

## ACTIVITY BUDGETS, FORAGING BEHAVIOR, AND DIET OF WHITE-TAILED KITES (*ELANUS LEUCURUS*) DURING BREEDING AND NONBREEDING SEASONS IN THE ARGENTINE PAMPAS

ALEJANDRO V. BALADRÓN<sup>1</sup>, MATÍAS G. PRETELLI, MATILDE CAVALLI, AND MARÍA S. BÓ  
*Laboratorio de Vertebrados, Instituto de Investigaciones Marinas y Costeras (IIMyC), Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Mar del Plata - Consejo Nacional de Investigaciones Científicas y Técnicas, Funes 3350, Mar del Plata (B7602AY), Argentina*

**ABSTRACT.**—From 2005 to 2009 we evaluated the activity patterns and food habits of White-tailed Kites (*Elanus leucurus*) during the breeding and nonbreeding seasons in the Argentine Pampas. According to time-activity budget analyses, perching was the most frequently observed activity during the nonbreeding season (52% of total time), whereas foraging was the most frequent activity during the breeding season (41% of total time). Flight was the least frequent of all kites' activities in both seasons (8% and 9% during the breeding and nonbreeding season, respectively). Even when kites spent a similar percentage of time foraging during both breeding and nonbreeding seasons (41% and 39%, respectively), their hunting technique differed between seasons. During the nonbreeding season, we only observed kites using active searching to forage, but during the breeding season, we observed them using active and passive searching in similar proportions. According to pellet analyses, the diet of kites was mostly composed of rodents (> 96% of total prey). Small rodents (body mass < 35 g) were dominant in numeric terms in the diet in both seasons, but larger rodents represented the bulk of biomass. Our results indicate that in the Argentine Pampas, White-tailed Kites are predominantly mammal-eating, active-search predators, as previously reported for the species in South America and North America and for other *Elanus* species around the world.

**KEY WORDS:** *White-tailed Kite*, *Elanus leucurus*; *active search*; *Argentina*; *behavioral patterns*; *diet*; *hunting mode*; *passive search*; *prey*; *small mammals*; *time-activity budget*.

---

### PATRONES DE ACTIVIDAD, COMPORTAMIENTO DE ALIMENTACIÓN Y DIETA DE *ELANUS LEUCURUS* DURANTE LAS ESTACIONES REPRODUCTIVAS Y NO REPRODUCTIVAS EN LAS PAMPAS DE ARGENTINA

**RESUMEN.**—De 2005 a 2009 evaluamos los patrones de actividad y los hábitos alimenticios de *Elanus leucurus* durante las estaciones reproductivas y no reproductivas en las Pampas de Argentina. De acuerdo al análisis de patrones de actividad por tiempo, el posado fue la actividad más frecuentemente observada durante la estación no reproductiva (52% del tiempo total), mientras que la búsqueda de alimento fue la actividad más frecuente durante la estación reproductiva (41% del tiempo total). El vuelo fue la actividad menos frecuentemente observada de *E. leucurus* (8% y 9%, durante la estación reproductiva y no reproductiva, respectivamente). Si bien los individuos destinaron una proporción similar de tiempo a la búsqueda de alimento durante las estaciones reproductivas y no reproductivas (41% y 39%, respectivamente), utilizaron diferentes estrategias de caza en ambas estaciones. Durante la estación no reproductiva, solo observamos individuos usando búsqueda activa para alimentarse, mientras que durante la estación reproductiva, los observamos usando búsqueda activa y pasiva en proporciones similares. De acuerdo al análisis de egagrópilas, la dieta de *E. leucurus* estuvo compuesta mayoritariamente por roedores (> 96% del total de presas). Los pequeños roedores (peso corporal <35 g) fueron dominantes en términos numéricos en ambas estaciones, pero el mayor aporte de biomasa lo hicieron los roedores más grandes. Los resultados de este estudio indican que en las Pampas de Argentina, *E. leucurus* se comportó como un depredador activo especializado en mamíferos,

---

<sup>1</sup> Email address: abaladro@mdp.edu.ar

características que son consistentes con estudios previos en Sudamérica y Norteamérica, como también con otras especies de *Elanus* de todo el mundo.

[Traducción de los autores editada]

Raptors can be characterized according to their allocation of time in different foraging activities, specifically, as active-search (wide-foraging or aerial hunters) or passive-search (sit-and-wait or perch hunters) predators (Schoener 1971, Jaksić et al. 1987). Active predators are considered time minimizers, as they expend energy actively searching for prey to increase their prey encounter rate. Passive predators are defined as energy maximizers, as they maximize the net energy intake by passively waiting for the most profitable prey (Jaksić and Carothers 1985). However, raptors' activity patterns and hunting modes may be influenced by multiple factors, such as the presence of competitors or agonistic species (Newton 1979, Jaksić 1985), seasonality (e.g., breeding; Newton 1979, Nadjafzadeh et al. 2016), or variations in prey availability (Steenhof and Kochert 1988, Steen et al. 2011), among others. Thus, this dichotomization between active-search and passive-search predators is an arbitrary simplification and represents only the extremes of a continuum of hunting modes. Moreover, the majority of raptors use the active-search hunting mode to some extent (Wakeley 1978, Sarasola and Negro 2005), although the mode (or combination of techniques) used to capture prey (e.g., hovering, cruising flight, quartering flight, soaring flight; Brown and Amadon 1968) usually varies among species.

The White-tailed Kite (*Elanus leucurus*) is a medium-sized raptor commonly found in open areas across the Americas (43° N–43° S) from the southwestern United States to Patagonia in southern Argentina and Chile (Thiollay 1994). This species specializes in capturing rodents and is thought to be an active-search predator (Dunk 1995, Scheibler 2004). This perception is likely related to the fact that kites are usually conspicuous when they search for prey by hovering in open areas (Mendelsohn and Jaksić 1989, Dunk 1995). A preponderance of rodents seems to be a consistent feature of the diets of kites during both breeding and nonbreeding seasons and in different vegetation communities in North America (Pickwell 1930, Hawbecker 1940, Bond 1940, Stoner 1947, Cunningham 1955, Dixon et al. 1957, Waian and Stendell 1970, Stendell and Myers 1973, Warner and Rudd 1975) and South

America (Meserve 1977; Schlatter et al. 1980; Leveau et al. 2002; Scheibler 2004, 2007; Sarasola et al. 2007, 2010; González-Acuña et al. 2009). Compared to diet, the behavior of White-tailed Kites has been much less studied, and most reports focus on hunting behavior (Warner and Rudd 1975, Mendelsohn and Jaksić 1989, Skonieczny and Dunk 1997). Thus, there is little information about how this species allocates time to different activities throughout the year (Jaksić et al. 1987).

