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BREEDING BIOLOGY OF APLOMADO FALCONS IN DESERT GRASSLANDS OF CHIHUAHUA, MEXICO

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Abstract.—We located two populations of endangered Aplomado Falcons (*Falco femoralis*) in desert grasslands in north-central Mexico in 1992. During spring 1993, we quantified breeding success, habitat use, and prey selection by the easternmost population, which is located 40 km from the United States. We captured 17 individuals (one subadult male, seven adult males, three subadult females, six adult females) and placed tail-mounted radio transmitters on 15 of them. Females weighed 50% more, had tails 9% longer, and had wing chords 11% longer than males. Breeding season ranges of six radio-tagged individuals monitored more than 100 d ranged from 3.3–21.4 km^2. Woody plant density ranged from 11.2–139.5/ha and percentage of ground-cover ranged from 28.9–69.5% in ten falcon territories. Six of seven nests were in yuccas (*Yucca elata, Y. torreyi*). Seven nesting pairs had a mean clutch size of 2.6, mean hatching success of 1.6, and a mean fledging success of 0.6. We identified 87 prey items from pellets, prey remains, and observed successful hunts; 82 were avian and 5 were insect. Meadowlarks (*Sturnella* spp.) were most abundant on potential prey transects and in the diet of Aplomado Falcons. Brown-headed Cowbirds (*Molothrus ater*), Greater Roadrunners (*Geococcyx californianus*) and hummingbirds (Trochilidae) were identified in diets, but were not detected on transects.

BIOLOGÍA REPRODUCTIVA DE *FALCO FEMORALIS* EN LOS YERBASALES DESÉRTICOS DE CHIHUAHUA, MÉXICO

Sinopsis.—En el 1992, localizamos dos poblaciones del amenazado con desaparecer *Falco femoralis* en los yerbasales desérticos de Chihuahua, México. Durante la primavera del 1993, cuantificamos el éxito reproductivo, uso de hábitat y selección de presas de la población más al este, que queda a 40 km. de los Estados Unidos. Capturamos 17 individuos y le colocamos radiotransmisores a 15 de éstos. Los rabos y alas de las hembras resultaron ser 9% y 11% más largas que los de los machos y además fueron un 50% más pesadas. El área cubierta durante la época de reproducción por seis individuos con radiotransmisores estudiados por más de 100 días varió entre 3.3–21.4 km^2. En el territorio de 10 falcones, la densidad de plantas leñosas varió de 11.2–139.5/ha y el porciento de covertura de suelo varió de 28.9–69.5%. Seis de siete nidos fueron construidos en yucas (*Yucca elata, Y. torryi*). Siete parejas reproductivas tuvieron como promedio una camada de 2.6 huevos, un éxito de eclosiona-

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miento 1.6 huevos y de 0.6 de pichones que dejaron el nido, respectivamente. Del examen de egagrópilos, restos de presas y cacería activa identificamos 87 presas; 82 aves y cinco insectos. Individuos de *Sturnella* spp. resultaron ser las presas más abundantes y presas potenciales en los transectos estudiados. Individuos de *Molothrus ater, Geococcyx californianus* y zumbadores también formaron parte de la dieta del falcón, pero no fueron detectados en los transectos.

The Aplomado Falcon (*Falco femoralis*) historically ranged north to southern Texas through Trans-Pecos Texas to southern New Mexico and southeastern Arizona in the United States (American Ornithologists' Union 1983). Specimen records and documented sightings indicated that it was common throughout its range in the United States until about 1930 (Hector 1987). After the 1930s, Aplomado Falcons apparently declined rapidly within the United States, with the last known nesting occurring near Deming, New Mexico in 1952 (Ligon 1961). Suspected extirpation from the United States, severe pesticide contamination in eastern Mexico (Kiff et al. 1980), and evidence of population declines in northern Mexico led to the 1986 listing of the Northern Aplomado Falcon (*F. f. septentrionalis*) as an endangered species (Shull 1986). By 1990, the nearest free-ranging population to the United States was believed to occur in the savannas of coastal Veracruz, Mexico (Williams and Hubbard 1991).

