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SEASONAL AND GEOGRAPHIC VARIATION IN THE DIET OF BARN OWLS (*TYTO ALBA*) IN TEMPERATE AGROECOSYSTEMS OF ARGENTINA

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Resumen. – Variaciones estacionales y geográficas en la dieta de la Lechuza de Campanario (*Tyto alba*) en agroecosistemas templados de Argentina. – Estudiamos el nicho trófico de la Lechuza de Campanario (*Tyto alba*) en agroecosistemas templados del centro de Argentina, describiendo la variación estacional y geográfica en los hábitos dietarios de esta lechuza en cuatro distritos de la región Pampeana (Pampa Deprimida, Interior, Ondulada y Austral). Se identificaron 21.925 ítems presa de muestras frescas de egagrópilas coleccionadas durante el verano (n = 23) y el invierno (n = 26). Los mamíferos, en su mayoría roedores sigmodontinos, fueron los ítems mejor representados (91,9%), seguidos por anfibios (6,5%) y aves (1,6%). Los artrópodos también fueron ítems comunes, presentes en el 45% de las muestras. El consumo de artrópodos y anfibios fue mayor en verano que en invierno, sugiriendo que las variaciones estacionales en la abundancia de presas se reflejan en la dieta de la lechuza. No encontramos diferencias en la amplitud de nicho trófico entre los cuatro distritos estudiados, aunque este parámetro varió entre estaciones, siendo mayor durante el verano. Seis especies de roedores fueron comunes a todos los distritos: *Calomys* spp., *Akodon azarae*, *Oligoryzomys flavescens*, *Mus musculus*, *Rattus* spp. y *Holochilus brasiliensis*. *Calomys* spp. fue numéricamente dominante en 46 de las 49 muestras estudiadas, y junto con *A. azarae* y *O. flavescens* constituyeron la mayor parte de la dieta (> 80%). La dinámica poblacional de los roedores se reflejaría en las proporciones en la que este grupo es utilizado por las lechuzas, con mayores frecuencias de consumo cuando éstos presentan picos de abundancia (otoño–invierno).

Abstract. – We studied the dietary niche of the Barn Owl (*Tyto alba*) in temperate agroecosystems of central Argentina by describing seasonal and geographic variation in the food habits of this owl in four districts of the Pampean region (Flooding, Inland, Rolling, and Southern Pampas). We identified 21,925 prey items from samples of fresh pellets collected in summer (n = 23) and winter (n = 26). Mammals, mostly sigmodontine rodents, were the main prey items (91.9%), followed by amphibians (6.5%) and birds (1.6%). Arthropods were also a common prey item (found in 45% of the samples). The consumption of arthropods and amphibians was higher in summer than in winter, indicating that seasonal changes in prey abundances are reflected in the Barn Owl diet. We found no differences in food-niche breadth among the four study districts, but food-niche breadth varied between seasons, being higher during summer. Six rodent species were common to all districts: *Calomys* spp., *Akodon azarae*, *Oligoryzomys flavescens*, *Mus musculus*, *Rattus* spp., and *Holochilus brasiliensis*. *Calomys* spp. was numerically dominant

in 46 of the 49 samples, and together with *A. azarae* and *O. flavescens* comprised the bulk of the diet (> 80%). Predation on rodents may reflect population dynamics of the prey species with high predation rates when peaks in abundance of sigmodontine rodents occurred (autumn–winter). *Accepted 2 May 2011.*

Key words: Barn Owl, *Tyto alba*, Buenos Aires, Cricetidae, food-niche breadth, Pampean region, small mammals, Tytonidae.

INTRODUCTION

The Barn Owl (*Tyto alba*, Tytonidae) is a cosmopolitan strigiform that typically preys on small (< 200 g) mammals (Taylor 1994, Marks *et al.* 1999, Marti 2010). It prefers open habitats, including grasslands, deserts, marshes, and agricultural fields (Taylor 1994). Numerous studies have been conducted on the Barn Owl diet in Argentina, mostly focused in describing small mammal distributions (Bellocq 2000, Pardiñas & Cirignoli 2002 and references therein) or some aspect of predator-prey relationships (e.g., Bellocq 1998). In contrast, few studies have examined dietary responses at large scales (e.g., Leveau *et al.* 2006, Trejo & Lambertucci 2007). Leveau *et al.* (2006) explored geographic variation in diet along the coast of Buenos Aires province in east-central Argentina, showing that dietary parameters were strongly influenced by the composition of rodent assemblages in different phytogeographic units. However, no comprehensive large scale studies have included the agriculturally modified areas of the entire Pampean region of Buenos Aires province, and seasonal variation in the diet of the Barn Owl has not been considered in any regional study in southern South America.

Our objectives were: 1) to provide new information on the niche dimension of the Barn Owl, and 2) to describe spatial and seasonal variation in its feeding habits in four districts of the Pampean region of central Argentina. To the best of our knowledge, the studied data base is larger than any other previously published for a South American country, encompassing an area of ~ 277,000 km^2.