In this study, we investigated the behavioral patterns and diet of White-tailed Kites in the Argentine Pampas. Our objectives were to (1) determine the time-activity budgets of kites in their foraging areas during the breeding and nonbreeding seasons, (2) describe the foraging behavior (hunting modes and techniques) used by kites to capture their prey, and (3) compare the prey consumed by this raptor during the breeding and nonbreeding seasons. Based on published literature on this species and other *Elanus* species around the world and on our prior observations, we expected to find that White-tailed Kites that inhabit the Argentine Pampas behave as active hunters and feed mainly on small rodents year round.

#### METHODS

**Study Area.** We conducted our study in the Pampas region (Cabrera 1971) of southeastern Buenos Aires Province, Argentina (37° 32'–37° 45' S, 57° 19'–57° 26' W). The landscape in this region is dominated by temperate grasslands, where the original gramineous vegetation community has been highly modified by agriculture (Soriano et al. 1991, Bilenca and Miñarro 2004). Thus, our study area is characterized by its heterogeneity, given that it includes a diverse array of natural vegetation, such as native grasslands, marshes, coastal dunes, and native forests, and modified environments, such as grazing fields, croplands, and periurban areas. Because cattle grazing is the main form of agriculture, most of the land is devoted to grazing fields and, to a lesser extent, to cropland that is cultivated for corn, soybean, and wheat production (Isacch 2008). Thus, the typical landscape is an agricultural matrix interspersed with patches of other cover types. This landscape heterogeneity supports a high

faunal diversity, which represents a wide spectrum of potential prey for raptors (Isacch et al. 2016).

We performed weekly surveys across the study area, which encompassed approximately 30 km north to south and 15 km east to west (approximately 400 km<sup>2</sup>). During these surveys we looked for kites from a vehicle or on foot. Once we spotted a kite, we observed the individual and recorded its perching sites and its activities until it was lost from view. The different sampling sites were similarly heterogeneous with respect to land uses, and we therefore assumed that prey composition and perch availability did not vary substantively among sites. During weekly surveys, we revisited each site where a kite was seen previously to check for the presence of kites and to collect prey remains and pellets. This procedure allowed us to identify seven areas used as hunting areas by kites, where we concentrated our efforts to collect pellets and to quantify activity budgets. However, as we sampled kites throughout the study area, we also included other hunting sites used in an occasional manner by the kites in our sampling. Because we did not mark individual kites, we do not know the number of kites sampled. However, previous studies indicate that the White-tailed Kite is a frequent and common species in the study area (approximately 0.15 individuals/km<sup>2</sup>; Baladrón et al. 2017).

#### **Time-activity Budgets and Foraging Behavior.**

From July 2005 to January 2009, we evaluated White-tailed Kite behavioral patterns by quantifying time-activity budgets during the breeding season and the nonbreeding season. The duration of the breeding season is variable in this species, as it commonly lays a second clutch when the conditions are favorable (Thiollay 1994, de la Peña 2016). We therefore inferred the duration of breeding periods each year based on our observations of breeding behavior and the presence of nests with eggs or nestlings or fledglings. In our study area, the breeding period of White-tailed Kites typically began in spring (September) and we observed first nestlings in summer (late January). However we also observed nestlings as late as middle autumn (May) in all sampling years. As a consequence, the nonbreeding period for our study was mostly limited to 2–3 winter months each year (June, July, and/or August).

During each observation day, we actively searched for kites in the study area, especially in areas where individuals were previously observed hunting (see above). Using 10 × 50 binoculars we recorded all

activities of kites individually from a fixed position, from the time each individual was sighted until it was lost from view (continuous recording method; Martin and Bateson 1993, Gaibani and Csermely 2007). During the period an individual kite was under observation, we classified its behaviors into the following categories: *Perching*, which included all activities while perched not related to foraging; *Foraging*, which included all activities related to food acquisition; and *Flying*, which included all directional flights not related to foraging (see Table 1 for details). We combined activities related directly to breeding behavior (courtship, prey deliveries, incubation, etc.) as *Reproductive*. We considered a perched bird as foraging when it was watchful and regularly scanning a patch. Because our objectives focused on general time-activity budgets with an emphasis on foraging activity of kites, our sampling effort was directed at foraging areas. Activities related to reproduction occurred primarily when individuals foraged close to nesting sites. Additionally, we recorded the sequence of activities involved in prey acquisition through both passive and active searching. During passive-searching bouts, we quantified the time that kites devoted to scanning the hunting patch from perches and their movements among perching sites. During active-searching bouts, we quantified the time that kites hovered, moved between patches (transit flights), and soared. In addition, we recorded the sequence and outcome of capture attempts (failed or successful), which included the duration of strikes (i.e., the transition time from hovering to the ground), the time on the ground, and the duration of prey handling and consumption.

To standardize differences in length of observation periods among observation days, we expressed time budgets as the proportion of time spent in each state/activity with respect to the total time of observation. Because the total observation time differed among years and sampling areas, and because observation time was low for some seasons, we pooled data from the same season (breeding or nonbreeding) across years. We calculated the minimum number of observation days required to adequately determine activity budgets by plotting the diversity (Rényi index) of behavioral categories as a function of sample size (function *renyiaccum*, package *vegan* in R; R Development Core Team 2016).

**Diet.** From April 2005 to February 2009, we collected pellets during breeding and nonbreeding

Table 1. Behavioral states and activities used to describe time-activity budgets of White-tailed Kites (*Elanus leucurus*) in the Argentine Pampas.

