

THE HUNTING BEHAVIOR OF BLACK-SHOULDERED KITES (*ELANUS CAERULEUS LEUCURUS*) IN CENTRAL CHILE¹

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Kites of the genus *Elanus* are found throughout the world principally in open areas such as grasslands, sparse shrublands, and agricultural fields (Brown and Amadon 1968). Because of their characteristic hover-hunting, and their widespread distribution, these kites make interesting subjects for analyses of their hunting behavior. Such studies have been conducted in several regions, including North America (Waian and Stendall 1970, Warner and Rudd 1974, Koplín et al. 1980), Europe (Amat 1979, Heredia 1983), Africa (Tarboton 1978, Mendelsohn 1982), and Australia (Baker-Gabb 1984). However, quantitative information on the hunting behavior of South American kites was nonexistent until now, and is reported here from a locality in central Chile.

MATERIAL AND METHODS

STUDY SITE

We chose the same area from which Meserve (1977) reported the food habits of Chilean kites (Polpaico: 33°09'S, 70°54'W, about 60 km NW of Santiago by road). Our study site was composed of three contiguous fenced agricultural plots planted initially with alfalfa, and later with wheat. Large trees of *Prosopis chilensis* and *Acacia caven* were sparsely distributed in the open fields. Along the edges, dense rows of poplars (*Populus* sp.) were interspersed with scattered willows (*Salix* sp.). All four tree species in addition to fence posts were used by the kites for perching and feeding, and poplars and willows also for nesting. Black-shouldered Kites in Chile belong to the subspecies *Elanus caeruleus leucurus*; miscellaneous information on their biology can be found in Housse (1935), Johnson (1965), Meserve (1977), and Schlatter et al. (1980).

FIELD TECHNIQUES

We formed a four-person field crew with three permanent members (the co-authors of this paper) and different temporary volunteers. These four people in turn formed two-person teams, each assigned to a single bird ("focal-animal sampling," Altmann 1974), with one person recording observations on a tape recorder, and the other provided with binoculars to confirm the

recordings, to determine whether prey items were caught by the kite, and to keep track of the kite when it flew beyond the range of the naked eye. We devised a system of single-letter key words to record the different behaviors of the kites, thus obtaining an alphabetically-coded ethogram similar to Walter's (1983) "actigram." The recordings were later played in the laboratory to time the observations with a stopwatch (precision = 0.01 sec). The two teams used the same model of tape recorder, and communicated by walkie-talkies to avoid confusing the target birds when flying in the same general area.

We quantified the behavior of the kites bimonthly between 1 April 1983 and 24 January 1984, dividing this time span into four seasons as follows: fall (1 April to 18 June), winter (25 June to 10 September), spring (24 September to 4 December), and summer (23 December to 24 January). We obtained a total of 2,613 min (= 43.5 hr) of continuous monitoring of kites. During the fall season, we tracked two kites, but could not make sure that they were the same individuals from day to day, because at least four kites were present in the study area. However, only two individuals wintered, and later nested in the area, thus making us confident that >75% of our observations were of only two individuals of different sex. Black-shouldered Kites are not strongly sexually dimorphic, so we could categorize their gender only after they courted and nested, and then, by focusing on particular molting patterns, we could determine their sex through spring and summer.

We observed that kites in our study area have bimodal hunting activity periods: early in the morning (3 to 4 hr after dawn) and late in the evening (3 to 4 hr before dusk). They seemed to spend most of their day resting, perhaps to a larger extent than nonraptorial birds (see Herbers 1981). During fall and winter, we only worked in the evenings, but during spring and summer both in the morning and in the evening.

