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THE RELATIONSHIP OF VEGETATIVE COVER TO DAILY RHYTHMS OF PREY CONSUMPTION BY AMERICAN KESTRELS WINTERING IN SOUTHCENTRAL FLORIDA

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ABSTRACT.—American Kestrels (*Falco sparverius*) wintering in southcentral Florida were captured in order to collect their pellets. Dry mass of pellets was used as an index to the accumulated mass of prey consumed between dawn, when pellets representing prey consumed the previous day were regurgitated, and time of capture. Kestrels holding territories covered by a large proportion of suitable hunting substrate (grasses and weedy forbs <25 cm in height) consumed greater prey mass during morning than did kestrels inhabiting territories of lesser foraging quality. No difference was found between territories of high and low foraging quality in terms of total prey mass consumed by the end of the day. For reasons unrelated to habitat preference, most territories of high foraging quality were occupied by females, but within habitats of either high or low foraging quality, the temporal patterns of prey mass accumulation by males and females were similar. These results are consistent with observed kestrel activity budgets, and lend further support to the hypothesis that observed temporal differences in foraging behavior between males and females were due to differences in foraging quality of their territories; there was no evidence of any inherent sex-specific differences in predatory behavior. Foraging quality of kestrel winter territories in the study area was a function of the extent to which locations were covered by open patches of mutually preferred foraging substrate.

Segregation by habitat in wintering American Kestrels (*Falco sparverius*) has been widely reported (Koplin 1973; Mills 1976; Stinson et al. 1981; Smallwood 1981, 1987; Bohall-Wood and Collopy 1986). Several lines of empirical evidence have been presented which strongly suggest that the solitary winter territories held by female kestrels in southcentral Florida differ substantially from those held by males in regard to foraging quality; 1) females were more common than males in habitats extensively covered by suitable hunting substrate, 2) the territories of females were characterized by fewer and smaller trees and shrubs (woody vegetation was negatively correlated with coverage by suitable hunting substrate and obstructed the views of foraging kestrels), 3) males were less likely than females to reject an opportunity to capture novel prey items, and 4) males suffered a greater absolute and relative weight loss in response to weather-related decreases in prey availability (Smallwood 1987).

Differential habitat use by the sexes was shown to be related to the date of arrival on wintering grounds, most of the adult males arriving last, rather than to differences in habitat preference (Smallwood 1988). In fact males and females established territories in the same type of habitat, when available, and all kestrels utilized open patches of the same type of foraging substrate regardless of the overall vegetative structure of the territory. Diets of males and females were also similar; both sexes fed exclusively on arthropods during winter (Smallwood 1987).

In a study of kestrel activity budgets (Smallwood 1987), it was shown that males and females had virtually identical capture success, once a capture was initiated, and captured similar numbers of prey each day. However, sexes exhibited markedly different daily rhythms of foraging activity. The rate at which males made capture attempts did not change significantly throughout the day. In females, however, rates increased during morning, reaching a peak before noon. Hunting activity of females was markedly lower during early afternoon, increased in mid-afternoon and then waned toward evening.

Differences in daily foraging rhythms were interpreted as evidence of differential foraging quality of the respective territories. Apparently, most males were constrained to forage actively throughout the day in order to capture a sufficient number of prey items. Because females were more likely to be occupying territories of relatively high foraging quality, they were able to meet a large portion of their prey requirements early in the day. Later in the day, females allotted more time toward nonforaging activities.

The above interpretation was based on the assumption that mean prey size did not differ for males and females, that is, the similar number of prey items consumed/d by males and females represented similar nutrient rewards. Given the observed differences in daily foraging rhythms between the sexes and the assumption of equal mean prey size, the cumulative prey mass (CPM) consumed by females should differ from the CPM of males in a predictable manner throughout the day. The CPM of females should be greater than that of males during morning, when female foraging rates reach a maximum. The much reduced foraging activity of females in the early afternoon, during which males still actively forage, and the similarity of the total daily number of prey captures should result in similar CPM values for males and females during afternoon. If differences in CPM values are due to differential foraging quality rather than to an inherent sex-specific difference in foraging behavior, then kestrels holding territories of similar foraging quality should exhibit similar temporal patterns of prey mass accumulation, regardless of gender.

The objective of this study was to examine the temporal patterns of prey mass accumulation by male and female kestrels occupying winter territories covered to various extents by grasses and weedy forbs <25 cm in height. In this manner, the importance of kestrel gender and territory habitat were compared in regard to foraging behavior. In addition percent coverage by suitable hunting substrate, as defined above, was evaluated as a reliable indicator of the foraging quality of kestrel winter territories.

STUDY AREA AND METHODS

The study area was centered on 27°00′N, 81°20′W, west of Lake Okeechobee in southcentral Florida and included portions of Highlands, Glades and Hendry counties. Most of this land is covered by pastures, citrus groves and residential developments. Numerous ponds, slash pine (*Pinus elliotii*) plantations, scrubby flatwoods and cypress (*Taxodium distichum*) sloughs are situated throughout the area (see Smallwood 1987).