Unconfirmed sightings and a confirmed sighting of an unbanded Aplomado Falcon in southern New Mexico led us to surmise that populations still existed in northern Mexico. We conducted roadside surveys in Chihuahua, Mexico, and found two populations: one approximately 160 km north and the other approximately 160 km north-northeast of Chihuahua City. The objective of this study was to quantify breeding success, habitat use, and prey selection by Aplomado Falcons in the easternmost population, which is located about 40 km from the United States.

STUDY AREA AND METHODS

From our roadside surveys, we determined that Aplomado Falcons occupied desert grassland (Dick-Peddie 1993) at elevations of 1509–1690 m in northern Chihuahua. The easternmost population, located at about 29°N latitude and 105°W longitude, occupied an area of approximately 47,000 ha, most of which was on a single private cattle ranch. Location of this population is on file with the U.S. Fish and Wildlife Service and Mexico's Secretaría de Desarrollo Social.

We trapped 17 Aplomado Falcons using quonset-shaped bal-chatri traps (Berger and Mueller 1959) from 6 Feb.–20 Apr. 1993. Traps were 30 × 21 × 16 cm, constructed of 1-cm^2 mesh hardware cloth. To minimize trap visibility, sand-colored paint was sprayed on traps prior to attachment of monofilament noose-lines with 7-cm diameter loops. We baited traps with 1–3 live House Sparrows (*Passer domesticus*), European Starlings (*Sturnus vulgaris*), or Rock Doves (*Columba livia*). Traps were placed in an open area or atop an earthen mound within 15–200 m of perched Aplomado Falcons.

Captured Aplomado Falcons were weighed to the nearest 1.0 g using

a Pesola spring scale (mention of brand names does not constitute endorsement by the federal government). Tail and wing chords were measured to the nearest 1.0 mm using a ruler. Sex of individual birds was assigned by comparison to previously recorded nonoverlapping masses for this subspecies (Hector 1981). Age was determined from plumage (Johnsgard 1990). After attaching color- and number-coded expandable plastic leg bands and a 6–8 g Telonics CHP-2P tail-mounted radio transmitter, falcons were released at the capture site.

Marked Aplomado Falcons were located intermittently with time between locations ranging from 1–12 d. Bearings used in triangulation were derived using the loudest signal method (Springer 1979). Pooled visual and triangulated locations were used to compute minimum convex polygon (Jennrich and Turner 1969) estimates of home-range size using the Microcomputer Program for Analysis of Animal Locations (Stüwe and Blohowiak 1985).

We characterized habitats used by Aplomado Falcons using two methods. Woody plant density was quantified using the Point-Centered Quarter Method (Bohnam 1989, Cottam and Curtis 1956), and ground cover was estimated using the Step-Point Method (Evans and Love 1957). Center of origin for three woody plant density transects was either a nest or a perch site that had been used more than four times. Direction for the initial transect was selected randomly with the other two transects being placed 120° on each side of the initial transect. Transects radiated outward to 200 m with sampling points at 100 and 200 m.

Percentage of ground cover was estimated from 1-km transects established parallel to and 5 m to the right (as viewed from the origin) of woody plant density transects. Sampling points on transects were at 1-m intervals. At each sampling point, bare ground, litter, or plant species were recorded. Percentage of ground cover was determined by the number of direct hits/km.

Small birds that were potential prey items were censused along a single 1-km transect established parallel to and 5 m to the left (as viewed from the origin) of the initial woody vegetation transect. These transects were established in eight territories and surveyed 12 times from April–August 1993. Two additional transects were established in mid-June, following the location of two additional nests. These transects were surveyed six times. All small birds within 300 m of the transect line were included in the calculations of potential prey abundance.

Prey selection was determined from observation of successful hunts (n = 9), and from identification of avian prey remains (n = 66) and pellets (n = 12) recovered at pluck and perch sites. Each pellet was considered an individual prey item except when more than one identifiable prey item was identified. We lumped prey items from all three methods for data analysis because of small sample sizes within each category. Means are reported ±1 SD.

RESULTS

We captured one subadult male, seven adult males, three subadult females, and six adult females. Females (421.8 ± 26.4 g, range = 380–458 g) were on average 50% heavier than males (280.6 ± 25.4 g, range = 260–334 g), but females' tail lengths (196.7 ± 7.0 mm, range = 188–208 mm) were only 9% longer on average than males' (181.4 ± 9.3 mm, range = 172–200 mm), and the average female's wing chord (305.8 ± 7.7 mm, range = 291–314 mm) was only 11% longer than that of males' (275.4 ± 5.8 mm, range = 271–289 mm).