METHODS

Study area. The Pampas included in Buenos Aires province (~ 33°–41° S, 57°–63° W) are classified into four ecological units or districts which can be distinguished according to differences in geomorphology, soils, drainage, physiography, and vegetation: the Rolling Pampa, the Southern Pampa, the Flooding Pampa, and the Inland Pampa (Soriano *et al.* 1992; Fig. 1). Mean annual temperature varies from 13ºC in the south to 17ºC in the north and mean annual precipitation varies from 600 mm in the southwest to 1200 mm in the northeast. The four units also have different land use patterns: in the Rolling Pampa, crops have replaced most of the native vegetation and crop fields cover about 70% of the land whereas in the Flooding Pampa grasslands or pastures remain (> 85%). The Southern and the Inland Pampas have a mixed production system with similar areas dedicated to crops and animal husbandry (48 and 45% for the Southern Pampa, and 27 and 47% for the Inland Pampa, respectively). In the Rolling, Inland, and Flooding Pampas summer crops (soybean *Glycine max* and maize *Zea mays*) are predominant, whereas in the Southern Pampa winter crops (i.e., wheat *Triticum aestivum*) prevail (INDEC 2006, Baldi & Paruelo 2008).

Small mammal assemblages of the Pampas are dominated by the native sigmodontine rodents *Calomys laucha*, *C. musculinus*, *Akodon azarae*, and *Oligoryzomys flavescens* (Pardiñas *et al.* 2010). Introduced rats and mice (i.e., *Rattus norvegicus*, *R. rattus*, and *Mus musculus*) are restricted mostly to pig and poultry farms and

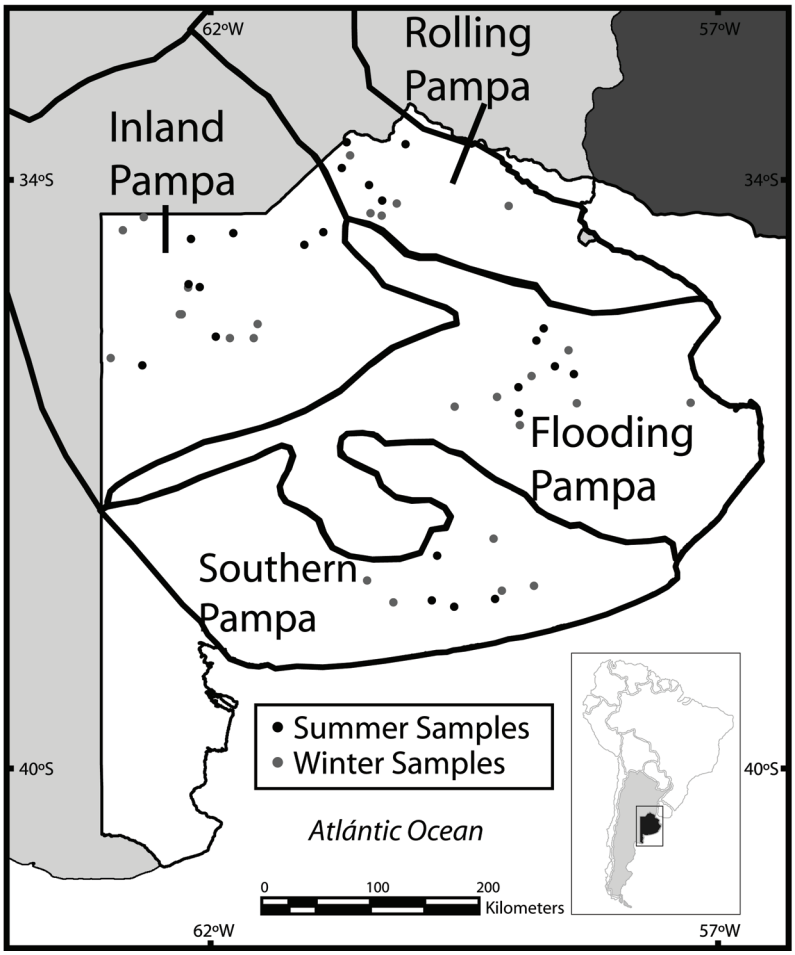

FIG. 1. Map of the study area indicating the collection sites of Barn Owl pellets and the four districts of the Pampean Region included in Buenos Aires province, Argentina.

the vicinities of human habitations cross the rural landscape (Gómez Villafañe & Busch 2007, Miño *et al.* 2007).

Field procedures and taxonomic identification. We collected fresh Barn Owl pellets during winter (July and August 2006–2007) and summer (January and February 2007–2008) from nest sites distributed in the four districts of the Pampean region included in Buenos Aires province (Fig. 1). Some areas, such as the eastern portion of the Rolling Pampa or the western portion of the Southern Pampa were not sampled. However, based on literature review (e.g., Pardiñas *et al.* 2010, Teta *et al.* 2010) and the relative environmental homogeneity within each unit (see Soriano *et al.* 1992) we made some conclusions extensive to these portions as well. Thus, with some confidence we think that the studied samples are coarsely

representative of the agriculturally modified areas of each district.