Kestrels do not begin their daily foraging activities until after regurgitation of the undigested material from prey consumed on the previous day (Balgooyen 1971; pers obs.). Thus, kestrels begin foraging "on an empty stomach," and the indigestible food material which then accumulates is a record of that day's prey consumption. Pellet mass was considered an index of the mass of consumed prey.

Kestrels were captured with a modified *bal-chatri* trap (Berger and Mueller 1959) from 3 January–23 February 1984, and from 18 December 1984–2 February 1985 Time of day of capture was recorded, and captured birds were held in cages overnight and regurgitated pellets collected the following morning. Each kestrel was subsequently released near its capture site. Pellets were air-dried at least 96 h prior to being weighed to the nearest 0.0001 g (Mettler AE 163 digital balance, Mettler Instrument Corp., Highstown, NJ).

Because 97.5% of all observed capture attempts by kestrels directed toward naturally occurring prey were made onto substrates of grasses or weedy forbs <25 cm in height (Smallwood 1987), this category of ground vegetation was operationally defined as suitable hunting substrate. The foraging quality of kestrel territories was estimated by sampling a 1-ha circular plot centered on each kestrel's hunting perch at the time of capture, measuring percent coverage by suitable hunting substrate (see Smallwood 1987 for a detailed description of the sampling technique)

Data were analyzed in the following manner. Kestrel territories were ranked with respect to the estimate of percent coverage by suitable hunting substrate. The ranked list of territories was then divided arbitrarily into two groups of approximately equal sample size, the respective pellets representing territories with >50% coverage by suitable hunting substrate (high foraging quality) or territories with coverage ≤50% (low foraging quality). Each pellet thus represented either a male or female kestrel captured either before or after solar noon (i.e., either a morning or afternoon CPM value) from a territory of either high or low foraging quality. Association between kestrel gender and foraging quality of the territory was tested for significance with a Chi-square test of homogeneity (Fienberg 1977). With respect to mass, pellets representing high and low foraging quality habitats were compared with Wilcoxon's rank sum tests (Hollander and Wolfe 1973) separately for four combinations of kestrel gender and time of day. In addition, males were compared to females with respect to pellet mass with Wilcoxon's rank sum tests separately for four combinations of foraging quality and time of day.

RESULTS

Pellets were collected from a total of 169 kestrels. Pellets from 33 individual kestrels were chosen at random and were sacrificed for a concurrent study. Thus, results were obtained from measurements of 136 pellet samples.

Foraging quality of territories was significantly associated with kestrel gender. Of the 82 females sampled, 67% occupied territories of high foraging quality; only 20% of the 54 males sampled were found in high quality habitats (χ^2 = 28.43, P < 0.001).

For birds captured before solar noon, pellets representing locations of high foraging quality had significantly greater mass than those representing territories of lower foraging quality for both males and females (Wilcoxon's Z = 1.81, P = 0.036, and Z = 1.69, P = 0.045, respectively; Fig. 1a). No association between pellet mass and the foraging quality of the respective territories was found for pellets representing afternoon CPM values for either males or females (Z = 0.68, P = 0.50, and Z = 0.88, P = 0.38, respectively; Fig. 1b). No differences in pellet mass were found between males and females in high quality habitats during morning (Z = 0.27, P = 0.80) or afternoon (Z = 0.93, P = 0.35), or in low quality habitats during morning (Z = 0.04, P = 0.97) or afternoon (Z = 0.91, P = 0.37).

DISCUSSION

Several interrelated conclusions may be drawn from these results. First, these data support the model of prey mass accumulation rhythms for kestrels inhabiting territories of various foraging quality, as suggested by the observed difference in kestrel activity budgets (Smallwood 1987). Kestrels occupying the "best" habitats differed from those in poorer habitats in rate of prey mass accumulation early in the day, but not in total prey mass consumed by the end of the day. It is unlikely that a kestrel would normally occupy a territory of such poor foraging quality that a sufficient mass of prey could not usually be captured on a daily basis.

It has been demonstrated previously that males and females consume a similar number of prey items per day (Smallwood 1987), and the present study suggests that the total daily mass of prey consumed by males and females is also similar. If the relation-

