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Comparación de la dieta estival del halconcito colorado (*Falco sparverius*) y el halcón plomizo (*Falco femoralis*) en un área agrícola de la araucaría, Sur de Chile

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SUMMER DIET COMPARISON BETWEEN THE AMERICAN KESTREL (*FALCO SPARVERIUS*) AND APLOMADO FALCON (*FALCO FEMORALIS*) IN AN AGRICULTURAL AREA OF ARAUCANÍA, SOUTHERN CHILE

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ABSTRACT.— The diet of the American Kestrel (*Falco sparverius*) and Aplomado Falcon (*Falco femoralis*) was quantified by analysis of their pellets during the summer 1997-1998 in an agricultural area of Araucanía, southern Chile. By number, the most important prey of the American Kestrel were insects (61% of all individual prey) followed by birds (23%), rodents (13.7%) and reptiles (2.6%). Avian prey accounted for the highest biomass contribution (79.6%), followed by rodents (18%). Biomass contribution of insects and reptiles was negligible. Birds were the staple prey of the Aplomado Falcon both by number (89%) and biomass (99%). Number and biomass contribution of rodent and insect prey was minute. Diet of both raptor species did not broadly overlap. Both the American Kestrel and Aplomado Falcon appeared to respond in an opportunistic manner to the most abundant bird prey in the field (*Sicalis luteola*), although the latter species could be consuming preferentially larger-sized avian prey.

KEY WORDS: *American Kestrel, Aplomado Falcon, diet overlap,* Falco sparverius, Falco femoralis, *prey size,* Sicalis luteola, *southern Chile.*

RESUMEN. COMPARACIÓN DE LA DIETA ESTIVAL DEL HALCONCITO COLORADO (*FALCO SPARVERIUS*) Y EL HALCÓN PLOMIZO (*FALCO FEMORALIS*) EN UN ÁREA AGRÍCOLA DE LA ARAUCANÍA, SUR DE CHILE.— La dieta del Halconcito Colorado (*Falco sparverius*) y del Halcón Plomizo (*Falco femoralis*) fue cuantificada a partir de regurgitados durante el verano de 1997-1998 en un área agrícola de la región de la Araucanía, sur de Chile. Numéricamente, las presas más importantes del Halconcito Colorado fueron los insectos (61% del total de presas), seguidos de aves (23%), roedores (13.7%) y reptiles (2.6%). Las aves tuvieron el mayor aporte de biomasa (79.6%), seguidas por los roedores (18%). La contribución de biomasa de insectos y reptiles fue insignificante. Las principales presas del Halcón Plomizo fueron las aves, tanto en número (89%) como en biomasa (99%). La contribución numérica y de biomasa de roedores e insectos fue mínima. La superposición trófica entre ambos halcones fue relativamente baja. Las dos especies parecieron consumir de manera oportunista a la especie de ave más abundante en el campo (*Sicalis luteola*), aunque el Halcón Plomizo podría estar consumiendo preferentemente a las aves presa de mayor tamaño.

PALABRAS CLAVE: Falco sparverius, Falco femoralis, *Halconcito Colorado, Halcón Plomizo,* Sicalis luteola, *sobreposición trófica, sur de Chile, tamaño de presa.*

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Birds of prey inhabiting agrosystems may be beneficial to humans because most of them prey on animals that invade cultivated lands or potentially transmit infectious diseases (e.g., Bellocq 1987, 1990). Furthermore, dietary studies of raptors may help in understanding prey distribution, abundance, behaviour and vulnerability (Fulk 1976, Marti 1987). In spite of their importance, birds of prey on agricultural lands have scarcely been studied in Chile (see Jaksic 1997 for a review).

