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TROPHIC ECOLOGY OF THE BURROWING OWL (*ATHENE CUNICULARIA*) IN URBAN ENVIRONMENTS OF MAR CHIQUITA BIOSPHERE RESERVE (BUENOS AIRES PROVINCE, ARGENTINA)

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Resumen. – Ecología trófica de la Lechucita de las Vizcacheras (*Athene cunicularia*) de ambientes urbanos de la Reserva de Biosfera Mar Chiquita (Provincia de Buenos Aires, Argentina). – La Lechucita de las Vizcacheras (*Athene cunicularia*) se encuentra en la mayor parte de los pastizales de Argentina y es una de las rapaces más abundantes en los agroecosistemas pampeanos. En la actualidad no existe información acerca de los hábitos tróficos de esta especie en ambientes urbanos de Argentina. El objetivo de este trabajo fue identificar y cuantificar la composición y variación estacional de la dieta de individuos de la Lechucita de las Vizcacheras de ambientes urbanos de la Provincia de Buenos Aires (Argentina). Entre Septiembre de 1998 y Agosto de 1999, 989 egagrópilas y 507 restos presa fueron colectados con una frecuencia quincenal. Los principales ítems tróficos consumidos fueron insectos (78,6%), anfibios (12,9%), mamíferos (4,8%) y crustáceos (3,5%), mientras que las arañas, falsas arañas, aves y reptiles fueron ítems secundarios en la dieta de la rapaz (0,3%). Los insectos fueron las presas más consumidas a lo largo de todo el año, seguidos por los anfibios durante la primavera y el verano, mamíferos en otoño y crustáceos en invierno. La biomasa aportada por los diferentes tipos de presa varió estacionalmente, aunque la mayor contribución a la biomasa consumida fue realizada por los anfibios (84,6%). Estos resultados evidencian una modalidad de caza de tipo oportunista por parte de la Lechucita de las Vizcacheras.

Abstract. – The Burrowing Owl (*Athene cunicularia*) is almost found in all temperate grassy plains of Argentina, being the most abundant raptor in pampean agrosystems. At present no information is available on feeding habits of this species settled in urban environments from Argentina. The aim of this work was to identify and quantify composition and seasonal changes in the diet of individual Burrowing Owls from urban areas of Buenos Aires Province (Argentina). Between September 1998 and August 1999, 989 pellets and 507 prey remains were collected at 2-week intervals. The main items consumed were insects (78.6%), amphibians (12.9%), mammals (4.8%), and crustaceans (3.5%), whereas spiders and false spiders, birds, and reptiles were less frequent in the owl´s diet (0.3%). Insects were the most abundant prey throughout the year, followed by amphibians during spring and summer, mammals in autumn, and crustaceans in winter. The biomass provided by different prey items varied seasonally, although the highest

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contribution to the consumed biomass was made by amphibians (84.6%). These results indicate an opportunistic hunting mode by Burrowing Owl. *Accepted 6 October 2007.*

Key words: Burrowing Owl, *Athene cunicularia*, diet, trophic ecology, urban environments, Mar Chiquita Biosphere Reserve, Argentina.

INTRODUCTION

The Burrowing Owl (*Athene cunicularia*) occurs from western Canada south through the western U.S.A., Mexico, Central, and South America. It inhabits open areas such as treeless plains, grasslands, prairies, savannas, from the sea-level to 3600 m (Marks *et al.* 1999). The Burrowing Owl is found in almost all grassy plains of Argentina, and is the most abundant owl in agrosystems (Bellocq & Kravetz 1994).

Previous dietary studies of the Burrowing Owl have been performed in several regions of South America, mainly in Chile (Jaksic & Marti 1981, Jaksic *et al.* 1992, Jaksic *et al.* 1993, Schlatter *et al.* 1982, Silva *et al.* 1995, Torres Contreras *et al.* 1994) and Argentina. In the latter, studies on trophic ecology have been conducted exclusively in pampean agrosystems, where it has been reported that this species is an opportunistic predator (Bellocq & Kravetz 1983, Bellocq & Kravetz 1994, Bellocq 1997, Andrade *et al.* 2004). Furthermore, this species behaves as a micromammals specialist predator during its breeding season, and as a generalist in the non-breeding season (Jaksic *et al.* 1993, Torres Contreras *et al.* 1994, Silva *et al.* 1995). In a bibliographic revision, Pardiñas & Cirignoli (2002) noted that most contribution on this species for Argentina give an emphasis on taxonomy, and geographic distribution, with few papers dealing with its trophic ecology.

The aim of this study was to identify and quantify the composition (in terms of frequency and biomass) and seasonal changes in the diet of individuals of the Burrowing Owl from urban areas of Mar Chiquita Biosphere Reserve (Buenos Aires Province, Argentina). Currently no information is available on feeding habits of this species settled in urban environments from Argentina.