STATE	ACTIVITY	DEFINITION
Perching	Perching	Resting or inactive on perch. Also includes grooming and other maintenance activities.
Flying	Circle flight	Flying in circles at elevated positions.
	Soaring/gliding	Flying using wind or thermal currents; reduced wing movements.
	Beating	Flying by flapping (active wing-beating).
	Cruising flight	Flying by flapping, combined with short bouts of soaring.
Foraging	Ascendant/descendant	Flying to gain or lose altitude.
	Passive search	Regularly scanning patches from perches. Also includes attacking prey and changing perches
	Active search	Scanning while flying. Also includes hovering, transit flights, and attacks on prey.
	Eating	Eating prey on perch or on the ground.
	Handling	Manipulating prey while perched.
Reproductive	Transporting	Carrying prey in talons.
	Reproductive	All activities related to breeding behavior: parental care, vigilance, prey delivery, copulation, etc.

seasons near previously identified perches used by kites in the same foraging areas where we recorded activity budgets. Later in the laboratory, we disintegrated each pellet in water to separate osseous and chitinous materials. We calculated the average number of prey items per pellet as the sum of all items divided by the total number of pellets. We identified each prey item to the lowest taxonomic level based on identification keys (Bellocq and Kravetz 1983, Morrone and Coscarón 1998, Gómez Villafaña et al. 2005) and voucher specimens preserved in the collection of Laboratorio de Vertebrados (Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Mar del Plata). Additionally, we classified each mammalian prey item by age class (juvenile, subadult, or adult) based on molar wear for rodents (Bellocq and Kravetz 1983) and length of dental series for marsupials (Redford and Eisenberg 1992) via comparison with voucher specimens.

Because the number of kite pellets collected for some seasons was too small to evaluate temporal changes in diet, we pooled data from the same season (breeding or nonbreeding) across years. We calculated the minimum number of pellets required to determine diet adequately by plotting the diversity (Rényi index) of prey items as a function of sample size (function *renyiaccum*, package *vegan* in R; R Development Core Team 2016). We expressed diet composition as the relative proportion of each prey item in the diet, calculated by dividing the number

of individuals in each identifiable category of prey by the total number of prey consumed (numeric frequency, %F), and as the contribution of each prey item to total biomass consumed, calculated as the number of individuals of each prey item multiplied by the corresponding mean body mass, divided by the total biomass consumed (percent biomass, %B; Marti et al. 2007). We derived mass of prey items from our own data on live-trapped specimens (A. Baladrón unpubl. data) or from the published literature (Redford and Eisenberg 1992, Gómez Villafaña et al. 2005, Vargas et al. 2007). In the case of mammals, we assigned different masses according to age class (juvenile, subadult, or adult) of prey items. In addition, we calculated the mean size of prey and the food-niche breadth in the diet of White-tailed Kites (Marti et al. 2007). These parameters were calculated to compare kites' diet between breeding and nonbreeding season, and with similar data from other raptors in the region. We estimated the mean size of prey as the geometric mean mass of prey:

$$GMWP = \text{antilog} (\sum n_i \log w_i / \sum n_i),$$

where  $n_i$  is the number of individuals of the  $i$ th species, and  $w_i$  is the mean mass. We calculated food-niche breadth using Levins' Index:

$$B = 1/(\sum p_i^2),$$

where  $p_i$  is the proportion of prey item  $i$  in the diet,

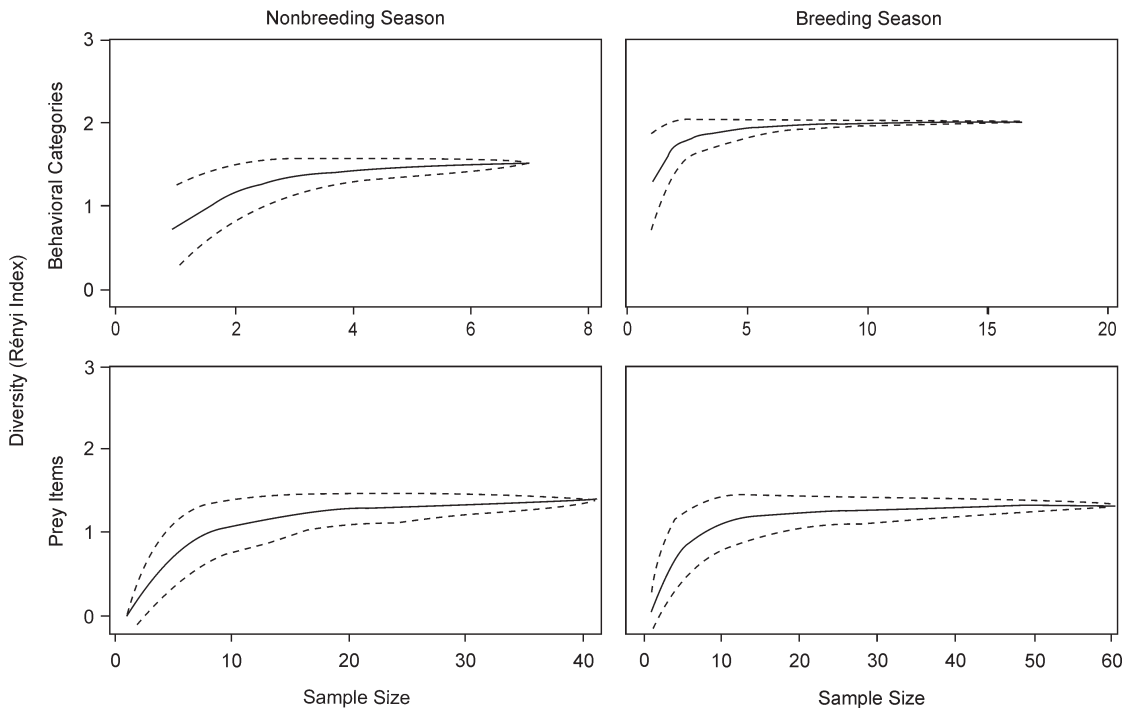


Figure 1. Cumulative curves used to determine if sample sizes were sufficient to describe behavior and diet of White-tailed Kites during the breeding and nonbreeding seasons in the Argentine Pampas. Diversity (Rényi Index) of behavioral categories (upper graphs) and prey items (lower graphs) were plotted as a function of sample size. In all cases, curves nearly reached an asymptote, indicating that sample sizes were adequate.

and the Standardized Levins' Index:

$$B_{sta} = (B_{obs} - B_{min}) / (B_{max} - B_{min}),$$

where  $B_{min} = 1$  and  $B_{max} = n$ ; values range from 0 to 1 and allow comparisons among samples with different numbers of prey items (Marti et al. 2007).