BEHAVIORS ANALYZED

We recognized the following behavioral categories:

Active perching. Here, we do not refer to total time perching, which apparently takes the most substantial part of the kite's day. On arriving at the study site we started scanning the field with binoculars. Apparently, kites were hidden in the trees, resting, and thus invisible to us. When about ready to start hunting, they moved to a more conspicuous perch and started grooming themselves for a few minutes. We did not start recording active perching observations until a giv-

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TABLE 1. Time allocated (in percentages of total time recorded) by Black-shouldered Kites to different activities; only evening observations are reported. Results are for both sexes combined.

| Activity | Fall | Winter | Spring | Summer |
|---------------------|-------|--------|--------|--------|
| Active perching | 44.6 | 34.9 | 76.8 | 41.2 |
| Hunting flight | 46.8 | 37.1 | 18.1 | 49.3 |
| Cruising flight | 8.6 | 28.0 | 3.8 | 1.1 |
| Other flight* | 0.0 | 0.0 | 1.3 | 1.8 |
| Feeding nestlings | 0.0 | 0.0 | 0.0 | 6.6 |
| Time observed (min) | 558.7 | 71.8 | 857.7 | 393.4 |

* Courtship and territorial displays.

en kite took off and returned to a perch. By symmetry, we discarded the last observation of perching when we decided that a kite was not going to hunt any more during that period. Consequently, the active perching behavior here refers to the time spent perching between flights.

Hunting flight. This includes those hunting bouts between the moment a given kite left a perch until it perched again. We recognized several subcategories of hunting flight: (a) hovering: the well-known stationary flight typical of kites; (b) interhovers: the glides between a hovering position and another; (c) strike: the descent from a hovering position to the ground; this behavior was sometimes punctuated by one or more stops in mid-air before the final descent, but we did not categorize it as a separate behavioral act; (d) ground: the time spent by a kite on the ground after a strike; (e) pre/posthovering: the time spent by a kite between leaving the perch and the first hover, plus the time between the last hover and the kite's alighting on a perch. On three occasions (during spring) we observed a different hunting technique: aerial pursuit, which a male kite used for capturing small birds. On four other occasions (also during spring) we observed perch hunting, with a male kite dropping directly from a fence post to the ground; presumably this technique was used to capture large insects (coleopterans or orthopterans).

Cruising flight. This refers to a fast, direct mid-altitude flight, apparently used to move between different perches or hunting grounds.

Other flight. This was recorded only during the pairing and nesting period (spring and summer) involving mainly the male. In some cases flight seemed to serve some courtship function: it consisted of an aerial display in front of the mate, approaching it frontally with a slow flight and with wings flapping in an undulating fashion. Sometimes this approach was followed by the transfer of a prey item, and its subsequent consumption by the mate. In some other cases similar aerial displays were made in front of intruding kites, resulting in expulsion of the intruder (the sex of which we could not determine).

Feeding nestlings. This was the time spent by the female (early in the nesting season) passing food to the nestlings, and by both male and female kites doing so later in the nesting season.

TABLE 2. Time allocated (in percentages of total time recorded) by male and female Black-shouldered Kites to different activities during spring and summer. Both morning and evening periods are reported.

| Season and activity | Morning | | Evening | |
|---------------------|---------|--------|---------|--------|
| | Male | Female | Male | Female |
| Spring | | | | |
| Active perching | 54.6 | 93.5 | 84.6 | 94.4 |
| Hunting flight | 30.2 | 0.0 | 10.1 | 3.3 |
| Cruising flight | 5.1 | 5.5 | 2.8 | 2.0 |
| Other flight* | 10.1 | 1.0 | 2.5 | 0.3 |
| Time observed (min) | 300.7 | 265.7 | 388.8 | 242.6 |
| Summer | | | | |
| Active perching | 22.8 | 96.9 | 43.9 | 38.7 |
| Hunting flight | 76.6 | 0.0 | 48.8 | 44.9 |
| Cruising flight | 0.6 | 3.1 | 0.9 | 0.8 |
| Other flight* | 0.0 | 0.0 | 3.7 | 0.0 |
| Feeding nestlings | 0.0 | 0.0 | 2.7 | 15.6 |
| Time observed (min) | 131.9 | 32.7 | 184.7 | 134.6 |

* Courtship and territorial displays.