Transmitters were attached to 15 individuals. We were unable to relocate one subadult female, and relocated one subadult male only once after transmitter attachment. Monitoring period for the 13 remaining birds ranged to 5 mo. Breeding-season home ranges for six falcons monitored more than 100 d varied from 3.3–21.4 km^2. Ten Aplomado Falcon territories were identified within the study area; eight of these were occupied by radio-tagged individuals.

Most nests were in yuccas (Table 1). The remaining nest was located in a honey mesquite (*Prosopis glandulosa*). Four young fledged from 18 eggs laid. We were probably responsible for the single nest abandonment, because we captured and handled the female just prior to her laying a second egg.

We were unable to determine causes for the seven nestling mortalities. These included emaciated carcasses of 2–3-wk-old individuals found in two separate nests, two from one nest that disappeared when 2-wk-old, and partial remains of two approximately 3-wk-old nestlings found on the ground near their intact nest. The remaining dead nestling was found at the base of the yucca that housed the intact nest.

We identified 25 woody plant species on transects (Montoya and Zwank, unpubl. rep.). Mormon tea (*Ephedra trifurca*) (27%), soaptree yucca (15%), bear-grass (*Nolina texanum*) (10%), honey mesquite (7%), groundsel (*Senecio douglasii*) (5%), creosotebush (*Larrea tridentata*) (5%) and baccharis (*Baccharis thesoides*) (5%) made up 74% of the woody plants found along transects. Yuccas were the only woody plants taller than 2 m. Woody plant density on territories ranged from 11.2–139.5/ha with an average of 72.6 ± 49.6. We identified 71 species along ground cover transects (Montoya and Zwank, unpubl. data). Percentage of ground cover on territories averaged 46.3 ± 12.1% and ranged from 28.9–69.5%.

We identified 87 prey items from Aplomado Falcon pellets, prey remains, and successful hunts that we observed. Of these, 82 were avian and five were insects. Nine species of birds made up 75.5% of the avian diet, with the remaining consisting of unidentifiable birds (8.5%) and 10 avian species occurring at ≤3% (Table 2).

We counted 2566 individuals in 1876 detections of 32 avian species along the potential prey transects (Table 2). Meadowlarks (*Sturnella* spp.) were the most abundant potential prey on transects and in the diet. Cas-

TABLE 1. Description and success for seven Aplomado Falcon nests in Chihuahua, Mexico during Spring 1993.

Site no.	Height[a] (cm)	Plant species on which nest was located	Lining materials	Eggs laid	Eggs hatched	Young fledged
1	274	*Yucca elata*	yucca leaves	3	2	1
2	229	*Yucca elata*	yucca leaves, grass, hair	3	2	0
3	249	*Yucca elata*	grass, hair	3	1	1
4	285	*Yucca elata*	yucca leaves, grass	1	0	0
5	264	*Yucca elata*	yucca leaves, grass	3	2	0
6	320	*Yucca torreyi*	yucca leaves, grass, hair	3	2	2
7	274	*Prosopis glandulosa*	grass, hair	2	2	0
$\bar{x} \pm SD$	270 ± 29			2.6 ± 0.8	1.6 ± 0.8	0.6 ± 0.8

[a] Height above ground.

TABLE 2. Relative abundance by species of avian prey from 82 successful hunts, bird remains and pellets and 2566 birds detected on transects in Aplomado Falcon territories in northern Mexico during spring and summer, 1993.

