observations of Kestrels were made during all daylight hours including as many full days as possible. Kestrels habitually used fence posts, power poles and power lines as perches; observations were readily obtainable. A spotting scope, binoculars and stop watch were used to observe and time the hunting activities of Kestrels under observation.

Rodent censuses in areas of hunting activities were made with use of Sherman live traps and the rate of capture technique (Davis 1963).

Prey Selection

Comparative analysis of the hunting efficiencies of male and female Kestrels was not possible because of the small number of males observed. The male to female ratio of Kestrels wintering in the Arcata Bottoms was one to nine (Koplin 1973). Observations of the males present were difficult to obtain; for this paper, data on both sexes were combined.

Observations were made on 24 American Kestrels, with intensive observations on six. Dives which resulted in the capture of prey or which resulted in landing on the ground were considered "completed dives."

Over the five-month period, 498 completed dives were recorded; of these, 233 were successful. Identification of food items showed that 34 were vertebrates and 199 were invertebrates. The relative frequency of each is shown in Table 1. Identifiable invertebrates included five grasshoppers, nine beetles, nine earthworms, and two butterflies. Identifiable vertebrates included six California Meadow Voles (*Microtus californicus*), three Western Harvest Mice (*Reithrodontomys megalotis*), and 18 Vagrant Shrews (*Sorex vagrans*). Two small birds and five small mammals could not be identified.

Considered on a seasonal basis, the data show that the number of invertebrate prey decreased and the number of vertebrate prey increased during the winter (Figure 1). The capture of vertebrates reached a peak during December, the coldest month in Humboldt County history. In subsequent months, the frequency of invertebrates taken increased with a corresponding decrease in the number of vertebrates taken.

Censuses of insect populations were not conducted. No quantitative evidence exists to determine whether the Kestrels selected rodents and shrews in preference to available insects, or fed primarily on rodents and shrews in the absence of insects. However, during December, unusually large numbers of Killdeer (*Charadrius vociferus*) moved into the study area from the north and from the

Table 1. Prey species captures by American Kestrels wintering in Humboldt County, California.

Prey Species	Number Captured	Percent of 233 Prey Captured
Invertebrates		
grasshoppers	5	2.2
beetles	9	3.9
earthworms	9	3.9
butterflies	2	0.9
unidentified insects	174	74.7
total invertebrates	199	85.6
Vertebrates		
<i>Microtus</i>	6	2.6
<i>Reithrodontomys</i>	3	1.3
<i>Sorex</i>	18	7.7
unidentified mammals	5	2.2
small birds	2	0.9
total vertebrates	34	14.7
Total Prey Captured	233	99.3

surrounding foothills. A great many of these terrestrial insect-eating birds subsequently starved to death. This was one indication that Kestrels were feeding primarily on rodents and shrews in the absence of insects.

An attempt was made to assess variation in the availability of rodents and shrews. Because of the small numbers captured by Kestrels and the lack of population estimates from trapping data, small birds and Western Harvest Mice were not included in the analyses. Through the fall and winter months, estimates of prey densities were obtained in two areas where Kestrels commonly hunted. During the census periods, there was no significant difference between the two areas in the relative numbers of prey species trapped ($X^2=0.72$; $p=0.25-0.50$, 1 d.f.).

There was a decline in prey densities in excess of 50 percent between the fall and winter censuses. However, in each area the difference between the relative number of prey species trapped in the winter, and in the fall, was not statistically significant ($X^2=3.19$; $p=0.10-0.05$, 1 d.f.).