The pellets were soaked in water and broken up into small fragments manually. Sodium hydroxide (NaOH) solution was used to dissolve fur and feathers (following the method described by Longlan 1985) and the skeletal material recovered was washed in water and dried. Mammalian preys were identified to the lowest taxonomic level possible by examination of skulls and dentaries. Osseous remains were identified by comparison of voucher specimens deposited in museum collections and also by a literature review. Taxonomy followed Wilson & Reeder (2005) for rodents and marsupials and D'Elía *et al.* (2008) in the punctual case of the rodent genus *Necromys*. The number of bird specimens was identified by the number of skulls and femurs, and amphibians were counted by numbers of pelvic girdles. In addition, we also recorded the presence or absence of arthropods in each sample. Those samples with less than 100 prey items were excluded from statistical analyses, since they were considered as inadequate to determine ow's diet (Love *et al.* 2000).

Data analyses. Frequencies of samples containing arthropods were compared between seasons for each district using Fisher's exact test (Zar 1996). Mean percentages of mammals, birds, and amphibians were compared among districts and seasons by means of two-way analyses of variance (ANOVAs, Zar 1996). Data transformation and Tukey's multiple comparison tests were performed when necessary (Zar 1996). In addition, we compared the mean percentages of each of the six rodent species that were common to all districts. For each sample we computed the following dietary parameters (see Marti 1987): food-niche breadth ($FNB = 1/\sum pi^2$; where pi is the proportion of each class "i" in the diet), and standardized food-niche breadth ($FNBst = [FNB - 1]/[n - 1]$; where n is the total number of class categories) and small mammal species richness per site (S). Values for these parameters were compared among districts and seasons with separated two-way ANOVAs, and we analyze their relationship with latitude and longitude by means of separated linear regressions.

RESULTS

We analyzed samples from 49 sites, 23 from the summer and 26 from the winter (Fig. 1), identifying a total of 21,925 prey items: 91.9% mammals, 6.5% amphibians, and 1.6% birds. Mammals and birds were present in all samples, whereas amphibians and arthropods were present in 76% and 45% of the samples, respectively. The percentage of samples including arthropods increased from 12% in winter to 82% in summer (Fisher's exact test; $P < 0.001$, Fig. 2). In contrast, the percentage of mammals in the diet decreased from 98% in winter to 81% in summer (ANOVA; $F_{1;41} = 26.59$, $P < 0.001$, Fig. 2). Amphibian percentages in owl's pellets also varied seasonally and geographically, ranging from less than 1% in winter samples from the Southern Pampa to 17% in summer samples from the Inland Pampa (ANOVA, $F_{1;41} = 37.29$, $P < 0.001$ and $F_{3;41} = 4.73$, $P = 0.006$ for seasons and districts, respectively).

Of the 20,150 mammals identified, 20,113 (99.8%) were small mammals (< 150 g), including 9 rodent genera and one of marsupials (Table 1). Larger mammals (= 500 g) found in low frequencies included lagomorphs (*Lepus europaeus*), caviomorphs (*Cavia aperea*), and marsupials (*Lutreolina crassicaudata*).

We found no differences in the food-niche breadth indexes (FNB and FNBst) among the four studied districts. In comparison, food-niche breadth varied between seasons, being highest during summer (ANOVA, $F_{1;41} = 13.16$, $P < 0.001$; Table 2). In addition,