The American Kestrel (*Falco sparverius*) and the Aplomado Falcon (*Falco femoralis*) typically inhabit agricultural lands and other open habitats (Brown and Amadon 1968, del Hoyo et al. 1994). Food habits of the American Kestrel have been extensively reported throughout the American continent (see del Hoyo et al. 1994 for a review). According to quantitative studies carried out in North (e.g., Heintzelman 1964, Jenkins 1970, Balgooyen 1976, Collopy and Koplin 1983) and South

America (e.g., Greer and Bullock 1966, Yañez et al. 1980, Simonetti et al. 1982, Beltzer 1990, Sarasola et al. 2003), the American Kestrel is a relatively plastic predator which consume a wide spectrum of prey types. The Aplomado Falcon, on the contrary, is considered a bird-specialist predator (Hector 1981, 1985, Jiménez 1993, Montoya et al. 1997, Bó 1999).

To our knowledge, diet of coexisting populations of American Kestrel and Aplomado Falcon has not been reported for South America. Here, we provide a comparison of the summer diet of these two species in an agricultural area of the Araucanía region, southern Chile.

METHODS

Our study area was in the Tricauco Farm (200 ha), 6 km south of Traiguén city (38°14'S, 72°38'W) in the Araucanía region, southern Chile. The landscape comprises extensive flat terrain with some ravines and low mountains. Vegetation is mainly composed of wheat and oat crop fields (>50% in area). Scattered abandoned pastures, marshes and small patches of non-native tree plantations (*Pinus* spp., *Eucalyptus* spp.) are found throughout crop fields and on borders of fence lines. Remnants of the original *Nothofagus* forest are found covering border of rivers, ravines and mountains. The climate is moist-temperate with a Mediterranean influence (di Castri and Hajek 1976). Mean annual rainfall and temperature are 1400 mm and 12°C, respectively.

From December 1997 to February 1998 (austral summer), we searched for pluck sites, perches or nests of American Kestrel and Aplomado Falcon with the purpose of collecting their pellets or prey remains. Fresh pellets of the American Kestrel were collected under an old southern beech (*Nothofagus obliqua*) where a pair nested and successfully yielded fledglings. Fresh pellets of an Aplomado Falcon pair were collected beneath an old pine (*Pinus radiata*) and adjacent fence posts used as pluck sites. Due to fragility and rainfall, most of pellets were broken. Although pellets of both raptor species could be confused with those of the sympatric Cinereous Harrier (*Circus cinereus*), identified perches of harriers were relatively far away from those of kestrels and falcons (1–1.5 km). In addition, the Aplomado Falcon is aggressive towards other raptors (Brown et al. 2003).

All pellets were air-dried in paper bags. For comparison purposes, only whole pellets were measured for length and width to the nearest 0.1 mm using a calliper and weighed on a digital balance to the nearest 0.01 g. Pellets were dissected to separate all prey remains. Avian prey were identified mainly on the basis of feathers, using two complementary methods: microscopic analysis of feather structures such as nodes and barbules (Reyes 1992) and comparison of feather coloration patterns with voucher specimens deposited in the Zoology Department of the Universidad Austral of Chile at Valdivia. We assumed that identified feathers of a species in a pellet represented only one individual. Small mammals were identified and quantified on the basis of skulls or dentition following keys in Pearson (1995). Reptiles were recognized by scales and bone elements, and quantified by mandible pairs when possible. When only hairs or scales were found in a pellet, we assumed that they represented only one individual. Insects were identified and quantified by head capsules or elytra following keys in Peña (1986). We identified prey items to the finest possible taxonomic category. Biomass contribution of prey consumed was estimated by multiplying the number of prey taken by the average mass of the prey type (Marti 1987). Because it was not possible to discriminate the prey's age class, we assumed all individuals of a given prey species to be adult-sized. Masses for mammalian and avian prey were taken from the literature and from our unpublished data. Based on our collections, we arbitrarily rounded the weight of all insects to 1 g. We assumed that unidentified prey masses were similar to the mean mass of the most closely related identified taxon; this assumption may be unrealistic, but our objective was obtain a coarse approximation of the biomass contribution.