Avian species	Detected in pellets (%)	Detected on transects (%)
Meadowlarks (*Sturnella* spp.)	19.5	35.78
Common Nighthawk (*Chordeiles minor*)	9.8	0.04
Northern Mockingbird (*Mimus polyglottos*)	9.8	4.71
Unidentified birds	8.5	0.39
Western Kingbird (*Tyrannus verticalis*)	8.5	0.35
Brown-headed Cowbird (*Molothrus ater*)	7.3	0.00
Scott's Oriole (*Icterus parisorum*)	7.3	1.91
Mourning Dove (*Zenaida macroura*)	6.1	4.09
Cactus Wren (*Campylorhynchus brunneicapillus*)	3.6	0.39
Pyrrhuloxia (*Cardinalis sinuatus*)	3.6	0.27

sin's Sparrows (*Aimophila cassinii*), Black-throated Sparrows (*Amphispiza bilineata*), and Horned Larks (*Eremophila alpestris*), the second, third and fifth most abundant species on transects, were not identified in Aplomado Falcon diets. Three prey items, Brown-headed Cowbirds (*Molothrus ater*) (7.3%), Greater Roadrunners (*Geococcyx californianus*) (1.2%) and hummingbirds (Trochilidae) (1.2%) were not detected along potential prey transects.

DISCUSSION

Desert grasslands were relatively homogeneous and extensive in the southwestern United States and adjacent northern Mexico at the time of European settlement (Buffington and Herbel 1965, Hastings and Turner 1965). These grasslands were heavily impacted by drought and overgrazing in the 1890s (Bock and Bock 1988). The Aplomado Falcon may have begun to decline as early as 1905–1909 (Hector 1987). Hector (1987) hypothesized that since overgrazing and this species' decline coincided, overgrazing was probably the primary factor responsible for the decline. While much of the overgrazing has been curtailed, few grasslands appear as they did prior to the turn of the century because of extensive shrub invasion (Buffington and Herbel 1965). Our study documents that Aplomado Falcons occupy the few relict desert grasslands that currently exist in the Southwest that have dense ground cover of grasses interspersed with tall yuccas.

The breeding biology of Aplomado Falcons in these areas appears similar to that reported in other parts of the range. Nests were similar in height to those reported by Bent (1938), but Hector (1981) found a 9.5 m average nest height in Mexico. Another exception was the low fledging success. Mean number of eggs laid on our study site (2.6) was identical to that reported by Hector (1987) as a reliable estimate of clutch size. However, our average brood size (1.6) was smaller than the 2.1–2.4 reported by Hector (1981), and our mean number of young fledged (0.6)

was also lower than the 1.7–3.2 reported as good for medium-sized falcons by Newton (1979).

Age or sexual maturity of paired Aplomado Falcons occupying territories may have influenced reproductive success. Two of three non-nesting pairs consisted of an immature and a mature bird. These pairs defended territories and copulated, but produced no eggs. Similar behavior was documented in Peregrine Falcons (*Falco peregrinus*) of subadult plumage by Temple (1972).

Low reproductive success may have been due, in part, to researcher disturbance. We approached active nests ≤8 times while monitoring nest success and collecting transect data. These ≤30 min disturbances may have contributed to low reproductive success, as raptors have been shown to be sensitive to disturbances during the nesting season (Swenson 1979, Wiley 1975). Researcher disturbance may have contributed to the 40% loss prior to hatching, as inability to complete incubation successfully had been noted by Fraser et al. (1985) to be the cause of most nest failures. Yet, at least one egg hatched from all nests except for the one where we captured the female after she laid her first egg. No additional nest abandonment suggests that Aplomado Falcons can tolerate some nest disturbances before abandoning nests.

Aplomado Falcon diets in northern Mexico consisted primarily of birds. Hector (1981, 1985) previously noted that 94% of the individuals found in prey remains of Aplomado Falcons were birds. Further, Hector (1985) and Jiménez (1993) reported an avian biomass of about 97% in this falcon's diet. Perez (1995), however, found that immature released Aplomado Falcons preyed primarily on insects in southern Texas and Jiménez (1993) found one reptile in Aplomado Falcon diets in Chile.

In 1986, the U.S. Fish and Wildlife Service implemented the reintroduction phase outlined in the Aplomado Falcon Recovery Plan (Keddy-Hector 1990) with a hacking program at the King Ranch and Laguna Atascosa National Wildlife Refuge in southern Texas. This area was chosen because of its proximity to wild populations known to exist in Mexico at that time. However, one concern in listing this species was severe pesticide contamination in eastern Mexico. With documentation of a reproducing population of Aplomado Falcons in Chihuahua, Mexico, the southwestern United States should now be considered as an alternate site for reintroductions because pesticide use is minimal in desert grasslands.

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