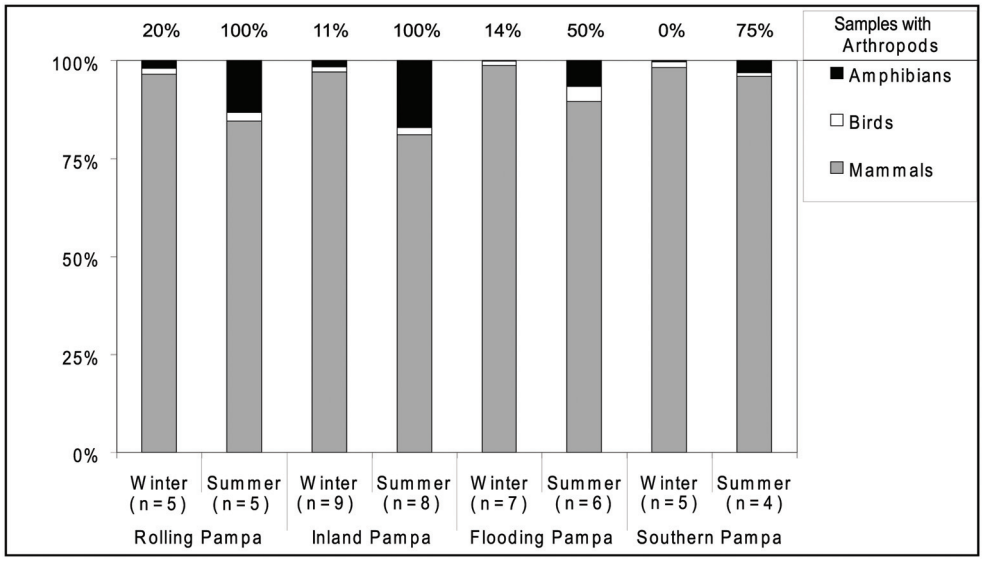

FIG. 2. Mean percentages of mammals, amphibians and birds in the diet of the Barn Owl, classified by season and ecological districts in Buenos Aires Province, Argentina. Values at the top of the bars indicate the percentage of samples with arthropods for each season and district.

no trend was observed between FNB or FNBst and latitude or longitude.

Mean small mammal species richness per site (S) was lowest in the Inland Pampa and highest in the Rolling Pampa (ANOVA, $F_{3;\,41} = 6.72$, $P < 0.001$; Table 1). Six rodent species were common to all ecological districts: *Calomys* spp. (including *C. laucha* and *C. musculinus*), *A. azarae*, *O. flavescens*, *Mus musculus*, *Rattus* spp., and *Holochilus brasiliensis* (Table 1). *Calomys* spp. were dominant in 46 of the 49 samples, and constituted the bulk of the sample along with *O. flavescens* and *A. azarae*. Mean percentage of both *O. flavescens* and *A. azarae* was lowest in the Southern Pampa and largest in the Flooding Pampa (ANOVA, $F_{3;\,41} = 4.71$, $P = 0.006$ and $F_{3;\,41} = 7.19$, $P < 0.001$ for *A. azarae* and *O. flavescens*, respectively). Moreover, the relative frequencies of *O. flavescens* in owl diets increased significantly from 10% in summer to 14% in winter (ANOVA, $F_{1;\,41} = 5.74$, $P = 0.021$), replacing *A. azarae* as the second more abundant species in winter pellet samples. Relative abundances of *Calomys* spp. showed a marginal variation among districts, ranging from 62% in the Flooding Pampa to 81% in the Southern Pampa (ANOVA, $F_{3;\,41} = 2.55$, $P = 0.069$). There was no significant variation among districts or between seasons in the presence of the other common species (Table 1).

DISCUSSION

We present the first comprehensive study of the feeding habits of Barn Owls in the Pampas of Buenos Aires province, Central Argentina. Our results agree with those reported in other studies conducted in southern South America, showing rodents of the subfamily Sigmodontinae as the main prey item (e.g., Massoia 1983, Bellocq 2000). Arthropods are usually found in Barn Owl pellets, sometimes even in great numbers (up to 50% of prey

TABLE 1. Percentages of each micro-mammal species (Mean ± SE and [minimum; maximum]) and species richness per site (S) estimated from Barn Owl pellet samples collected in summer and winter from the four districts of the Pampean Region included in Buenos Aires province, Central Argentina. N = Total number of individuals [minimum; maximum] micro-mammal prey items per sample for each district.