Thus, it was possible to combine the data from both areas for estimates of densities of *Microtus* and *Sorex* populations. A Chi-square test was made of the

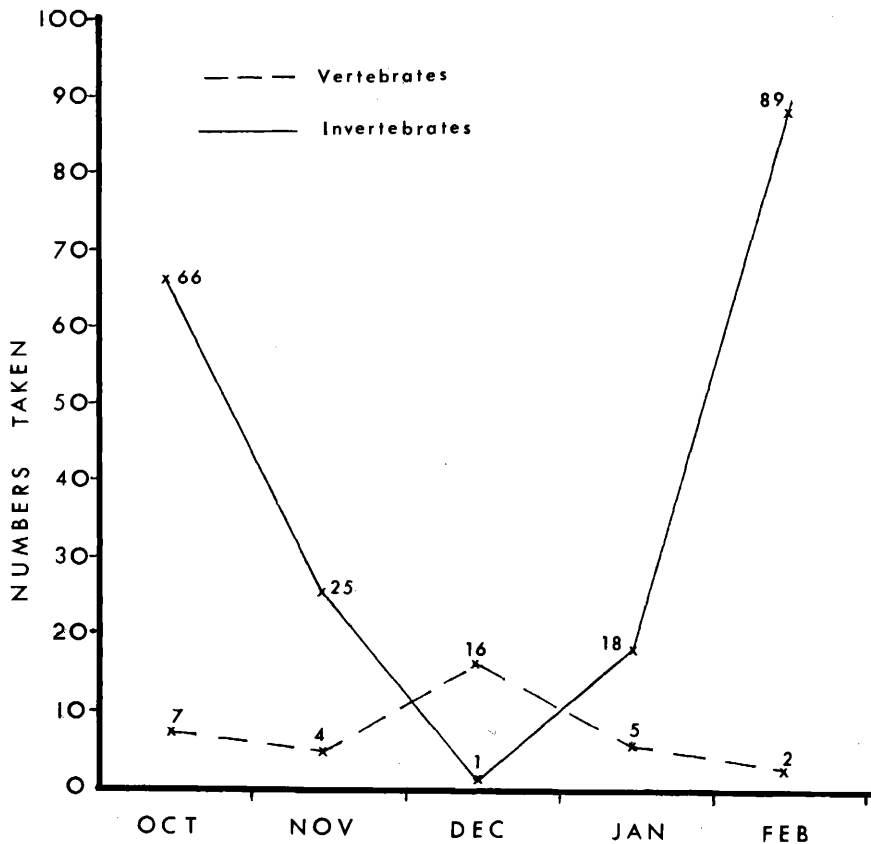


Figure 1. Numbers of vertebrates and invertebrates captured monthly by wintering American Kestrels.

relative frequency of *Microtus* and *Sorex* captured by the Kestrels, and the relative numbers trapped. This test was made to determine if selection for a particular prey species was occurring. The Kestrels captured *Microtus* and *Sorex* in the same relative proportions as trapped ($X^2=1.18$; $p=0.025-0.500$, 1 d.f.). This indicates no measurable selection for either of the two major vertebrate prey species.

A final comparison was made between the fall and winter rodent and shrew densities, and the fall and winter rodent and shrew captures by the Kestrels. The increase in the incidence of captures in the winter and the measured decreases in the densities were significantly different ($X^2=9.28$; $p=0.005$, 1 d.f.). This supports the postulate that Kestrels exploited the rodent and shrew populations in the absence of insect prey.

Hunting Efficiency

I observed 498 capture attempts; of these, 233 (47 percent) were successful, 221 (44 percent) were unsuccessful and 44 (9 percent) were undetermined (Figure 2). The inability to assess the success of a dive resulted from a Kestrel diving into a gully, behind a bush or behind other visual obstructions. Eliminating such observations, the Kestrels captured prey during 51 percent of their capture attempts.

Kestrels most commonly hunted from a perch; however, they also hovered while hunting. Of 95 completed dives from a hovering position, 22 (i.e. 23 percent) were successful, 69 (73 percent) were unsuccessful, and 4 (4 percent) were undetermined. Of the 403 completed dives from a perch, 211 (52 percent) were successful, 152 (38 percent) were unsuccessful and 40 (10 percent) were undetermined. These data demonstrate that hunting from a perch was a more

