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DIET OF ADULT LESSER KESTRELS *FALCO NAUMANNI* DURING THE BREEDING SEASON IN CENTRAL SPAIN

DIETA DE LOS ADULTOS DE CERNÍCALO PRIMILLA *FALCO NAUMANNI* DURANTE LA ÉPOCA REPRODUCTORA EN ESPAÑA CENTRAL

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SUMMARY.—Pellet analyses were used to study dietary variation in the lesser kestrel during spring 2009 at a colony in central Spain. Coleoptera (92%) were preferred in early spring and Orthoptera (22%) in May and June. No seasonal changes in the abundance of other prey items were detected. Small mammals were the principal prey (50%), in biomass terms, during the breeding season. Comparisons with previous studies show that lesser kestrel diet varies between colonies, chiefly according to the surrounding land use. It may also vary between and within years at the same colony according to changes in availability of different types of prey.

RESUMEN.—En este trabajo se estudia la variación en la alimentación del cernícalo primilla, mediante la recogida de egagrópilas, durante la primavera de 2009 en una colonia de la Comunidad de Madrid. La especie tiene clara preferencia por los coleópteros durante marzo y abril (92%), pasando a depredar también sobre ortópteros (22%) en mayo y junio. No presenta variaciones para el resto de presas. Los micromamíferos se manifiestan como la principal presa (50%) en términos de biomasa a lo largo del periodo reproductor. Tras la comparación con estudios anteriores, se puede concluir que la dieta del cernícalo primilla varía entre colonias, debido principalmente al uso del territorio, e incluso entre años y meses dentro de la misma colonia en función de la disponibilidad de los distintos tipos de presa.

Pellet analysis has been used to study raptor diets since the early 20th century (Errington, 1930; Howard, 1958), providing information on food preferences. The lesser kestrel *Falco naumanni* has a mainly insectivorous diet based on large insects, including Orthoptera and Coleoptera. Small mammals are also taken frequently during the breeding season but birds and reptiles are rarely caught. The entomophagous diet of the lesser kestrel has been corroborated by studies in Europe (Franco and Andrada, 1977; Choisy *et al.*, 1999; Lepley *et al.*, 2000; Rodríguez *et al.*, 2010), Africa (Kopij, 2002) and Asia (Hüe and

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Etchecopar, 1970). The main goals of the present investigation were to examine dietary variation in the lesser kestrel during the breeding season in central Spain, making comparisons with earlier studies and considering possible implications for species management.

The study was carried out during March-June 2009 at a purpose-built lesser kestrel nesting house at Perales del Río, Madrid (30TVK365, 643 masl). The principal land use is cereal cultivation, c. 55% of the area being barley *Hordeum* sp., with a further 30% fallow. Field boundaries and uncultivated land (10%) were the other two biotopes in the study area, natural vegetation comprising dwarf gypsium shrubs (*Gypsophila hispanica*, *Gypsophila struthium*, *Thymus* spp.). Human disturbance within the study area was minimal since GREFA (Grupo de Rehabilitación de la Fauna Autóctona y su Hábitat) manages 500 ha where phytosanitary treatments and cattle rearing are prohibited. Although this area does not include the total home range of the species (Tella *et al.*, 1998) it does take in its critical foraging habitat (Rodríguez and Bustamante, 2008). The area sustains one of the principal colonies in Madrid, with 26 breeding pairs in 2009.

Pellets were collected at communal roosts surrounding the colony so the study only considered the adult diet. Prey remains were examined using a hand lens and a binocular microscope and identified from various guides and keys (Zahradník, 1990; Chinery, 2006). Remains were separated into four taxonomic categories: Orthoptera, Coleoptera, small mammals and birds. The maximum number of hard structures found was used to quantify insect numbers. The number of individual prey items in each pellet was based conservatively on the number of same-side anatomical structures found, treating each pellet as an independent unit since the lesser kestrel does not return to prey remains (Franco and Andrada, 1977). Ingested biomass was estimated using the size category classi-

TABLE 1

Lesser kestrel diet at Perales del Río during the 2009 breeding season, as percentages of total frequency (fN) and biomass (fB). The asterisks indicate values significantly different from those of previous months ($p < 0.01$).

[Dieta del cernícalo primilla en el área de Perales del Río durante el periodo reproductor de 2009, basada en porcentaje de cada tipo de presa sobre el número total de presas (fN) y porcentaje de biomasa (fB). Los asteriscos indican valores significativamente diferentes al mes anterior (p < 0,01).]