District/Season	Rolling Pampa		Inland Pampa		Flooding Pampa		Southern Pampa	
Species	Winter (N = 5)	Summer (N = 5)	Winter (N = 9)	Summer (N = 8)	Winter (N = 7)	Summer (N = 6)	Winter (N = 5)	Summer (N = 4)
Calomys spp.	63.7 ± 3.0	74.8 ± 5.7	74.8 ± 5.8	73.0 ± 4.0	64.5 ± 8.3	59.9 ± 10.6	81.6 ± 3.8	81.2 ± 8.3
	[57.0; 73.3]	[53.2; 87.1]	[40.1; 92.6]	[52.9; 85.3]	[21.4; 89.0]	[24.2; 85.1]	[72.4; 90.0]	[59.8; 94.7]
Oligoryzomys flavescens	20.7 ± 3.9	9.8 ± 1.9	13.1 ± 3.5	11.6 ± 2.2	15.6 ± 3.0	16.4 ± 4.7	6.9 ± 1.6	1.3 ± 0.8
	[13; 32.6]	[2.8; 13.7]	[3.0; 32.3]	[3.3; 19.8]	[6.0; 25.6]	[4.5; 34.2]	[3.7; 13.0]	[0.0; 3.4]
Akodon azarae	10.8 ± 2.2	12.7 ± 4.2	11.7 ± 2.4	13.9 ± 2.1	18.9 ± 6.0	23.3 ± 6.7	5.3 ± 1.7	5.1 ± 2.1
	[6.6; 16.9]	[6.1; 29.0]	[3.0; 27.2]	[5.9; 23.0]	[5.0; 52.9]	[3.4; 49.5]	[1.1; 11.1]	[0.9; 10.7]
Mus musculus	2.8 ± 2.6	0.9 ± 0.6	0.3 ± 0.1	0.9 ± 0.3	-	0.2 ± 0.1	3.6 ± 2.5	1.8 ± 0.8
	[0.0; 13.1]	[0.0; 3.0]	[0.0; 0.9]	[0.0; 2.7]	-	[0.0; 0.6]	[0.3; 13.6]	[0.0; 3.7]
Holochilus brasiliensis	0.3 ± 0.2	0.7 ± 0.6	-	0.5 ± 0.2	0.2 ± 0.1	-	0.1 ± 0.1	0.3 ± 0.3
	[0.0; 1.2]	[0.0; 3.2]	-	[0.0; 1.6]	[0.0; 0.4]	-	[0.0; 0.5]	[0.0; 1.3]
Rattus spp.	0.8 ± 0.4	0.04 ± 0.0	0.04 ± 0.0	0.1 ± 0.1	0.2 ± 0.2	0.1 ± 0.1	0.03 ± 0.0	-
	[0.0; 2.5]	[0.0; 0.2]	[0.0; 0.4]	[0.0; 0.5]	[0.0; 1.4]	[0.0; 0.9]	[0.0; 0.2]	-
Reithrodon auritus	-	-	-	-	0.5 ± 0.2	0.1 ± 0.1	1.9 ± 0.7	9.9 ± 8.0
	-	-	-	-	[0.0; 1.4]	[0.0; 0.4]	[0.2; 4.5]	[0.0; 33.6]
Necromys lasiurus	0.6 ± 0.3	0.8 ± 0.2	-	-	-	-	0.1 ± 0.1	-
	[0.0; 1.9]	[0.4; 1.4]	-	-	-	-	[0.0; 0.3]	-
Oxymycterus rufus	0.04 ± 0.0	-	-	-	0.1 ± 0.1	-	0.4 ± 0.4	-
	[0.0; 0.2]	-	-	-	[0.0; 0.7]	-	[0.0; 1.8]	-
Monodelphis dimidiata	0.2 ± 0.1	0.3 ± 0.2	-	-	0.05 ± 0.0	-	0.1 ± 0.1	0.3 ± 0.2
	[0.0; 0.6]	[0.0; 1.1]	-	-	[0.0; 0.3]	-	[0.0; 0.3]	[0.0; 0.9]
Necromys obscurus	-	-	-	-	-	-	0.02 ± 0	0.1 ± 0.1
	-	-	-	-	-	-	[0.0; 0.1]	[0.0; 0.3]
N	2459	1803	3556	2563	2542	1442	3704	2044
	[161; 1018]	[124; 743]	[148; 761]	[133; 1071]	[140; 620]	[117; 519]	[366; 889]	[107; 877]
S	6.2 ± 0.66	6.0 ± 0.63	3.9 ± 0.20	4.6 ± 0.26	4.7 ± 0.47	3.8 ± 0.31	6.2 ± 0.97	5.0 ± 0.82

TABLE 2. Food-niche breadth (FNB) and standardized food-niche breadth (FNBst) (Mean ± SE and [minimum; maximum]) estimated from Barn Owl pellet samples (taking classes as categories) collected in summer and winter from the four districts of the Pampean Region included in Buenos Aires province, Central Argentina.

District/Season	Rolling Pampa		Inland Pampa		Flooding Pampa		Southern Pampa	
	Winter (N = 5)	Summer (N = 5)	Winter (N = 9)	Summer (N = 8)	Winter (N = 7)	Summer (N = 6)	Winter (N = 5)	Summer (N = 4)
FNB	1.07 ± 0.06 [1.01; 1.41]	1.38 ± 0.32 [1.05; 1.83]	1.06 ± 0.07 [1.01; 1.23]	1.46 ± 0.32 [1.07; 1.96]	1.03 ± 0.02 [1.01; 1.85]	1.26 ± 0.31 [1.01; 1.85]	1.03 ± 0.04 [1.00; 1.08]	1.08 ± 0.06 [1.01; 1.14]
FNBst	0.37 ± 0.32 [0.01; 0.64]	0.88 ± 0.32 [0.55; 1.33]	0.45 ± 0.25 [0.01; 0.73]	0.95 ± 0.32 [0.57; 1.46]	0.24 ± 0.27 [0.01; 0.54]	0.68 ± 0.43 [0.01; 1.35]	0.34 ± 0.28 [0; 0.59]	0.45 ± 0.29 [0.01; 0.64]

items). However, even in high percentages their contribution in terms of biomass is negligible (Bellocq 2000, Motta-Junior 2006). In fact, most studies regarding the diet of the Barn Owl are focused on small vertebrates, and generally arthropod data is either not registered at all or not included in the publications (Love *et al.* 2000). Dominance of small mammals in the diet at all districts explained the low values for food-niche breadth. The lower relative proportion of small mammals in summer and the higher consumption of arthropods and amphibians during this period compared with winter are consistent with seasonal changes in the abundance of each of these prey items in the environment (Mills *et al.* 1991, Busch & Kravetz 1992, Bilenca & Kravetz 1998, Attademo *et al.* 2005). Moreover, it is widely documented that birds, amphibians, arthropods, and bats have been reported as prey of the Barn Owl in some areas when preferred mammalian prey species declined (Bosè & Guidali 2001). In fact, field densities of rodents in Pampean agroecosystems are lower in spring and summer (Crespo *et al.* 1970, Mills *et al.* 1991). Our results are in agreement with previous studies showing that changes in prey availability are reflected in the diet of Barn Owls (Taylor 1994, Bellocq 1998, Love *et al.* 2000).