#### RESULTS

**Time-activity Budgets.** We recorded kite activity during 17 observation days in the breeding season (2006–2007: 634 min; 2007–2008: 640 min; 2008–2009: 576 min) and 7 observation days in the nonbreeding season (2005: 28 min; 2006: 104 min; 2007: 35 min; 2008: 122 min). Cumulative curves of behavioral data nearly reached an asymptote, indicating that sample size was sufficient to describe kites' activity patterns for each season (Fig. 1). During the nonbreeding season, we commonly observed kites perching and foraging, and more rarely when they flew. During the breeding season, kites reduced their perching activity and devoted up to 20% of time to reproduction (Fig. 2). However,

the time devoted to foraging by kites showed little variation between seasons. During the nonbreeding season kites allocated most of their foraging time to active searching and we did not observe any instance of passive searching, whereas during the breeding season kites used both active and passive searching (Fig. 2). In addition, kites tended to use cruising flights more often than other types of directional flight in both seasons (Fig. 2).

**Foraging Behavior.** Passive-searching bouts averaged  $8.1 \pm 2.6$  min (range = 8 sec–42 min,  $n = 19$ ). During these bouts, kites scanned the ground from elevated perches, often making rapid changes of perch. Passive-searching activity ended when the individual under observation stayed on the perch but stopped scanning and began other activity such as resting or grooming (56% of cases), switched to active searching (22%), initiated an attack (11%), or flew away (11%). We observed only one case in which a kite successfully captured prey using passive searching.

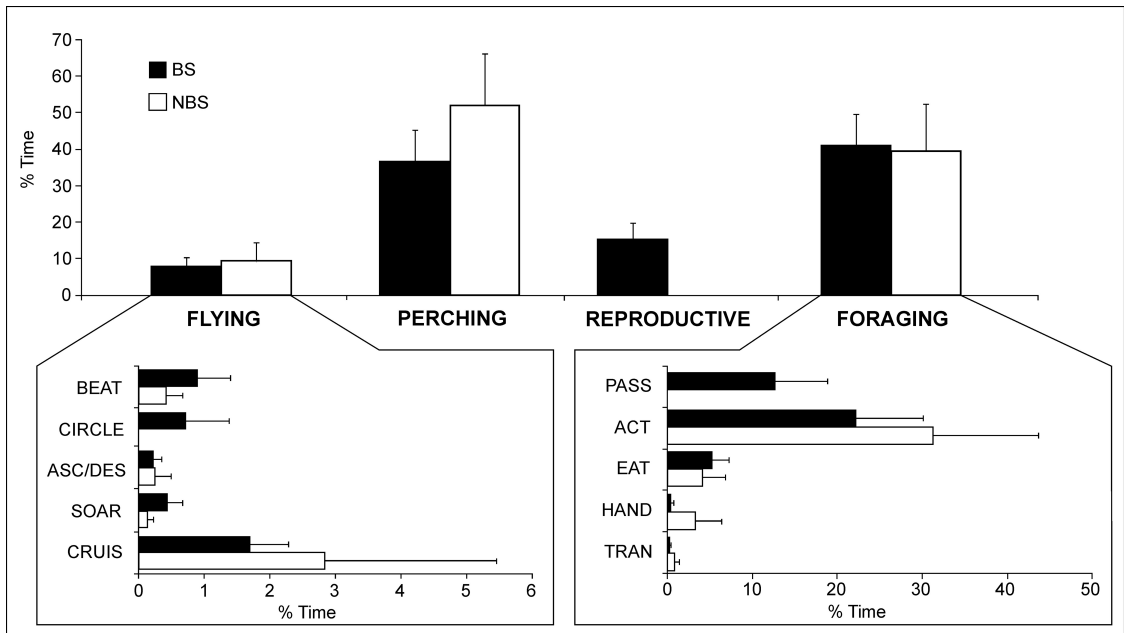


Figure 2. Time allocated by White-tailed Kites (*Elanus leucurus*) to different activities during the breeding (BS) and nonbreeding seasons (NBS) in the Argentine Pampas. We quantified the percent time that kites devoted to different flight types; these include when kites used active flapping flight (BEAT), flew in circles at elevated positions (CIRCLE), performed flights to gain or lose altitude (ASC/DES), flew using wind or thermal currents (SOAR), or when they used a combination of these flight techniques (CRUIS). In addition, we quantified the percent time that kites devoted to different activities related to foraging; these included the time they devoted to searching and capturing prey passively from perches (PASS) and actively by flying over the hunting patches (ACT), and the time they used carrying (TRAN), manipulating (HAND), and consuming (EAT) the prey captured. Values are expressed as average percentages ( $\pm$ SE) of total time recorded.

During active searching, kites searched for prey via aerial hunting, in bouts averaging  $8.2 \pm 1.7$  min (range = 20 sec–39 min,  $n = 24$ ). These bouts consisted of a combination of brief hovering ( $7.5 \pm 0.3$  sec, range = 1–38 sec) interspersed with transit flights, made typically by flapping flight (wing-beating;  $5.6 \pm 0.4$  sec, range = 1–36 sec) or more rarely by soaring ( $4.4 \pm 0.3$  sec, range = 1–15 sec). After an individual located prey while hovering, it performed a strike ( $1.9 \pm 0.4$  sec, range = 1–3 sec,  $n = 8$ ) with talons down, until it reached the ground, where it remained briefly (up to 6 sec). We observed kites capture 14 prey items, all of them of rodents, using active searching. In most cases, prey was handled and consumed on a tree or pole (13 instances) or more rarely on the ground (one instance). Handling lasted in average  $30.8 \pm 9.7$  sec (range = 1–240 sec). We observed one case of a kite killing its prey with its bill during aerial transportation. Individuals spent an average  $5.3 \pm$

0.97 min (range = 6 sec–20 min;  $n = 28$ ) consuming prey.