	March		April		May		June		Total	
Prey type	fN	fB	fN	fB	fN	fB	fN	fB	fN	fB
Coleoptera	91.5	49.5	93.7	54.6	73.1*	34.6*	67.3	32.9	77.7	39.6
Orthoptera	2.1	1.6	0.6	0.6	18.1*	11.1*	26	16.9	14.5	9.8
Small mammals	6.4	48.9	5.7	44.8	8.3	52.4	6.7	50.2	6.7	50.1
Birds	0	0	0	0	0.5	1.9	0	0	0.1	0.5
Number of pellets	20		30		53		53		156	

fication of Franco and Andrada (1977), with four categories for Coleoptera (category 1, 0.1 g; 2, 0.2 g; 3, 0.75 g; and 4, 1.5 g), and three for Orthoptera (category 1, 0.5 g; 2, 1 g; and 3, 1.5 g). Biomass of small mammals was taken as the maximum pellet size recorded (16 g; Franco and Andrada, 1977).

All diet analyses were tested by one-way analysis of variance using pellets as independent units. Tukey's HSD *post hoc* test was used to examine differences between successive months. The analysis used different months as independent variables and the percentages of each prey type and biomass as dependent variables. The category birds was not considered since bird remains only occurred in one pellet. In total 156 pellets were collected over the four months (table 1). In all, 650 prey items were identified, 78.8% Coleoptera and 14.5% Orthoptera (table 1), these two insect orders constituting the core diet (93.3%). Small mammals amounted to 6.7% of prey items but 50.1% of the ingested biomass (table 1). Coleoptera were second to mammals in terms of ingested biomass (39.6%), followed by Orthoptera (9.8%).

Differences between months in Coleoptera and Orthoptera were significant (fig. 1; ANOVA: Coleoptera, $F_{3, 152} = 12.137$, $P < 0.01$; Orthoptera, $F_{3, 152} = 8.316$, $P < 0.01$). Coleoptera were the most abundant prey items in early spring (Tukey's HSD, $P < 0.01$), accounting for over 90% of captures. They became significantly less important in May and represented less than 70% of prey items at the end of the breeding period (table 1), whereas Orthoptera increased significantly in terms both of capture frequency (Tukey's HSD, $P = 0.017$), constituting 0.6% of the captures in April and 26% in June (table 1). There were no significant inter-month differences in capture frequencies of small mammals (ANOVA: $F_{3, 152} = 0.164$, $P = 0.926$) across the breeding season.

Biomass showed similar trends, with between month differences in both Coleoptera

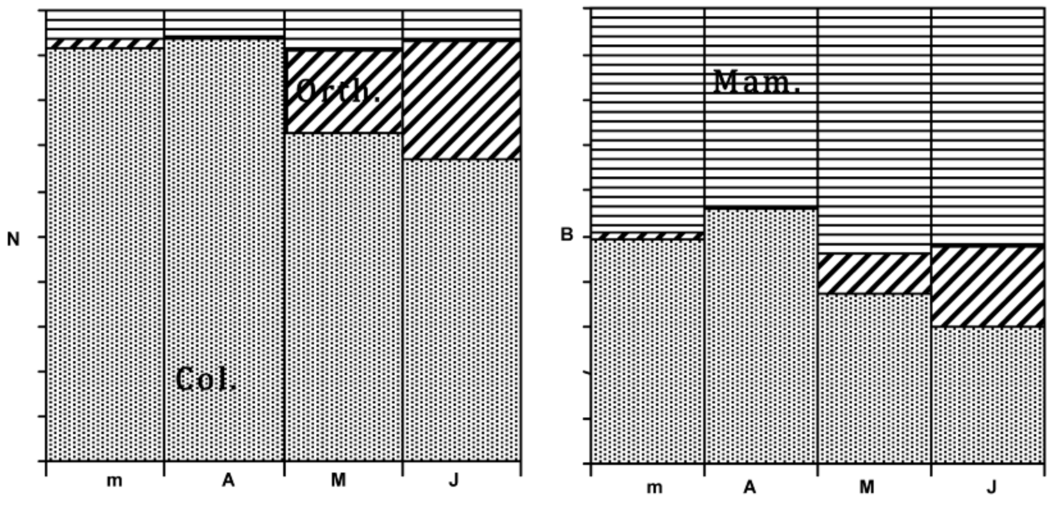

FIG. 1.—Monthly variation in the percentage representation of different prey types in terms of frequency (N) and biomass (B).
[Evolución mensual del porcentaje de cada tipo de presa sobre el total (N) y biomasa (B).]

and Orthoptera (ANOVA: $F_{3, 152} = 13.58$, $P < 0.01$ and $F_{3, 152} = 8.52$, $P < 0.01$, respectively). Coleopteran biomass was lowest in May and June and highest in March and April, and vice-versa for Orthoptera (fig. 1). Mean prey biomasses were 0.9 g in Coleoptera, 1.2 g in Orthoptera and 12.6 g in small mammals, giving a mean prey biomass of 1.74 g, a higher value that the 1.6 g estimated by Rodríguez *et al.* (2006) as necessary to guarantee population survival.