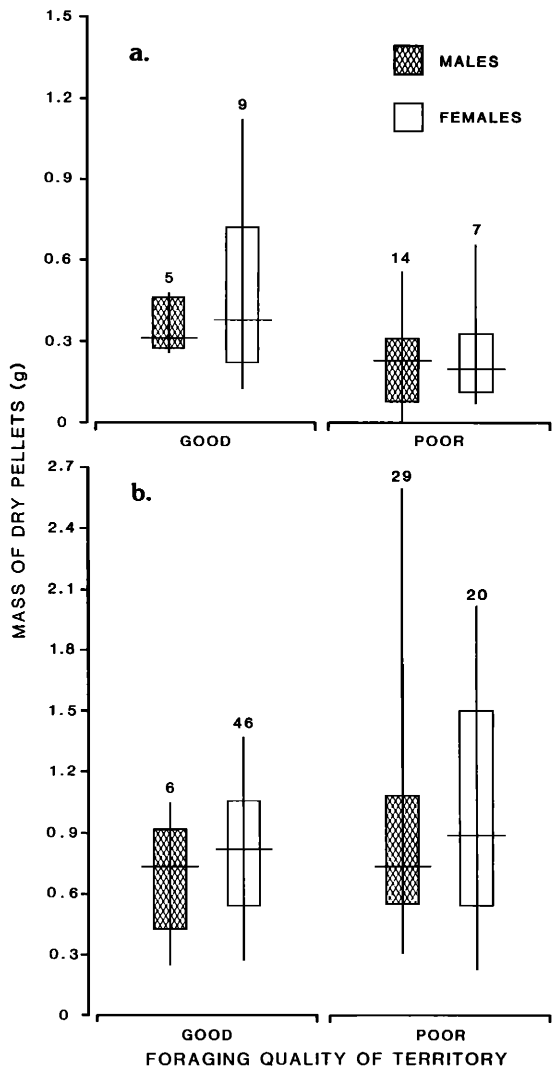

Figure 1. Cumulative mass of prey consumed a) before solar noon and b) throughout the day by American Kestrels occupying winter territories in southcentral Florida. Mass of dry pellets was used as an index of consumed prey mass. Ranges, quartile deviations and sample sizes are shown. Territories with >50% coverage by suitable hunting substrate (grasses or weedy forbs <25 cm in height) were considered to be of good foraging quality; territories with suitable hunting substrate coverage ≤50% were considered poor.

ship between prey mass and pellet mass is the same for each sex, then mean size of prey captured by males and females must also be similar. In addition it appears that mean size of prey captured by kestrels is not dependent on foraging quality of a territory. Relative to large patches, small patches of suitable hunting substrate apparently support prey communities which are similar in terms of prey size. If prey density is a function of the type and height of ground vegetation, rather than of patch size, then total prey mass available to kestrels is proportional to patch size.

The amount of coverage by suitable hunting substrate was successfully used to predict differences in CPM values. This result corroborates that percent coverage by grasses or weedy forbs <25 cm in height is a biologically meaningful measure of the quality of a location in southcentral Florida with respect to foraging by kestrels. Preference for open patches of short ground vegetation by hunting kestrels has been well documented (e.g., Balgooyen 1976).

Results of this study lend further support to the hypothesis that observed temporal differences in foraging behavior between males and females (Smallwood 1987) were due to differences in the foraging quality of their territories rather than to inherent sex-specific differences in predatory behavior. Although males and females, on average, occupy different macrohabitats (Smallwood 1987, 1988), they depend on the same microhabitats for foraging. Both sexes feed on the same kinds of prey (see also Cade 1960; Balgooyen 1976) captured in open patches covered by the same kind of hunting substrate. It appears that the foraging quality of kestrel winter territories in southcentral Florida is a function of the extent to which locations are covered by open patches of grasses and weedy forbs <25 cm in height. Those kestrels which occupy territories of similar foraging quality forage similarly, regardless of gender.

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LITERATURE CITED

BALGOOYEN, T. G. 1971. Pellet regurgitation by captive Sparrow Hawks (*Falco sparverius*). *Condor* 73:382–385.

———. 1976. Behavior and ecology of the American Kestrel (*Falco sparverius* L.) in the Sierra Nevada of California. *Univ. Calif. Publ. Zool.* 103:1–83.

BERGER, D. D. AND H. C. MUELLER. 1959. The bal-chatri: a trap for the birds of prey. *Bird-Banding* 30: 18–26.

BOHALL-WOOD, P. AND M. W. COLLOPY. 1986. Abundance and habitat selection of two American Kestrel subspecies in north-central Florida. *Auk* 103:557–563.

CADE, T. J. 1960. Ecology of the Peregrine and Gyrfalcon populations in Alaska. *Univ. Calif. Publ. Zool* 63:151–290.

FIENBERG, S. E. 1977. The analysis of cross-classified data. MIT Press, Cambridge.

HOLLANDER, M. AND D. A. WOLFE. 1973. Nonparametric statistical methods. John Wiley & Sons, New York.

KOPLIN, J. R. 1973. Differential habitat use by sexes of American Kestrels wintering in northern California *Raptor Res.* 7:39–42.

MILLS, G. S. 1976. American Kestrel sex ratios and habitat separation. *Auk* 93:740–748.

SMALLWOOD, J. A. 1981. Prey size selection by wild American Kestrels (*Falco sparverius*) wintering in southcentral Florida. M.Sc. thesis, Miami Univ., Oxford, Ohio.

———. 1987. Sexual segregation by habitat in American Kestrels (*Falco sparverius*) wintering in southcentral Florida: vegetative structure and responses to differential prey availability. *Condor* 89:842–849.

———. 1988. A mechanism of sexual segregation by habitat in American Kestrels (*Falco sparverius*) wintering in south-central Florida. *Auk* 105:36–46.

STINSON, C. H., D. L. CRAWFORD AND J. LAUTHNER 1981. Sex differences in winter habitat of American Kestrels in Georgia. *J. Field Ornith.* 52:29–35.

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