**Diet.** We collected 119 pellets during the sampling period; 68 from the breeding season (2005–2006: 16 pellets; 2006–2007: 6 pellets; 2007–2008: 2 pellets; 2008–2009: 42 pellets; 2009–2010: 2 pellets) and 51 from the nonbreeding season (2007: 4 pellets; 2008: 47 pellets). Cumulative curves of dietary data nearly reached an asymptote, indicating that sample size was sufficient to describe kites’ diet for each season (Fig. 1). We identified 157 individual prey items from the pellets, with an average of  $1.54 \pm 0.07$  prey per pellet (range = 1–4). During both the breeding and nonbreeding seasons, the diet of kites was almost exclusively composed of small mammals (with the exception of one orthopteran in nonbreeding season 2007), and dominated by rodents (> 96% of total prey items).



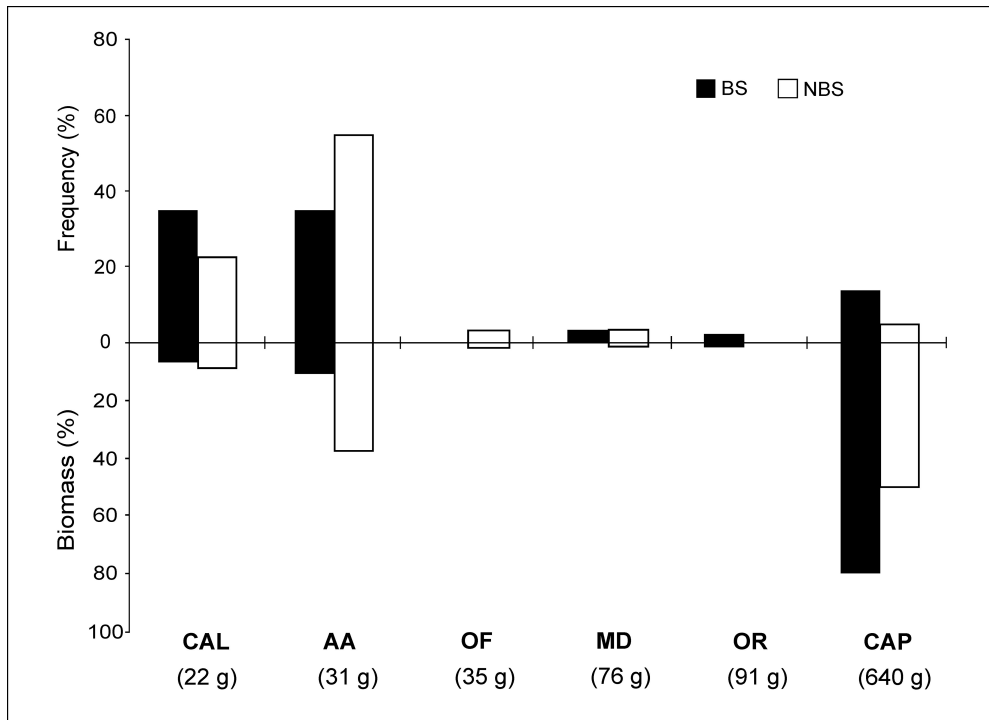


Figure 3. Numeric frequency (%) and percent biomass (%) of mammalian prey consumed by White-tailed Kites (*Elanus leucurus*) during the breeding (BS) and nonbreeding seasons (NBS) in the Argentine Pampas. Prey are arranged from left to right according to increasing body mass. Prey species: CAL = vesper mice (*Calomys* spp.), AA = Azara's grass mouse (*Akodon azarae*), OF = yellow pygmy rice rat (*Oligoryzomys flavescens*), MD = southern short-tailed opossum (*Monodelphis dimidiata*), OR = red hocihudo (*Oxymycterus rufus*), CAP = Brazilian guinea pig (*Cavia aperea*). Body mass of adult individuals for each species is shown in parentheses below prey item acronyms.

The main prey items were Azara's grass mice (*Akodon azarae*, mean mass: 31 g) and vesper mice (*Calomys* spp., 22 g), which together represented 69% and 77% of total prey items in the breeding and nonbreeding seasons, respectively (Fig. 3). Brazilian guinea pigs (*Cavia aperea*, mean mass: 640 g) comprised the bulk of biomass in the diet, and represented 80% and 50% of total biomass during the breeding and nonbreeding seasons, respectively (Fig. 3). For the entire sampling period (all breeding and nonbreeding seasons), the food-niche breadth indices were  $B = 3.45$  and  $B_{sta} = 0.31$ ; the Standardized Levins' Index was broader during the breeding season ( $B_{sta} = 0.46$ ) than during the nonbreeding season ( $B_{sta} = 0.29$ ). The geometric mean mass of prey for the entire diet was  $34.7 \pm 10.4$  g, with little variation between seasons (breeding season =  $36.5 \pm 3.1$  g; nonbreeding season =  $32.4 \pm 2.9$  g).

#### DISCUSSION

We found that White-tailed Kites in the Argentine Pampas were primarily mammal-eating, active-search predators. This characterization coincides with previous reports of White-tailed Kite foraging behavior in different parts of their distribution in South America (e.g., Chile: Meserve 1977, Schlatter et al. 1980, González-Acuña et al. 2009; Brazil: Scheibler 2004; Argentina: Leveau et al. 2002, Sarasola et al. 2007, 2010), and North America (see Dunk 1995 and references therein). Moreover, our results are consistent with those reported for other *Elanus* species around the world (Mendelsohn and Jaksić 1989, Thiollay 1994).