RESULTS AND DISCUSSION

Allocation of time by Black-shouldered Kites to different activities throughout the year (evenings only) is reported in Table 1. These evening records add up to 1,882 min (= 31.4 hr) of continuous monitoring (i.e., 72% of the total observations). The remainder were recorded during morning periods. Because kites could not be separated by sex during both fall and winter, results from spring and summer (when kites could be assigned to either sex) were pooled into an unsexed category to render figures comparable. Active perching time was constant at about 40% throughout the year, except for spring, when kites devoted almost twice the time (77%) to this activity. Perhaps the incidence of hunting from perches increased during this season, but we have no data to substantiate this. Time allocated to hunting flight decreased from fall to spring, returning to the original levels during summer, when kites were raising nestlings. Cruising flight was generally rare except during winter when kites shifted hunting positions more frequently and over greater distances. Perhaps this reflected the lower availability of prey resources during winter (Glanz 1977, Jaksic et al. 1981). Other flight involved courtship or territorial displays, and was observed only during spring and summer.

It was possible to separate behavioral activities by sex during spring and summer months, when morning observations (731 min = 12.2 hr of monitoring) were made (Table 2). The female spent more time perching and less time hunting in flight than did the male, particularly during summer mornings, when the male did all the hunting. No clear differences were observed in cruising flight between the sexes. The male was more frequently involved in displays than was the female. Feeding of nestlings was observed only during summer evenings, with the female devoting more time than the

TABLE 3. Duration of different activities of Black-shouldered Kites by season (sexes pooled); only evening observations are reported. None of the differences between means in (A), (B), (C), or (D) are significant (all $P_s > 0.20$) by the test of equality of means when the variances are heterogeneous (Sokal and Rohlf 1981:409).

| Activity | Fall | | Winter | | Spring | | Summer | |
|-----------------------|--------------------------|----------|--------------------------|----------|--------------------------|----------|--------------------------|----------|
| | $\bar{x} \pm 2$ SE (sec) | <i>n</i> |
| (A) Active perching | 339 ± 105 | 44 | 215 ± 182 | 7 | 599 ± 212 | 66 | 648 ± 505 | 15 |
| (B) Hunting flight | 391 ± 175 | 23 | 250 ± 144 | 5 | 345 ± 285 | 4 | 152 ± — | 1 |
| Pre/posthovering | 119 ± 27 | 112 | 39 ± 18 | 14 | 124 ± 66 | 14 | 35 ± — | 1 |
| Hovering | 115 ± 14 | 460 | 75 ± 11 | 61 | 62 ± 14 | 33 | 4 ± 1 | 4 |
| Interhover | 92 ± 10 | 379 | 56 ± 11 | 49 | 34 ± 11 | 25 | 5 ± 5 | 4 |
| Strike | 7 ± 3 | 26 | 2 ± 1 | 8 | 5 ± 2 | 2 | | |
| Ground | 11 ± 9 | 7 | 11 ± 9 | 3 | 6 ± — | 1 | | |
| (C) Cruising flight | 58 ± 31 | 12 | 1,205 ± — | 1 | 26 ± 7 | 36 | 20 ± 9 | 13 |
| (D) Other flight* | | | | | 37 ± 16 | 10 | 104 ± 54 | 4 |
| (E) Feeding nestlings | | | | | | | 520 ± 223 | 3 |

* Courtship and territorial displays.

male to this activity. In general, the male was on the wing more in the mornings than in the evenings in both spring and summer, whereas the female did the opposite during summer, with no clear pattern during spring. The proximate cause of differential time allocation by the male during the breeding period seemed to be the need to collect enough prey to feed the female and nestlings. The incubation period apparently affected how the female used its time; during spring it was hardly seen on the wing, whereas during summer evenings it behaved similar to the male.

Mean duration of different activities throughout the year (using only evening observations) is reported in Table 3. There were no statistically significant differences between seasons in either perching, hunting flight, cruising flight, or other flight. Kites appeared remarkably constant in the duration of these specific activities. We did not test for differences in subcategories of hunting flight (pre/posthovering, hovering, interhover, strike,

and ground) because these activities were sequential and constrained by the total time spent in hunting flight, which was not significantly different anyway. Consequently, these data are inherently nonindependent, rendering them inadequate for statistical analysis (Gurevitch and Chester 1986, Swihart and Slade 1986, and references therein).