A number of studies have demonstrated that the utilization of an unique food sampling method to describe quantitatively bird of prey diets may give highly biased results (e.g., Mearns 1983, Mersmann et al. 1992, Oro and Tella 1995, Redpath et al. 2001). Pellets have been suggested as the less biased source of information on diet because many prey species occurring in pellets are seldom found in prey remains (e.g., Simmons et al. 1991, Real

Table 1. Mean (± SE) size, width and weight of pellets of free-range American Kestrel and Aplomado Falcon in Argentina and Chile. Only whole pellets were included for this analysis.

	Length (mm)	Width (mm)	Weight (g)	*n*	Site	Source
American Kestrel	24.7 ±0.5	11.3 ±0.3	0.48 ±0.01	142	Central Chile	Yañez et al. (1980)
	19.1 ±1.6	12.8 ±0.8	0.63 ±0.10	32	Central Chile	Simonetti et al. (1982)
	21.1 ±0.5	12.3 ±0.1	-	8	Southern Argentina	Trejo and Ojeda (2002)
	26.7 ±1.1	14.3 ±0.9	1.08 ±0.15	21	Southern Chile	This study
Aplomado Falcon	29.6 ±0.1	12.9 ±2.1	0.93 ±0.72	16	Southern Chile	This study

1996). The usefulness of pellets to quantify the diet of falconiforms, however, could be limited because many species dismember prey prior to swallowing and may not ingest all portions or break insect prey into very small fragments that are difficult to identify (Marti 1987). Thus, potential biases could be considered in our analysis and results should be viewed cautiously.

Diet overlap was estimated by using the Horn index, R_o (Krebs 1989). This index ranges from 0 (no similarity) to 1 (complete similarity). Although Greene and Jaksic (1983) recommended the use of the best possible level of prey identification for food-niche metrics, we only made calculations to the class-resolution level. This decision was taken owing to the small number of pellets, which could have led us to either, under- or overestimate the proportion of some prey item. This coarse-resolution estimate has previously been used in food-niche comparisons of raptor assemblages (Jaksic and Carothers 1985). In addition, comparisons using the class level are useful to evaluate the degree of prey specialization of predators (Jaksic and Delibes 1987). Because of the small sample size of pellets analyzed, other food-niche metrics (e.g., diet diversity, geometric mean weight of prey) were not calculated.

Concurrent to the pellet collections, we evaluated avian and mammalian prey abundance in the field. We estimated bird abundance using three parallel, fixed-band (2000 m length, 100 m wide) line transects (Bibby et al. 1993) placed 400 m apart in the hunting areas of falcons. The abundance of small mammals was evaluated in trapping transects (Call 1986) using medium Sherman live traps (10–15 m apart) placed in unaltered pastures and marshes (total effort: 51 traps/night). We were unable to estimate insect abundance because of limited time and logistic difficulties. Insects have diverse life modes (e.g., flying, arboreal, terrestrial, aquatic) and stages (e.g., larvae, imago), and inhabits a number of microhabitats making difficult abundance estimations. As we studied only one pair of American Kestrel and Aplomado Falcon and because of the number of pellets was small, we did not made statistical comparisons between the frequency distribution of prey in pellets and the abundance of prey in the field.

RESULTS

Pellets of the American Kestrel and Aplomado Falcon did not statistically differ neither in length (t = -1.31, $P > 0.05$), nor width (t = 1.11, $P > 0.05$), nor weight (t = 0.77, $P > 0.05$) (Table 1). We identified 154 prey items in the American Kestrel's pellets including rodents, birds, lizards, and insects. By number, most important prey were insects followed by birds and rodents (Table 2). *Sicalis luteola*, *Turdus falcklandii* and *Abrothrix olivaceus* were the vertebrate species most frequently eaten. Birds accounted for the highest biomass contribution, with *Columba araucana* and *Turdus falcklandii* being the most important (Table 2). Rodents accounted for almost 18% of the total biomass. Biomass contribution of insects and reptiles was negligible. We identified 42 prey items in the Aplomado Falcon's pellets including birds, rodents, and insects (Table 2). By both number and biomass, birds were the staple prey of the Aplomado Falcon (Table 2). Most of the avian prey were passerines, with *Turdus falcklandii* and *Sicalis luteola* being the most frequently eaten (Table 2). By