In the Argentine Pampas, White-tailed Kites' time was primarily devoted to perching and foraging. However, we found differences in kites' time-activity budgets between the breeding and nonbreeding seasons, primarily related to differences in their

foraging behavior. Thus, even when kites spent a similar percentage of time foraging during both breeding and nonbreeding seasons, they differed in the hunting modes used to capture prey. Kites frequently used passive searching during the breeding season, but exclusively used active searching in the nonbreeding season. Such difference may be attributed to the fact that during the breeding season kites may be hunting in areas close to their nesting site (Warner and Rudd 1975). Engaging in passive searching then may serve two functions, foraging and nest vigilance, thus optimizing the trade-off between both activities (Lima and Dill 1990, Schmidt 1999). In addition, we observed that kites tended to perform more cruising flights during the nonbreeding season than during the breeding season, which may be associated with an expansion of foraging areas during the nonbreeding season (Watson 1940, Warner and Rudd 1975). Cases of reduction in the activity area associated with reproduction have been reported for other raptors (e.g., Marzluff et al. 1997, Bosch et al. 2010).

Rodents were the dominant prey item in the diet of White-tailed Kites in the Argentine Pampas in terms of both numbers and biomass. This dominance of rodents is similar to previous reports at the regional (Scheibler 2004) and continental scales (Dunk 1995). This also coincides with the habits of most *Elanus* species around the world, such as Black-shouldered Kites (*E. axillaris*; Mendelsohn and Jaksic 1989, Debus et al. 2006), Black-winged Kites (*E. caeruleus*; Slotow et al. 1988, Vosoghi et al. 2012, Manaa et al. 2013), and Letter-winged Kites (*E. scriptus*; Pavey et al. 2008). The number of rodent species in the diet of kites in our study area (six species) was similar to that of other sympatric small-mammal specialist diurnal raptors in the study area, such as Roadside Hawks (*Rupornis magnirostris*) and Variable Hawks (*Geranoaetus polyosoma*; Baladrón et al. 2006, 2011). These three raptor species showed a similar pattern of prey consumption, with Azara's grass mice and vesper mice as major prey in numerical terms (Baladrón et al. 2006, 2011). These sigmodontine rodents are the most abundant species in the Pampas (de Villafañe et al. 1988, González-Fischer et al. 2012), alternating prevalence associated with cover-type characteristics (Bilenca et al. 2007). Azara's grass mice are competitively dominant in grasslands and agricultural borders, whereas vesper mice are dominant in crops (Bilenca and Kravetz 1995). These rodents represent a considerable proportion of White-tailed Kites' diet

in agricultural areas of central Argentina (Leveau et al. 2002, Sarasola et al. 2007), which suggests that this raptor may be preying on the most locally abundant species. At a regional scale, our results correspond with those from Chile, where White-tailed Kites prey on the most abundant sigmodontine rodents in agricultural areas (Meserve 1977, Schlatter et al. 1980, González-Acuña et al. 2009).

Even when small rodents were numerically dominant in the diet of White-tailed Kites, the bulk of dietary biomass was composed of larger rodents, in particular Brazilian guinea pigs. This species may reach high population densities in grasslands and field margins with tall vegetation in our study area (up to 38.7 individuals per ha; Malizia et al. 2001). Its high abundance and profitability in terms of energetic return explain the importance of this prey item for kites. Sarasola et al. (2007) reported a similar tendency in semiarid forest of Argentina, where other larger rodents (tuco-tuco [*Ctenomys* spp.]) represented > 90% of total biomass in White-tailed Kites' diet. The standardized food-niche breadth value for White-tailed Kites in our study (0.31) was intermediate between those reported for Roadside Hawks (0.10) and Variable Hawks (0.55) in our study area (Baladrón et al. 2006, 2011). In addition, the food-niche breadth in our study was similar to that reported for agricultural areas of Argentina (0.35, Leveau et al. 2002; 0.33, Sarasola et al. 2007). These results suggest that agricultural cover types may be the principal hunting areas for White-tailed Kites in the southern portion of their distribution.

#### ACKNOWLEDGMENTS

We thank P. Urrutia and his family for their courtesy and permission to work on his ranch and M. Román for his help with data analyses. We are grateful to R. Figueroa Rojas and two anonymous reviewers who made valuable criticisms on an early version of this report. Our work was supported by Universidad Nacional de Mar del Plata Fund to Laboratorio de Vertebrados (15/E317), and a CONICET Scholarship to A. Baladrón. Equipment for this research was provided through an Idea Wild Grant to A. Baladrón.

#### LITERATURE CITED

- Baladrón, A. V., M. S. Bó, M. J. Bechard, and A. I. Malizia (2017). Relative abundance, habitat use, and seasonal variability of raptor assemblages in the flooding Pampas of Argentina. *Journal of Raptor Research* 51:38–49.
- Baladrón, A. V., M. S. Bó, and A. I. Malizia (2006). Winter diet and time-activity budgets of Red-backed