In general, our results confirm the insectivorous nature of the lesser kestrel, Coleoptera and Orthoptera being the basis of the diet. Inter-month variation in biomass and capture frequency of different prey categories seem to correspond with seasonal fluctuations of the prey populations themselves. Coleoptera are most abundant in early spring, although most imagos emerge in autumn they do not leave their pupal refuges until spring which is why they are most numerous and most consumed in March and April (Lepley *et al.*, 2000; Romero *et al.*, 2008; Rodríguez *et al.*, 2010). According to diverse authors (García and Arroyo, 2005; Romero *et al.*, 2008), the general density of Orthoptera increases across the lesser kestrel breeding season. However, since Orthoptera do not pupate but instead pass through several nymphal stages before adulthood, the smaller size of nymphs is associated with lower orthopteran captures in March and April, since prey selection by the lesser kestrel is based more on prey size than availability (Rodríguez *et al.*, 2006). Population maxima of small mammals correspond with the end of drought periods, in early autumn and in spring, but this was not seen in our study where there was a slight increase in small mammal captures in late spring (fig. 1.). This may have been due to spring 2009 being particularly hot and with low rainfall in March and April (AEMET, 2009), which may have led to reproductive losses in early spring and a later peak in reproductive output, in May, corresponding with late spring rainfall. The contribution of small mammals to the diet shown by the present study is greater than in any previous investigations.

Similar breeding season diet studies have been carried out in southwest Spain in 1976 (Franco and Andrada, 1977), in south Portugal in 1994 (Rocha, 1998) and in La Crau, southeast France, in 1999 (Lepley *et al.*, 2001). According to Franco and Andrada (1977) insects accounted for 62.1% of the total biomass, with Orthoptera comprising 54.8% and Coleoptera 7.3%. Small mammals formed 26.3% of the biomass, the remaining captures being reptiles, birds and other types of invertebrate. French lesser kestrels are more insectivorous than those from central Spain where insects comprised 60.2% of dietary biomass in France compared with 49.4% in the present study, and Orthoptera were the principal dietary items (44.4%) in France. The principal difference between both studies was the virtual non-existence of small mammals in the diet in France. Invertebrates comprised 99.6% of prey items in south Portugal (Rocha, 1998), these being chiefly Coleoptera (39.2%) and Orthoptera (27.7%).

The relatively low contribution of Orthoptera consumed by the study population is due to the absence of mole crickets *Gryllotalpa gryllotalpa*, which made a high contribution to dietary biomass in other studies (30%; Franco and Andrada, 1977; Lepley *et al.*, 2001; Rodríguez *et al.*, 2010). In contrast, the high frequency of coleoptera captures by the Perales del Río colony, unlike those studied elsewhere, could be due to the steppe biotope in which the colony is located. Franco and Andrada (1977) demonstrated a correlation between biotope type and the heterogeneity of captured prey, and in steppe land, the most homogeneous biotope, the diet is basically constituted of Coleoptera and Orthoptera. However, small mammals are typical of steppe lands with traditional agri-grazing systems (Tella *et al.*, 1998), as in the study area. Moreover, the study colony is in an area where there are different species of small mammals (Palomo *et al.*, 2007) and some of them may have produced an overabundance of such a prey. For example, during the studied year, a high increase of *Microtus arvalis* populations was registered in different areas of the Iberian peninsule (Olea *et al.*, 2009; Javier Viñuela, *pers. com.*). The high frequency of cereal crops and fallows around the colony also favours high prey diversity, especially of vertebrates (Tella *et al.*, 1998; Rodríguez and Bustamante, 2008).

Lesser kestrel diet changes with habitat, including land use around the colony, agricultural intensity, mean field size and fallow cover. Such differences are not only regional but also reflect changes in land use around colonies, so that there may be large between-year differences in diet at the same colony (Rodríguez and Bustamante, 2006; Rodríguez *et al.*, 2008). It is clear that diet studies are important to managing colonies and to identifying the principal habitats in which new lesser kestrel nesting houses should be built.

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