The relative consumption of amphibians by Barn Owls in this study is among the highest recorded for the Pampean region (Bellocq 2000, but see Fernández *et al.* 2010), even though they are lower than those reported for some tropical areas in South America (Delgado & Calderón 2007, but see Pardiñas *et al.* 2005). The higher proportion of amphibians in the diet recorded for the Inland Pampa could be related to the higher availability of habitats suitable for amphibians associated with wetland cover in this district (LART 2004).

The relative abundance of *Calomys* spp. was higher that reported in several previous studies (e.g., Bellocq 2000, Leveau *et al.* 2006). Ecological, paleontological and genetic studies have associated the dominance of *Calomys* spp. with anthropogenic disturbance and intensification of the agriculture in the Pampean region (Kravetz *et al.* 1986, Bilenca & Kravetz 1995, Pardiñas 1999, Chiappero *et al.* 2002a, 2002b; Bilenca *et al.* 2007, González-Ittig *et al.* 2007) and Patagonia (Pardiñas *et al.* 2000). High consumption of one or two micromammalian species by Barn Owls is a frequent situation in agricultural regions through the world (Marti 1988, 2010; Love *et al.* 2000, Keene 2009).

The relative abundances of other common sigmodontine species found in our study partially differ from those found in previous studies for coastal Buenos Aires province (Leveau *et al.* 2006). In particular, Leveau *et al.* (2006) found that *O. flavescens* and *A. azarae* were the dominant prey species in the Flooding Pampa, whereas in our study *Calomys* spp. were the most common prey species in all districts, including the Flooding Pampa (Table 1). However, the relative abundances of *A. azarae* and *O. flavescens* in our study were significantly higher in the Flooding Pampa than in the other districts. The only sites in which *A. azarae* or *O. flavescens* were the dominant prey species belonged to the Flooding Pampa and were the closest to those reported by Leveau *et al.* (2006). Thus, as has been previously indicated by Pardiñas (1999), it seems that *A. azarae* and *O. flavescens* are still the dominant species towards the eastern part of the Flooding Pampas near to the coast, where the low terrain and soil restrictions prevent the expansion of agriculture, and keeps the abundances of *Calomys* spp. at lower levels.

Barn Owls specialize on small mammals throughout their range and the variety of small prey taken appears to vary with availability and environmental and geographical features (Taylor 1994, Bellocq 1998, Love *et al.* 2000, Marti 2010). Accordingly, species

richness was high toward the Rolling Pampas and lower at the Inland Pampa, following the general trends of small mammal richness in the Pampean region (see Pardiñas *et al.* 2010). The predation on rodents that we observed may have been a reflection of the population dynamics of the prey species. In fact, we recorded the highest predation rates when peaks in abundance of sigmodontine occurred (autumn–winter; see Mills *et al.* 1991, Busch & Kravetz 1992, Bilenca & Kravetz 1998).

Taking into account the recent changes observed in the Pampean biota related to different land use and landscape structure, such as the case of amphibians (Attademo *et al.* 2005) and birds (Codesido *et al.* 2008, Schrag *et al.* 2009, Codesido *et al.* in press), analysis of owl pellets is a promising tool for evaluating the composition of small mammal assemblages in short-term periods (Love *et al.* 2000). In this context, a large regional database such as ours is the first step toward making future contributions of this kind.

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REFERENCES

Attademo, A. M., P. M. Peltzer, & R. C. Lajmanovich. 2005. Amphibians occurring in soybean and implications for biological control in Argentina. Agric. Ecosyst. Environ. 106: 389–394.

Baldi, G., & J. M. Paruelo. 2008. Land-use and land cover dynamics in South American temperate grasslands. Ecol. Soc. 13: 6.

Bellocq, M. I. 1998. Prey selection by breeding and nonbreeding Barn Owls in Argentina. Auk 115: 224–229.

Bellocq, M. I. 2000. A review of the trophic ecology of the Barn Owl in Argentina. J. Raptor Res. 34: 108–119.

Bilenca, D. N., & F. O. Kravetz. 1995. Patrones de abundancia relativa en ensambles de pequeños roedores de la Región Pampeana. Ecol. Austral 5: 21–30.

Bilenca, D. N., & F. O. Kravetz. 1998. Seasonal variations in microhabitat use and food habits of the Pampas mouse, *Akodon azarae*, in agroecosystems of central Argentina. Acta Theriol. 43: 195–203.