- Hawk (*Buteo polyosoma*) in the coastal grasslands of Buenos Aires Province, Argentina. *Journal of Raptor Research* 40:65–70.
- Baladrón, A. V., M. S. Bó, A. I. Malizia, and M. J. Bechard (2011). Food habits of the Roadside Hawk (*Buteo magnirostris*) during the nonbreeding season in the southeastern Pampas of Argentina. *Journal of Raptor Research* 45:257–261.
- Belloq, M. I., and F. Kravetz (1983). Identificación de especies, sexo, y edad relativa a partir de restos óseos de roedores de la provincia de Buenos Aires, Argentina. *Historia Natural* 3:101–112.
- Bilenca, D., C. M. González-Fischer, P. Teta, and M. Zamero (2007). Agricultural intensification and small mammal assemblages in agroecosystems of the rolling Pampas, central Argentina. *Agriculture, Ecosystems & Environment* 121:371–375.
- Bilenca, D., and F. Kravetz (1995). Patrones de abundancia relativa en ensambles de pequeños roedores de la región pampeana. *Ecología Austral* 5:21–30.
- Bilenca, D., and F. Miñarro (2004). Identificación de Áreas Valiosas de Pastizal en las Pampas y Campos de Argentina, Uruguay y Sur de Brasil. Fundación Vida Silvestre Argentina, Buenos Aires, Argentina.
- Bond, R. M. (1940). Food habits of the White-tailed Kite. *The Condor* 42:168.
- Bosch, R., J. Real, A. Tintó, E. L. Zozaya, and C. Castell (2010). Home-ranges and patterns of spatial use in territorial Bonelli's Eagles *Aquila fasciata*. *Ibis* 152:105–117.
- Brown, L., and D. Amadon (1968). *Eagles, Hawks and Falcons of the World*, Vol. 1. Country Life Books, London, UK.
- Cabrera, A. L. (1971). Fitogeografía de la República Argentina. *Boletín de la Sociedad Argentina de Botánica* 19:1–42.
- Cunningham, J. D. (1955). Notes on food habits of the White-tailed Kite in southern California. *The Condor* 57:371.
- Debus, S. J. S., G. S. Olde, N. Marshall, J. Meyer, and A. B. Rose (2006). Foraging, breeding behavior and diet of a family of Black-winged Kite *Elanus axillaris* near Tamworth New South Wales. *Australian Field Ornithology* 23:130–143.
- de la Peña, M. R. (2016). Aves Argentinas: descripción, comportamiento, reproducción y distribución. Ciconiidae a Heliornithidae. *Comunicaciones del Museo Provincial de Ciencias Naturales Florentino Ameghino (Nueva Serie)* 19:1–436.
- de Villafañe, G., S. M. Bonaventura, M. I. Belloq, and R. E. Percich (1988). Habitat selection, social structure, density and predation in populations of Cricetine rodents in the pampa region of Argentina and the effects of agricultural practices on them. *Mammalia* 52:339–359.
- Dixon, J. B., R. E. Dixon, and J. E. Dixon (1957). Natural history of the White-tailed Kite in San Diego County, California. *The Condor* 59:156–165.
- Dunk, J. R. (1995). White-tailed Kite (*Elanus leucurus*). *The Birds of North America* (A. F. Poole, and F. B. Gill, Editors) Cornell Lab of Ornithology, Ithaca, NJ, USA. <https://birdsna.org/Species-Account/bna/species/whtkit>.
- Gaibani, G., and D. Csermely (2007). Behavioral studies. In *Raptor Research and Management Techniques* (D. M. Bird, and K. L. Bildstein, Editors). Hancock House, WA, USA. pp. 117–128.
- Gómez Villafañe, I. E., M. Miño, R. Cavia, K. Hodara, P. Courtalón, O. Suárez, and M. Busch (2005). *Guía de Roedores de la Provincia de Buenos Aires*. L.O.L.A. (Literature of Latin America), Buenos Aires, Argentina.
- González-Acuña, D., E. Briones, K. Ardiles, G. Valenzuela-Dellarossa, S. Corales, and R. A. Figueroa R. (2009). Seasonal variation in the diet of the White-tailed Kite (*Elanus leucurus*) in a suburban area of southern Chile. *Journal of Raptor Research* 43:134–141.
- González-Fischer, C. M., G. Baldi, M. Codesido, and D. Bilenca (2012). Seasonal variations in small mammal-landscape associations in temperate agroecosystems: a study case in Buenos Aires province, central Argentina. *Mammalia* 76:339–406.
- Hawbecker, A. C. (1940). The nesting of the White-tailed Kite in southern Santa Cruz County, California. *The Condor* 42:106–111.
- Isacch, J. P. (2008). Implementing the biosphere reserve concept: the case of Parque Atlántico Mar Chiquito Biosphere Reserve from Argentina. *Biodiversity and Conservation* 17:1799–1804.
- Isacch, J. P., M. S. Bó, L. E. Vega, M. Favero, A. V. Baladrón, M. G. Pretelli, O. A. Stellatelli, D. A. Cardoni, S. Copello, C. Block, M. Cavalli, et al. (2016). Diversidad de Tetrápodos en un mosaico de ambientes del sudeste de la ecorregión Pampas como herramienta para planificar en conservación. *Revista del Museo Argentino de Ciencias Naturales* 18:211–233.
- Jaksić, F. M. (1985). Toward raptor community ecology: behavior bases of assemblage structure. *Journal of Raptor Research* 19:107–112.
- Jaksić, F. M., and J. H. Carothers (1985). Ecological, morphological and bioenergetic correlates of hunting mode in hawks and owls. *Ornis Scandinavica* 16:165–172.
- Jaksić, F. M., R. Rozzi, A. Labra, and J. E. Jiménez (1987). The hunting behavior of Black-shouldered Kites