The diversity of habitats within the study area potentially provides the opportunity of assessing how prey frequencies vary with habitat availability, which could open new research avenues in the future, such as understanding the relationship between owl density and/or population trends and habitat quality.

MATERIAL AND METHODS

The study was conducted in an urban settlement (10 m a.s.l.), located at Mar Chiquita Biosphere Reserve (37º32S, 37º45S; 57º19W, 57º26W.), Buenos Aires Province, Argentina. This area comprises a coastal village, characterized by a low human population density (less than 300 inhabitants) dominated by woodlots of *Eucalyptus* spp. and *Pinus* spp., and by open areas where nests of 29 Burrowing Owls were located. The coastal village is situated at the inlet of a coastal lagoon of 4600 ha (named Mar Chiquita, with marine and continental water incidence) and it is surrounded by wild areas (marshes, coastal dunes, natural halophytic grasslands) and agrosystems (woodlots, pastures, and cultivated fields. This environmental heterogeneity is also reflected in a high faunal diversity, which represents a wide spectrum of potential prey for raptors (Martínez 2001, Bó *et al.* 2002).

Between September 1998 and August 1999, pellets and prey remains from Burrowing Owls were collected every two weeks at burrows and fence posts. Both pellets and prey remains collected at the same site and time were pooled for analysis. Combining pellets and prey remains is an accurate method for estimating overall diet composition (Marti 1987). They were separated into bones, arthropods exoskeletons, furs, and feathers following procedures outlined by Marti (1987). Prey were identified to the finest possible taxonomic level by comparing chitinous material, skulls, teeth, beaks, pectorial and pelvic girdless, and feathers using taxonomic keys (Bland & Jaques 1978, Cei 1980, Bellocq & Kravetz 1983, Barquez *et al.* 1993, Langone 1994). Reference collections were deposited at Laboratorio de Vertebrados, Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Mar del Plata and Museo Municipal de Ciencias Naturales "Lorenzo Scaglia" from Mar del Plata, Argentina.

Diet composition was expressed as the relative frequency of each prey category (number of prey in each prey category divided by the total number of prey) and as relative biomass (number of individuals in each prey category multiplied by mean body weight for prey category) expressed as a percent of the total prey biomass consumed. Mean body weight of prey was taken from literature (Salvador 1988, 1990; Redford & Eisenberg 1992 for mammals; Farías 2000 for birds; Langone 1994 and Vega unpubl. for amphibians and reptiles; Farías 2000 and Luppi pers. com. for crustaceans). A biomass of 1 g was assigned to each insect prey item, following Bó *et al.* (1996). Diet composition was analyzed using the geometric mean of prey, the food niche breadth, and diet similarity. The geometric mean of prey was based on biomass values expressed as (mean ± SE) following Marti (1987) and Marti *et al* (1993). Food niche breadth (FNB) was calculated at the finest taxonomic level (mainly species level) using the Levins (1968) equation: $FNB = 1/(\Sigma pi^2)$, where p_i is the proportion of prey taxon *i* in the diet. For comparisons among samples with different numbers of prey categories, a standardized food niche breadth value (FNB_s) was calculated following Levins (1968): $FNB_s = (FNB-1)/(n - 1)$, where n is the number of prey categories (Levins 1968). This index renged from 0 to 1, with larger values indicating a broader diet. Diet similarity was calculated using an overlap index (Pianka 1973): $O = \Sigma p_{ij}p_{ik} /(\Sigma p_{ij}^2 p_{ik}^2)^{1/2}$, where p_{ij} and p_{ik} are the proportions of the taxon *i* in seasons *j* and *k,* respectively. O values ranged from 0 to 1, with higher values indicating greater similarities. Statistical comparisons of diet composition between seasons were made using G-tests (Zar 1984).

RESULTS

A total of 7272 prey item were identified from 989 pellets and 507 prey remains. Diet was composed of seven taxonomic classes. Although insects dominated diet composition (78.6%), amphibians, mammals, and crustaceans were also important (12.9%, 4.8% and 3.5%, respectively), whereas birds, spiders, false spiders, and reptiles made up a minor portion of prey diversity (0.3%; Table 1).

Coleopterans represented 90.3% of insects (mainly Carabidae, Scarabidae and Curculionidae) followed by 8.6% orthopterans (Tettigonidae, Gryllotalpidae and Gryllidae), whereas the remaining 1.1% were Hemiptera, Hymenoptera, Lepidoptera, and Odonata.

Among amphibians, three anuran species were found in owls diet in decreasing order of importance: common toad (*Bufo arenarum*), common tree-frog (*Hyla pulchella*) and yellow belly toad (*Bufo d´orbigniy)* (Tabla 1).