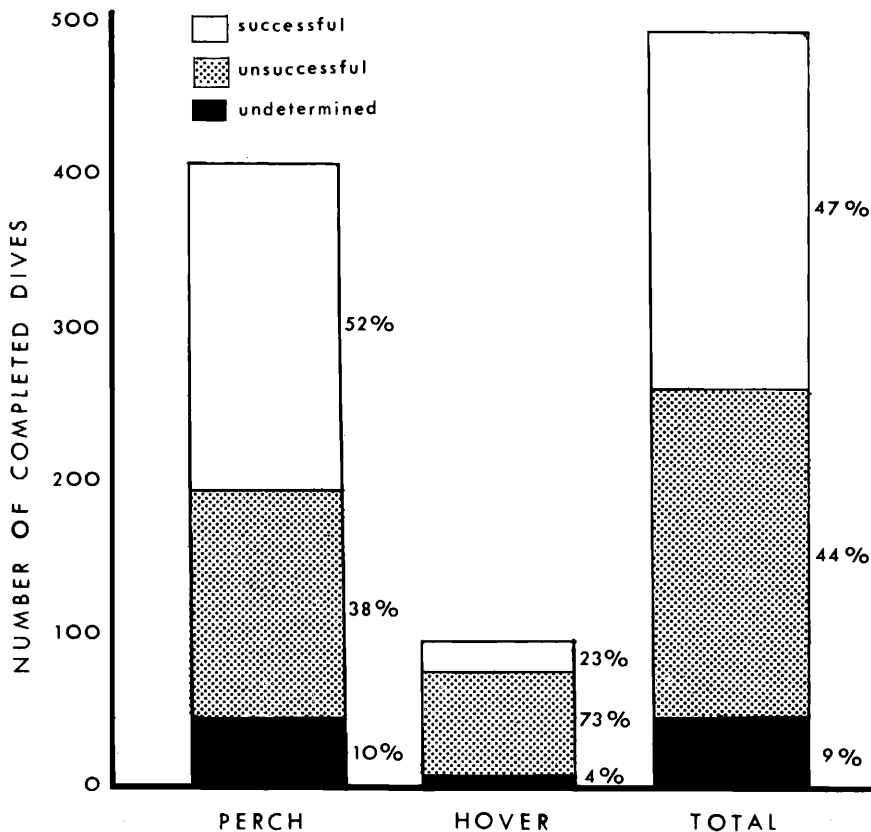


Figure 2. The success of hunting methods used by wintering American Kestrels.

efficient means of capturing prey.

I attempted to differentiate vertebrate hunting attempts from invertebrate hunting attempts. This separation was based on observed differences in hunting methods. Fast, flex-gliding dives were classified as "vertebrate dives", and soft, fluttering dives were classified as "invertebrate dives." Of those dives in which the success was determined, 36 of 145 (25 percent) of the "vertebrate dives" were successful, while 198 of 309 (64 percent) of the "invertebrate dives" were successful. These results reflect the greater mobility of the rodent and shrew prey. Considering the diverse diet of the Kestrel, the possible existence of prey-specific hunting behavior should be investigated. The evolution of specialized hunting methods might be a contributing factor in the widespread success of this species.

Discussion

Several recent studies provide additional information on the hunting success of Kestrels. In Costa Rica, Jenkins (1970) recorded a hunting efficiency of 39 percent by a male Kestrel. Sparrowe (1972) observed 54 capture attempts by 20 Kestrels in Michigan; of these, 33 percent were successful. The differences in predatory efficiency between these studies and mine could be attributed to small sample size. However, these differences could also reflect differences in habitats, or differences in availability of prey species, or a combination of both.

Rudebeck (1951) recorded an over-all hunting efficiency of eight percent among migrating European Sparrow Hawks (*Accipiter nisus*), Peregrine Falcons (*Falco peregrinus*), Merlins (*F. columbarius*) and White-tailed Sea Eagles (*Haliaeetus albicilla*). This is considerably lower than the 51 percent hunting success recorded among American Kestrels wintering in the Arcata Bottoms, indicating the advantage of maintaining a territory. Increased hunting efficiency could result from familiarity of winter residents with locations of available food resources. Future observations on hunting efficiency of migrating Kestrels in the Arcata Bottoms should indicate whether or not this is the case.

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