Bilenca, D. N., C. M. Gonzalez-Fischer, P. Teta, & M. Zamero. 2007. Agricultural intensification and small mammal assemblages in agroecosystems of the Rolling Pampas, central Argentina. Agric. Ecosyst. Environ. 121: 371–375.

Bosè, M., & F. Guidali. 2001. Seasonal and geographic differences in the diet of the Barn Owl in an agro-ecosystem in northern Italy. J. Raptor Res. 35: 240–246.

Busch, M., & F. O. Kravetz. 1992. Competitive interactions among rodents (*Akodon azarae*, *Calomys laucha*, *C. musculinus* and *Oligorzomys flavescens*) in a two-habitat system. I. Spatial and numerical relationships. Mammalia 56: 541–554.

Chiappero M. B., M. S. Sabattini, A. Blanco, G. E. Calderón, & C. N. Gardenal. 2002a. Gene flow among *Calomys musculinus* (Rodentia, Muridae) populations in Argentina. Genetica 114: 63–72.

Chiappero M. B., A. Blanco, G. E. Calderón, M. S. Sabattini, & C. N. Gardenal. 2002b. Genetic structure of populations of *Calomys laucha* (Muridae, Sigmodontinae) from Central Argentina. Biochem. Syst. Ecol. 30: 1023–1036.

Codesido, M., C. M. González-Fischer, & D. N. Bilenca. 2008. Asociaciones entre diferentes patrones de uso de la tierra y ensambles de aves en agroecosistemas de la Región Pampeana, Argentina. Ornitol. Neotrop. 19 (Suppl.): 4–11.

Codesido, M., C. M. González-Fischer, & D. N. Bilenca. In press. Distributional changes of

landbird species in agroecosystems of central Argentina. Condor 113: – .

Crespo, J. A., M. S. Sabattini, M. J. Piantanida, & G. N. de Villafañe. 1970. Estudios ecológicos sobre roedores silvestres. Publicación especial de la Secretaría de Estado de Salud Pública, Ministerio de Bienestar Social de la República Argentina, Buenos Aires, Argentina.

Delgado, C. A., & F. D. Calderón. 2007. La dieta de la lechuza común *Tyto alba* (Tytonidae) en una localidad urbana de Urabá, Colombia. Bol. SAO 17: 94–97.

D'Elía, G., U. F. J. Pardiñas, J. P. Jayat, & J. Salazar-Bravo. 2008. Systematics of *Necromys* (Rodentia, Cricetidae, Sigmodontinae): species limits and groups, with comments on historical biogeography. J. Mammal. 89: 778–790.

Fernández, F. J., G. Moreira, D. Ferraro, & L. De Santis. 2009. Presas consumidas por la lechuza de campanario (*Tyto alba*) en la localidad de Olavarría, Buenos Aires: un caso de elevada batracofagia. Nuestras Aves 54: 20–21.

Gómez Villafañe, I. E., & M. Busch. 2007. Spatial and temporal patterns of Brown Rat (*Rattus norvegicus*) abundance variation in poultry farms. Mamm. Biol. 72: 364–371.

González-Ittig, R. E., J. L. Patton, & C. N. Gardenal. 2007. Analysis of cytochrome-b nucloetide diversity confirms a recent range expansion in *Calomys musculinus* (Rodentia, Muridae). J. Mammal. 88: 777–783.

INDEC. 2006. Censo Nacional Agropecuario 2002: Resultados Generales. Instituto Nacional de Estadística y Censos de la República Argentina, Buenos Aires, Argentina.

Keene, A. 2009. Study of small mammal populations within two Barn Owl corridors at Folly Farm. Biosci. Horiz. 2: 9.

Kravetz, F. O., R. E. Percich, G. A. Zuleta, M. A. Callelo, & M. C. Weissembacher. 1986. Distribution of Junin Virus and its reservoirs. A tool for Argentine Hemorrhagic Fever risk. evaluation in non-endemic areas. Interciencia 11: 185–188.

LART. 2004. Estimación de áreas y distribución de las diferentes clases de cobertura de suelo durante el período inverno-primaveral para la Provincia de Buenos Aires. Laboratorio de Análisis Regional y Teledetección. Accessed on 12 December 2009 from http://www.agro.uba.ar/users/lart/estimacionesagricolas/estimaciones/resultados.htm.

Leveau, L. M., P. Teta, R. Bogdaschewsky, & U. F. J. Pardiñas. 2006. Feeding habits of the Barn Owl (*Tyto alba*) along a longitudinal–latitudinal gradient in Central Argentina. Ornitol. Neotrop. 17: 353–362.

Longlan, W. S. 1985. Comments on preparing owl pellets by boiling in NaOH. J. Field Ornithol. 56: 277.

Love, R. A., C. Webbon, D. E. Blue, & S. Harris. 2000. Changes in the food of British Barn Owls (*Tyto alba*) between 1947 and 1997. Mamm. Rev. 30: 107–129.