- (*Elanus caeruleus leucurus*) in central Chile. *The Condor* 89:907–911.
- Leveau, L. M., C. M. Leveau, and U. F. J. Pardiñas (2002). Dieta del milano blanco (*Elanus leucurus*) en Argentina. *Ornitología Neotropical* 13:307–311.
- Lima, S. L., and L. M. Dill (1990). Behavioral decisions made under the risk of predation: a review and prospectus. *Canadian Journal of Zoology* 68:619–640.
- Malizia, A. I., D. Antinuchi, and A. I. Vassallo (2001). Aspectos ecológicos de la comunidad de roedores de la Reserva de Mar Chiquita con énfasis en el roedor subterráneo *Ctenomys talarum*. In *Reserva de Biosfera Mar Chiquita: Características Físicas, Biológicas y Ecológicas* (O. Iribarne, Editor). UNESCO-Editorial Martín, Mar del Plata, Argentina. pp. 287–302.
- Manaa, A., K. Souttou, M. Sekour, D. Bendjoudi, O. Guezoul, F. Baziz-Neffah, S. Doumandji, E. Stoetzel, and C. Denys (2013). Diet of Black-shouldered Kite *Elanus caeruleus* in a farmland area near Algiers, Algeria. *Ostrich* 84:113–117.
- Marti, C. D., M. J. Becharad, and F. M. Jaksić (2007). Food habits. In *Raptor Research and Management Techniques* (D. M. Bird and K. L. Bildstein, Editors). Hancock House, Blaine, WA, USA. pp. 129–151.
- Martin, P., and P. Bateson (1993). *Measuring Behavior: An Introductory Guide*. Second ed. Cambridge University Press, Cambridge, UK.
- Marzluff, J. M., S. T. Knick, M. S. Vekasy, L. S. Schueck, and T. J. Zarriello (1997). Spatial use and habitat selection of Golden Eagles in southeastern Idaho. *The Auk* 114:673–687.
- Mendelsohn, J. M., and F. M. Jaksić (1989). Hunting behaviour of Black-shouldered Kites in the Americas, Europe, Africa and Australia. *Ostrich* 60:1–12.
- Meserve, P. L. (1977). Food habits of a White-tailed Kite population in central Chile. *The Condor* 79:263–265.
- Morrone, J. J., and S. Coscarón (1998). Biodiversidad de Artrópodos Argentinos: Una Perspectiva Biotaxonómica. Ediciones SUR, La Plata, Argentina.
- Nadjafzadeh, M., H. Hofer, and O. Krone (2016). Sit-and-wait for large prey: foraging strategy and prey choice of White-tailed Eagles. *Journal of Ornithology* 157:165–178.
- Newton, I. (1979). *Population Ecology of Raptors*. Buteo Books, Vermillion, SD, USA.
- Pavey, C. R., J. Gorman, and M. Heywood (2008). Dietary overlap between the nocturnal Letter-winged Kite *Elanus scriptus* and Barn Owl *Tyto alba* during a rodent outbreak in arid Australia. *Journal of Arid Environments* 72:2282–2286.
- Pickwell, G. (1930). The White-tailed Kite. *The Condor* 32:221–239.
- R Development Core Team (2016). R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. <http://www.r-project.org>.
- Redford, K. H., and J. F. Eisenberg (1992). *Mammals of the Neotropics: The Southern Cone*. Vol. 2. The University of Chicago Press, Chicago, IL, USA.
- Sarasola, J. H., and J. J. Negro (2005). Hunting success of wintering Swainson's Hawks: environmental effects on timing and choice of foraging method. *Canadian Journal of Zoology* 83:1353–1359.
- Sarasola, J. H., M. A. Santillán, and M. A. Galmes (2007). Comparison of foods habits and prey selection of the White-tailed Kite, *Elanus leucurus*, between natural and disturbed areas in central Argentina. *Studies on Neotropical Fauna and Environment* 42:85–91.
- Sarasola, J. H., C. Solaro, M. A. Santillán, and M. A. Galmes (2010). Communal roosting behavior and winter diet of the White-tailed Kite (*Elanus leucurus*) in an agricultural habitat on the Argentine Pampas. *Journal of Raptor Research* 44:202–207.
- Scheibler, D. R. (2004). Geographic variation in the size of mammalian prey taken by White-tailed Kites in the Americas. *Journal of Field Ornithology* 75:218–222.
- Scheibler, D. R. (2007). Food partitioning between breeding White-tailed Kites (*Elanus leucurus*; Aves; Accipitridae) and Barn Owls (*Tyto alba*; Aves; Tytonidae) in southern Brazil. *Brazilian Journal of Biology* 67:65–71.
- Schlatter, R. P., J. L. Yáñez, and F. M. Jaksić (1980). Food-niche relationships between Chilean Eagles and Red-backed Buzzards in central Chile. *The Auk* 97:897–898.
- Schmidt, K. A. (1999). Foraging theory as a conceptual framework for studying nest predation. *Oikos* 85:151–160.
- Schoener, T. (1971). Theory of feeding strategies. *Annual Review of Ecology and Systematics* 2:369–404.
- Skonieczny, M. F., and J. R. Dunk (1997). Hunting synchrony in White-tailed Kites. *Journal of Raptor Research* 31:79–81.
- Slotow, R. H., J. M. Mendelsohn, and M. R. Perrin (1988). The diet of adult and nestling Black-shouldered Kites, and breeding success. *Ostrich* 59:150–154.
- Soriano, A., R. J. León, O. E. Sala, R. S. Lavado, V. A. Deregibus, M. A. Cauhépe, O. A. Scaglia, C. A. Velázquez, and J. H. Lemcoff (1991). Río de la Plata grasslands. In *Natural Grasslands* (R. T. Coupland, Editor). Elsevier, NY, USA. pp. 367–407.
- Steen, R., L. M. Løw, and G. A. Sonerud (2011). Delivery of common lizards (*Zootoca* (*Lacerta*) *vivipara*) to nests of Eurasian Kestrels (*Falco tinnunculus*) deter-

- mined by solar height and ambient temperature. *Canadian Journal of Zoology* 89:199–205.
- Steenhof, K., and M. N. Kochert (1988). Dietary responses of three raptor species to changing prey densities in a natural environment. *Journal of Animal Ecology* 57:37–48.
- Stendell, R. C., and P. Myers (1973). White-tailed Kite predation on a fluctuating vole population. *The Condor* 75:359–360.
- Stoner, E. A. (1947). Food of White-tailed Kites on the Suisun Marsh. *The Condor* 49:84–85.
- Thiollay, J. M. (1994). Family Accipitridae (hawks and eagles). In *Handbook of Birds of the World, Vol. 2. New World Vultures to Guineafowl* (J. del Hoyo, A. Elliott, and J. Sargatal, Editors). Lynx Editions, Barcelona, Spain. pp. 52–205.
- Vargas, R. J., M. S. Bó, and M. Favero (2007). Diet of the Southern Caracara (*Caracara plancus*) in Mar Chiquita Reserve, southern Argentina. *Journal of Raptor Research* 41:113–121.
- Vosoghi, M. H., A. Ashoori, and H. G. Kami (2012). Breeding of the Black-winged Kite *Elanus caeruleus* in Fars Province, Iran. *Podoces* 7:16–20.
- Waian, L., and R. C. Stendell (1970). The White-tailed Kite in California with observations of the Santa Barbara population. *California Fish and Game* 56:188–198.
- Wakeley, J. S. (1978). Factors affecting the use of hunting sites by Ferruginous Hawks. *The Condor* 80:316–334.
- Warner, J. S., and R. L. Rudd (1975). Hunting by the White-tailed Kite (*Elanus leucurus*). *The Condor* 77:226–230.
- Watson, F. G. (1940). A behavior study of the White-tailed Kite. *The Condor* 42:295–304.

Received 4 July 2017; accepted 3 May 2018

Associate Editor: David E. Andersen