Table 2. Prey consumption by American Kestrel and Aplomado Falcon in an agricultural area of Araucanía, southern Chile. Masses for *Loxodontomys micropus*, *Anthus correndera*, and *Zonotrichia capensis* were taken from unpublished data of the authors; mass for *Colaptes pitius* was given by RP Schlatter; masses for remaining vertebrate species were taken from Figueroa and Corales (1999).

		American Kestrel		Aplomado Falcon	
Prey species	Mass (g)	Number (%)	Biomass (%)	Number (%)	Biomass (%)
Rodents		13.7	17.7	2.4	0.7
Abrothrix olivaceus	23	5.2	3.8	0	0
Loxodontomys micropus	49	0.6	1.0	0	0
Mus domesticus	21	1.3	0.9	0	0
Unidentified	58	6.6	12.0	2.4	0.7
Birds		22.7	79.6	88.1	99.2
Nothoprocta perdicaria	160	0.6	3.3	0	0
Vanellus chilensis	270	1.3	11.2	0	0
Columba araucana	300	3.2	31.1	4.7	19.2
Zenaida auriculata	137	0	0	14.4	26.3
Colaptes pitius	300	1.3	12.5	0	0
Turdus falcklandii	90	4.6	13.0	23.8	28.8
Anthus correndera	22	0	0	4.7	1.4
Sicalis luteola	16	9.8	5.0	23.8	5.1
Zonotrichia capensis	22	0	0	0	0
Sturnella loyca	96	0.6	2.0	12.0	15.3
Passeriform unidentified	36	1.3	1.5	4.7	3.1
Reptiles		2.6	0.7	0	0
Liolaemus spp.	8	2.6	0.7	0	0
Insects		61.0	2.0	9.5	<0.1
Odonata	1	0	0	2.4	<0.1
Orthoptera	1	1.3	<0.1	0	0
Coleoptera	1			7.1	<0.1
Calosoma vagans	1	22.1	0.7		
Modialis prasinella	1	0.6	<0.1		
Sericoides spp.	1	0.6	<0.1		
Brachysternus angostus	1	11.7	0.4		
Brachysternus viridis	1	2.6	<0.1		
Hylamorpha cilindrica	1	11.0	0.3		
Auslacopalpus spp.	1	0.6	<0.1		
Scarabeidae	1	2.0	<0.1		
Buprestidae	1	1.3	<0.1		
Unidentified	1	7.2	0.2	0	0
Total pellets		54		25	
Total prey items		154		42	
Total biomass (g)		4819		3130	

biomass, *Turdus falcklandii* and *Zenaida auriculata* were the most important avian prey. Rodents and insects were negligible either by number or biomass (Table 2). Diet of both raptor species did not broadly overlap (R_o = 0.50).

In the field, we counted 193 non-raptor birds comprising 14 species. The most numerous species were *Sicalis luteola*, *Vanellus chilensis*, *Zonotrichia capensis* and *Sturnella loyca* (Fig. 1). The results suggest an opportunistic consumption of the most abundant avian prey in the field (*Sicalis luteola*) by both raptor species, and a preferential consumption of *Zenaida auriculata*, *Turdus falcklandii*, and *Sturnella loyca* by the Aplomado Falcon (Fig. 1). Regarding rodents, we only captured one individual each of *Abrothrix longipilis* and *Loxodontomys micropus*.