Marks, J. S., R. J. Cannings, & H. Mikkola. 1999. Family Strigidae (typical owls). Pp. 76–42 *in* del Hoyo, J., A. Elliott, & J. Sargatal (eds). Handbook of the birds of the world. Volume 5: Barn owls to hummingbirds. Lynx Edicions, Barcelona, Spain.

Marti, C. D. 1987. Raptor food habits studies. Pp. 67–80 *in* Giron Pendleton, B. A, B. A. Millsap, K. W. Cline, & D. M. Bird (eds). Raptor management techniques manual. National Wildlife Federation, Washington, D.C., USA.

Marti, C. D. 1988. A long-term study of food–niche dinamics in the Common Barn Owl: comparisons within and between populations. Can. J. Zool. 66: 1803–1812.

Marti, C. D. 2010. Dietary trends of Barn Owls in an agricultural ecosystem in northern Utah. Wilson J. Ornithol. 122: 60–67.

Massoia, E. 1983 La alimentación de algunas aves del Orden Strigiformes en la Argentina. Hornero (N. Extraordinario): 124–148.

Mills, J. N., B. A. Ellis, K. T. McKee, J. I. Maiztegui, & J. E. Childs. 1991. Habitat associations and relative densities of rodent populations in cultivated areas of Central Argentina. J. Mammal. 72: 470–479.

Miño, M. H., R. Cavia, I. E Gomez Villafañe, D. N. Bilenca, & M. Busch. 2007. Seasonal abundance and distribution among habitats of small rodents on poultry farms. A contribution for their control. Int. J. Pest Manage. 53: 311–316.

Motta-Junior, J. C. 2006. Relações tróficas entre cinco Strigiformes simpátricas na região central do Estado de São Paulo, Brasil. Rev. Bras. Orni-

tol. 14: 359–377.

Pardiñas, U. F. J. 1999. Los roedores muroideos del Pleistoceno tardío - Holoceno en la región pampeana (sector este) y Patagonia (República Argentina): aspectos taxonómicos, importancia bioestratigráfica y significación paleoambiental. Ph.D. diss., Facultad de Ciencias Naturales y Museo, Univ. Nacional La Plata, La Plata, Argentina.

Pardiñas, U. F. J., & S. Cirignoli. 2002. Bibliografía comentada sobre los análisis de egagrópilas de aves rapaces en Argentina. Ornitol. Neotrop. 13: 31–59.

Pardiñas, U. F. J., G. Moreira, C. García-Esponda, & L. M. J. De Santis. 2000. Deterioro ambiental y micromamíferos durante el Holoceno en el nordeste de la estepa patagónica (Argentina). Rev. Chil. Hist. Nat. 72: 541–556.

Pardiñas, U. F. J., P. Teta, & S. Heinonen Fortabat. 2005. Vertebrate prey of the Barn Owl (*Tyto alba*) in subtropical wetlands of northeastern Argentina and eastern Paraguay. J. Raptor Res. 39: 65–69.

Pardiñas, U. F. J., P. Teta, & D. N. Bilenca. 2010. Roedores sigmodontinos de la región pampeana: una introducción zoogeográfica. Pp. 37–57 *in* Polop, J., & M. Busch (eds). Biología y ecología de pequeños roedores en la región pampeana de Argentina. Editorial Univ. Nacional de Córdoba, Córdoba, Argentina.

Schrag, A. M., M. E. Zaccagnini, N. Calamari, & S. Canavelli. 2009. Climate and land-use influences on avifauna in central Argentina: broad-scale patterns and implications of agricultural conversion for biodiversity. Agric. Ecosyst. Environ. 132: 135–142.

Soriano, A., R. J. C. León, O. E. Sala, R. S. Lavado, V. A. Deregibus, M. A. Cahuépé, O. A. Scaglia, C. A. Velázquez, & J. H. Lemcoff. 1992. Río de la Plata grasslands. Pp. 367–407 *in* Coupland, R. T. (ed.). Ecosystems of the world 8A. Natural grasslands. Introduction and western hemisphere. Elsevier, New York, USA.

Taylor, I., 1994. Barn owls. Predator-prey relationships and conservation. Cambridge Univ. Press, Cambridge, UK.

Teta, P., C. M. González-Fischer, M. Codesido, & D. N. Bilenca. 2010. A contribution from Barn Owl pellets analysis to known micromammalian distributions in Buenos Aires province, Argentina. Mammalia 74: 97–103.

Trejo, A., & S. Lambertucci. 2007. Feeding habits of Barn Owls along a vegetative gradient in northern Patagonia. J. Raptor Res. 41: 277–287.

Wilson, D. E., & D. M. Reeder (eds). 2005. Mammal species of the World. Johns Hopkins Univ. Press, Baltimore, Maryland, USA.

Zar, J. H. 1996. Biostatistical analysis. Prentice Hall, Englewood Cliffs, New Jersey, USA.