Most mammals found were rodents (96%). Pampas rice rat (*Oligoryzomys flavescens*), vesper mouse (*Calomys* spp.) and field mouse (*Akodon azarae*) were the most abundant spe-

TABLE 1. Seasonal dietary composition of the Burrowing Owl. N = prey number, F% = percent frequency, and B% = percent biomass.

Prey categories			Total		Spring		Summer		Autumn		Winter	
	Mass (g)	N	F%	B%	F%	B%	F%	B%	F%	B%	F%	B%
INVERTEBRATES												
Chelicerata												
Lycosa spp.	1	4	< 0.1	< 0.1	0.3	< 0.1						
Acanthopachylus aculeatus	1	3	< 0.1	< 0.1			< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Subtotal Chelicerata			0.1	< 0.1	0.4	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Malacostraca												
Armadillidium spp.	1	29	0.4	< 0.1	0.3	< 0.1	0.3	< 0.1	0.4	< 0.1	0.6	0.1
Chasmagnatus granulata	8	181	2.5	0.9	1.1	0.1	0.5	0.2	1.8	2.1	6.4	9.8
Cyrtograpsus angulatus	8	42	0.6	0.2	1.6	0.2	0.2	< 0.1	0.2	< 0.1	0.8	1.2
Uca uruguayensis	3	1	< 0.1	< 0.1							< 0.1	< 0.1
Subtotal Malacostraca	19	253	3.5	1.2	3.0	0.4	0.9	0.2	2.4	2.4	7.8	11.2
Insecta												
Calosoma retusum	1	47	0.6	< 0.1	1.8	< 0.1	1.02	< 0.1	< 0.1	< 0.1		
Cinthidia planodisca	1	6	0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	0.2	< 0.1		
Scarites melanarius	1	105	1.4	< 0.1	3.2	< 0.1	1.5	0.06	1.1	0.2	0.5	0.1
Trirammathus striatulus	1	1434	19.7	0.9	5.0	< 0.1	2.6	0.1	42.5	6.4	27.3	5.2
Argutoridius bonariensis	1	817	11.2	0.5	2.0	< 0.1	27.6	1.1	1.5	0.2	7.5	1.4
Megacephala distinguenda	1	6	0.1	< 0.1			0.2	< 0.1	< 0.1	< 0.1		
Chrysomelidae unidentified	1	2	< 0.1	< 0.1	0.1	< 0.1					< 0.1	< 0.1
Calendra spp.	1	3	< 0.1	< 0.1	0.2	< 0.1			< 0.1	< 0.1		
Curculionidae unidentified	1	1034	14.2	0.7	3.2	< 0.1	2.7	0.1	21.4	3.2	28.1	5.4
Megadytes glaucus	1	21	0.3	< 0.1	0.3	< 0.1	0.4	< 0.1	0.3	< 0.1	0.2	< 0.1
Conoderus spp.	1	13	0.2	< 0.1	0.6	< 0.1	0.2	< 0.1	< 0.1	< 0.1		
Dibolocelus palpalis	1	50	0.7	< 0.1	1.4	< 0.1	0.8	< 0.1	0.6	0.1	0.1	< 0.1
Tropisternus spp.	1	1	< 0.1	< 0.1	0.1	< 0.1						
Dyscinetus rugifrons	1	582	8	0.4	1.3	< 0.1	15.9	0.7	10.1	1.5	1.0	0.2
Phileurus spp.	1	141	1.9	< 0.1	0.9	< 0.1	5.2	0.2	0.5	< 0.1	0.2	< 0.1
Diloboderus abderus	1	49	0.7	< 0.1	0.1	< 0.1	2.1	< 0.1	< 0.1	< 0.1		
Heterogomphus pauson	1	271	3.7	0.2	7.8	< 0.1	6.5	0.3	0.6	< 0.1	1.0	0.2

TABLE 1. Continued.