DISCUSSION

The American Kestrel's and Aplomado Falcon's pellets could be difficult to discriminate because of similarity in size and weight. However, pellets of the Aplomado Falcon appeared to be longer than those of the American Kestrel. This could be due to differences in body size; the Aplomado Falcon (mean weight = 352 g; figure taken from Montoya et al. 1997 combining male and female weights) is threefold heavier than the American Kestrel (mean weight = 120 g, figure taken from Jaksic and Braker 1983). A confident discrimination of pellets during the breeding period could be difficult because fledglings yield most of them. This would explain the high overlap in size and weight of the pellets of both falcon species. Although little longer and heavier, pellets of American Kestrel in Tricauco were similar to those described elsewhere (see Table 1). Apparent differences could be an artefact of our small sample size or a result of prey composition of pellets (Balgooyen 1971).

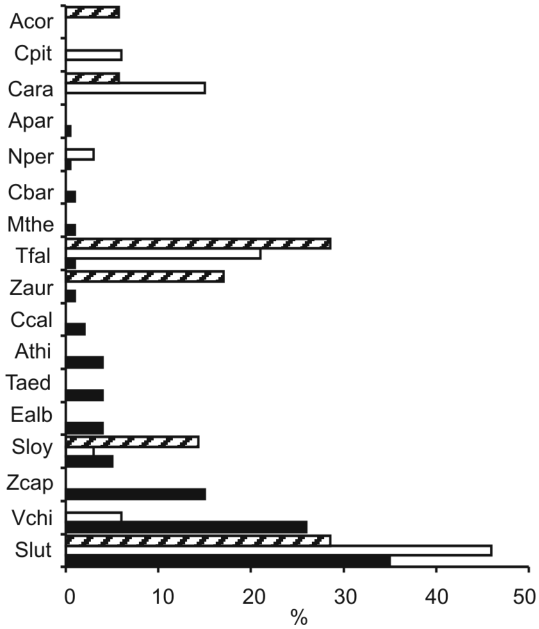

Figure 1. Contribution of bird species found in pellets of American Kestrel (white bars) and Aplomado Falcon (cross-lined bars), and relative abundance of birds in the field (black bars) in an agricultural area of Araucanía, southern Chile. Slut: *Sicalis luteola*, Vchi: *Vanellus chilensis*, Zcap: *Zonotrichia capensis*, Sloy: *Sturnella loyca*, Ealb: *Elaenia albiceps*, Taed: *Troglodytes aedon*, Athi: *Agelaius thilius*, Ccal: *Callipepla californica*, Zaur: *Zenaida auriculata*, Tfal: *Turdus falcklandii*, Mthe: *Mimus thenca*, Cbar: *Carduelis barbata*, Nper: *Nothoprocta perdicaria*, Apar: *Anairetes parulus*, Cara: *Columba araucana*, Cpit: *Colaptes pitius*, Acor: *Anthus correndera*.

In general, the summer diet of American Kestrel in Tricauco was similar to those reported elsewhere (e.g., Greer and Bullock 1966, Yañez et al. 1980, Simonetti et al. 1982). By number of prey items in the diet, the American Kestrel appears to be essentially an insectivorous predator (Yañez et al. 1980, Simonetti et al. 1982, Sarasola et al. 2003). This trophic character, however, may vary according to geographic area or season (Jaksic 1997). In central Chile, Jaksic et al. (1991) observed that the American Kestrel mainly consumed birds during the non-breeding season and mainly insects during breeding season. When the American Kestrel's diet is analyzed in term of biomass, vertebrates become the most important prey (Sarasola et al. 2003). In southernmost Chile, rodents may constitute the staple prey during winter (80% by number, 95% by biomass; Figueroa and Corales 2002). As a consequence of its eclectic diet, the American Kestrel has been classified as a carnivorous/insectivorous predator (Jaksic et al. 1981, Sarasola et al. 2003) or as "a vertebrate eater that frequently preys on insects" (Jaksic and Delibes 1987). Our results clearly support those conclusions. As in previous studies (Hector 1985, Jiménez 1993, Montoya et al. 1997, Bó 1999), the Aplomado Falcon in Tricauco was essentially an avian predator. Like in Tricauco, passerines and doves are the most important prey of the Aplomado Falcon in agricultural areas of Mexico and Argentina during the breeding season (Hector 1985, Bó 1999).