Similar results were obtained when scrutinizing the mean duration of different activities in morning and evening periods (Table 4). Except for a significant difference observed in mean duration of cruising flight in spring, none of the other means differed between morning and evening periods. Because mean duration of specific hunting activities did not vary between seasons in Black-shouldered Kites, this indicates a relatively constant duration of the components of their hunting repertoire, independent of climatic conditions and prey abundances.

Hunting success of Black-shouldered Kites, how-

TABLE 4. Duration of different activities of Black-shouldered Kites (sexes pooled) in morning and evening periods. There are no significant differences (all $P_s > 0.40$) between morning and evening periods in either spring or summer in (A), (B), (C) (summer only), or (D) by the test of equality of the means of two samples whose variances are assumed to be unequal (Sokal and Rohlf 1981:411). C differs at $P < 0.02$ during spring only.

| Activity | Spring | | | | Summer | | | |
|-----------------------|--------------------------|----------|--------------------------|----------|--------------------------|----------|--------------------------|----------|
| | Morning | | Evening | | Morning | | Evening | |
| | $\bar{x} \pm 2$ SE (sec) | <i>n</i> |
| (A) Active perching | 627 ± 205 | 73 | 599 ± 212 | 66 | 451 ± 252 | 9 | 648 ± 505 | 15 |
| (B) Hunting flight | 428 ± 287 | 7 | 345 ± 285 | 4 | 990 ± 946 | 2 | 152 ± — | 1 |
| Pre/posthover | 171 ± 38 | 45 | 124 ± 66 | 14 | 137 ± 27 | 12 | 35 ± — | 1 |
| Hovering | 67 ± 17 | 98 | 62 ± 14 | 33 | 167 ± 3 | 65 | 4 ± 1 | 4 |
| Interhover | 89 ± 19 | 80 | 34 ± 11 | 25 | 125 ± 13 | 57 | 5 ± 5 | 4 |
| Strike | 10 ± 5 | 6 | 5 ± 2 | 2 | 6 ± 0 | 3 | | |
| Ground | 17 ± 5 | 4 | 5 ± — | 1 | 43 ± — | 1 | | |
| (C) Cruising flight | 79 ± 40 | 23 | 26 ± 7 | 36 | 15 ± 12 | 8 | 20 ± 9 | 13 |
| (D) Other flight* | 48 ± 25 | 8 | 37 ± 16 | 10 | | | 104 ± 54 | 4 |
| (E) Feeding nestlings | | | | | | | 520 ± 223 | 3 |

* Courtship and territorial displays.

TABLE 5. Hover-hunting success of Black-shouldered Kites in different currencies (figures in parentheses are percentages).

| Currency | Fall | Winter | Spring | Summer |
|---------------|------------|----------|------------|------------|
| Strikes/hunts | 14/23 (61) | 3/5 (60) | 23/27 (85) | 21/25 (84) |
| Kills/strikes | 0/14 (0) | 0/3 (0) | 13/23 (57) | 11/21 (52) |
| Kills/hunts | 0/23 (0) | 0/5 (0) | 13/27 (48) | 11/25 (44) |
| Minutes/kill | 262/0 | 27/0 | 246/13 | 295/11 |

ever, changed markedly throughout the year (Table 5). The number of strikes per hunt was relatively low in both fall and winter (when each kite was hunting for itself) and higher in spring and summer (when the male was feeding the nesting female). Kills per strike and per hunt were both surprisingly low during fall and winter, and much higher during spring and summer. Kites observed hunting during fall and winter made no kills, but they made a kill every 19 and 27 min on the average during spring and summer, respectively. Black-shouldered Kites appeared to be remarkably inefficient at hunting when not raising nestlings.