According to results from Tricauco, the American Kestrel and Aplomado Falcon appear to differ in prey type utilization, at least during the breeding season. As discussed above, the first behaves as a generalized predator and the second as a bird-eating predator; it would explain the low diet overlap between both species. The difference in this food-niche metric could not convincingly be explained by either spatial or temporal segregation because both species widely overlap in habitats and activity period (Brown and Amadon 1968). It could also be argued that such differences were due to utilization of distinct hunting modes, but both species hunt mainly by sit-and-wait and secondarily by active searching techniques (Brown and

Amadon 1968, Jaksic and Carothers 1985). Cooperative hunting and piracy has also been documented for the Aplomado Falcon (Hector 1986, Brown et al. 2003), but we have not observed it in southern Chile. Even when differences may occur, hunting modes do not appear to greatly influence access to prey (Jaksic and Carothers 1985). It is interesting to note that the two species, which greatly differ in body size, show a low diet overlap. This suggests a differential prey type utilization influenced by raptor's body size. Nonetheless, Jaksic (1989) proved that raptors' weight is not a good predictor of trophic estimates such as diet diversity and overlap.

Both raptor species in Tricauco preyed most on *Sicalis luteola*, which was the most abundant bird in the field. In addition, the most consumed insect prey by the American Kestrel in Tricauco are relatively common in pastures (e.g., *Calosoma vagans*), and at the border of the native forest remnants (e.g., *Hylamopha cilindrica*, *Brachysternus* spp.) that form part of agricultural lands in southern Chile (Peña 1986, Figueroa Rojas and Corales Stappung, pers. obs.). The American Kestrel have previously been described elsewhere as an opportunist predator consuming their prey according to its local (Jaksic et al. 1981, Jaksic and Braker 1983) or temporal (Sarasola et al. 2003) availability. The Aplomado Falcon, however, seems to have concentrated predation more on relatively large-sized avian prey species than did the American Kestrel, which suggests selection based on prey size. Jaksic et al. (1981) found that larger-sized raptors consumed larger prey in comparison with the smaller-sized ones and argued that it would be due to greater killing and handling capabilities. The American Kestrel also included large-sized avian prey species in its diet (90–300 g; Tabla 2), but we did not know whether those were taken as adult- or nestling-sized. We have not observed predation on large-sized birds by breeding American Kestrel in other sites of southern Chile. It has been demonstrated that kestrels choose prey significantly more on the basis of activity than body size (Smallwood 1989, Sarno and Gubanich 1995) which would be likely influenced by its high visual sensitivity (Hirsch 1982). Sarasola et al. (2003) suggest that prey selection among small- and medium-sized (16–80 g) vertebrate prey eaten by breeding American Kestrel could also be influenced by energy requirement of nestlings.

In sum, both the American Kestrel and Aplomado Falcon appeared to respond in a opportunistic manner to the most abundant bird prey (in spite of its small size) in Tricauco, although the latter species appeared preferentially prey on larger-sized birds, which in turn would be a consequence of its higher energy requirements and handling capabilities (Bozinovic and Medel 1988, Jaksic 1989). Other additional factors such as search image, hunger state of falcons, behaviour, oddity, conspicuousness, and habitats of preys might be implied in prey preference (Mueller 1971, 1973, 1974, Rudolph 1982, Smallwood 1987, 1989, Götmark and Unger 1994, Sarno and Gubanich 1995). Notwithstanding, because of the limitations of our study, we are unable to draw conclusions with the data at hand.

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