Provided that the main prey of the kites in the study area were the rodents *Akodon olivaceus* and *Mus musculus* (Meserve 1977; pers. observ.) the differential hunting success of these kites through the seasons was a likely consequence of temporal changes in the abundance of local prey resources. Indeed, both rodent species peak in numbers during spring and summer (cf. Glanz 1977 and Jaksic et al. 1981 for *Akodon* sp., Péfaur et al. 1978 for *Mus* sp.), becoming scarcer during fall and winter. The low numbers of strikes observed during these latter seasons may be a reflection of the lower availability of those rodents in the field. The fact that most strikes were unsuccessful suggests that winter months constitute a survival bottleneck for kites in central Chile. However, given that the two overwintering kites in our study site remained paired instead of dispersing to communal roosts (Meserve 1977) speaks against this interpretation. With increased prey availability in spring and summer the number of strikes (and their success) increased accordingly, in keeping with the higher impositions of the breeding period. It is interesting to recall that the duration of hunting did not vary seasonally (Table 3). Consequently, changes in food requirements (breeding vs. nonbreeding) were met entirely by changes in hunting yield (success per unit time, Table 5). Mendelsohn and Jaksic (unpubl.) address this topic in a comparative study of kite hunting behavior in North and South America, Europe, Africa, and Australia.

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SEXUALLY MOSAIC PLUMAGE IN A FEMALE AMERICAN KESTREL¹

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Key words: American Kestrel; *Falco sparverius*; bilateral gynandromorphism; plumage mosaic; endocrine abnormality.

The plumage of the American Kestrel (*Falco sparverius*) is well recognized to be dichromic between the sexes (Mearns 1892, Bent 1938, Bond 1943, Friedman 1950, Parkes 1955, Cade 1982). On 24 July 1986, a female American Kestrel was found along a roadside in Salt Lake City, Utah, apparently having collided with an automobile. The right wing was missing, and the bird was emaciated and generally in poor condition. The bird was euthanized and upon examination showed both male and female plumage characteristics (Fig. 1). The breast plumage color pattern was characteristically female except for the lower left abdominal region (Fig. 1a), where dark brown/black spotting similar to male breast plumage pattern was present.

The rectrices were most aberrant (Figs. 1a, b, c), and hereafter are numbered 1 (outermost) through 6 (central). Rectrix 1 right (1R) is characteristic of a typical female, except the subterminal, black band is considerably wider (Fig. 1c). Rectrix 2R is incompletely barred with black on the outer vane decreasing proximally to form tiny black spots on the margin. The inner vane contains only two partial black bars immediately proximal to a broad, subterminal black band. Rectrix 3R is incompletely barred with black on the outer vane decreasing proximally to form tiny spots as in rectrix 2R. The inner vane contains only a small black spot immediately proximal to a broad, subterminal black band, typical of males. Rectrix 4R contains no barring on either side of the vane. One small, black spot occurs

on the inner vane, near the margin, and immediately proximal to a broad, subterminal black band. Rectrix 5R is virtually identical in color pattern to rectrix 4R. Rectrix 6R is incompletely barred in black on either side of the vane with the inner vane more heavily barred, but the proximal black bars do not meet at the rachis. Rectrix 6R terminates in a broad, black band, proximal to a rust colored tip. Rectrices 1R to 5R are tipped in an ivory/whitish color, typical of males. Rectrices 6R, 6L, and 2L to 5L are tipped in a pale rust color, typical of females. Rectrix 1L is tipped in an ivory/whitish color similar to rectrix 1R.

In general, rectrices 3R, 4R, and 5R are virtually without female characteristics, with the exception of the incomplete barring on the outer vane margin of rectrix 3R. The length of the rectrices does not vary abnormally, but the vane of rectrices 2R to 5R is approximately 2 mm wider than rectrices 2L to 5L. None of the tips of the rectrices show signs of wear (Fig. 1c). Based on crown plumage characteristics (Parkes 1955) the kestrel was considered to be a hatch-year bird.

The gonads were paired, not an uncommon condition that has been found in 30 to 50% of females of the genus *Falco* (see White 1969). The left gonad measured 1.50 × 1.00 mm and the right measured 0.66 × 0.66 mm. The right gonad was somewhat lighter in color and smoother in texture than the left, and neither was enlarged nor contained enlarged follicles. Results of a histological examination of the gonads proved inconclusive in determining whether testicular tissue was present. Visually, both gonads appeared to be ovaries.

The occurrence of sexually mosaic plumage is somewhat difficult to explain, since a variety of systems control secondary sex characteristics in birds. One case of gynandromorphism has been reported for the American Kestrel (Brodkorb 1935), and generally refers to individuals visually one-half male and one-half female

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