Prey categories	Mass (g)	N	Total F%	Total B%	Spring F%	Spring B%	Summer F%	Summer B%	Autumn F%	Autumn B%	Winter F%	Winter B%
Sulcophanaenus menelas	1	1	< 0.1	< 0.1					< 0.1	< 0.1		
Cyclocephala signaticollis	1	474	6.5	0.3	6.5	0.1	2.9	0.1	< 0.1	< 0.1	17.0	3.5
Bolborhynus spp.	1	62	0.8	< 0.1	1.7	< 0.1	1.2	< 0.1	0.4	< 0.1	0.3	< 0.1
Tenebrionidae unidentified	1	43	0.6	< 0.1	0.5	< 0.1	0.4	< 0.1	0.7	0.11	0.7	0.1
Lethocerus annulipes	1	1	< 0.1	< 0.1	0.1	< 0.1						
Notonectidae unidentified	1	6	< 0.1	< 0.1	0.2	< 0.1			0.1	< 0.1	0.1	< 0.1
Bombus bellicosus	1	1	< 0.1	< 0.1					< 0.1	< 0.1		
Noctuidae unidentified	1	25	0.3	< 0.1	0.9	< 0.1	0.1	< 0.1	0.2	< 0.1	0.4	0.1
Lepidoptera unidentified	1	29	0.4	< 0.1	0.9	< 0.1	< 0.1	< 0.1	0.2	< 0.1	0.7	0.1
Libellulidae unidentified	1	1	< 0.1	< 0.1	0.1	< 0.1						
Dichroplus spp.	1	1	< 0.1	< 0.1					< 0.1	< 0.1		
Acridiidae unidentified	1	1	< 0.1	< 0.1					< 0.1	< 0.1		
Gryllus spp.	1	59	0.8	< 0.1	1.3	< 0.1	1.4	< 0.1	0.6	0.1		
Scapteriscus spp.	1	176	2.4	0.1	9.4	0.1	1.0	< 0.1	1.8	0.3	< 0.1	< 0.1
Neoconocephalus spp.	1	255	3.5	0.2	4.9	0.1	6.2	0.3	2.5	0.4	0.4	0.1
Subtotal Insecta	32	5717	78.6	3.3	54.5	0.9	80.0	3.3	85.8	13.0	85.9	16.4
VERTEBRATES												
Amphibia												
Bufo arenarum	180	457	6.3	53.7	23.0	67.8	6.8	50.9	0.7	20.5	< 0.1	1.8
Bufo d'orbigniy	40.5	12	0.2	0.3	0.3	0.2	0.2	0.4	< 0.1	0.3	0.1	0.8
Bufo unidentified	110.2	422	5.8	30.4	16.1	29.0	9.0	41.6	0.4	7.2	0.4	8.8
Hyla pulchella	5	44	0.6	0.1	0.7	< 0.1	1.1	0.2	0.4	0.3	0.2	0.2
Subtotal Amphibia	335.7	935	12.9	84.6	40.3	97.1	17.0	93.1	1.6	28.3	0.8	11.6
Reptilia												
Ophiodes vertebralis	7	1	< 0.1	< 0.1							< 0.1	< 0.1
Subtotal Reptilia	7	1	< 0.1	< 0.1							< 0.1	< 0.1
Aves												
Furnarius rufus	64	2	< 0.1	< 0.1	< 0.1	< 0.1			< 0.1	0.5		
Molothrus bonariensis	62	1	< 0.1	< 0.1	< 0.1	< 0.1						

TABLE 1. Continued.

Prey categories	Mass (g)	N	Total F%	Total B%	Spring F%	Spring B%	Summer F%	Summer B%	Autumn F%	Autumn B%	Winter F%	Winter B%
Hymenops perspicillata	25.5	1	< 0.1	< 0.1			< 0.1	< 0.1				
Passer domesticus	30.4	1	< 0.1	< 0.1			< 0.1	< 0.1				
Passeriformes unidentified	45.5	4	< 0.1	0.1	0.2	0.1	0.1	0.2				
Subtotal Aves	227.3	9	< 0.1	0.1	0.1	0.3	0.2	0.3	0.2	0.5		
Mammalia												
Monodelphis dimidiata	51	2	< 0.1	< 0.1	0.2	0.1						
Tadarida brasiliensis	13.2	11	0.1	< 0.1	0.1	< 0.1	0.1	< 0.1			0.4	1.7
Oligoryzomys flavescens	19	88	1.2	1.1	0.2	0.1	0.3	0.2	3.5	10.1	0.7	2.5
Calomys spp.	15	87	1.2	0.8	0.2	0.1	0.3	0.2	2.8	6.5	1.3	3.7
Reithrodon auritus	79	2	< 0.1	0.1					< 0.1	0.6	< 0.1	0.8
Akodon azarae	25	38	0.5	0.6	0.3	0.1	0.4	0.4	1.2	4.5	0.2	1.0
Oxymycterus rufus	75.43	6	< 0.1	0.3			< 0.1	0.1	0.2	2.5	< 0.1	0.8
Rattus spp.	200	24	0.2	1.8	0.2	0.5			0.2	6.5	0.4	16.0
Murid unidentified	68.90	84	1.1	3.8	0.4	0.4	0.6	1.8	1.6	16.3	1.9	24.8
Cavia aperea	57.6	6	< 0.1	0.2					0.3	2.3	< 0.1	0.6
Ctenomys talarum	157	12	0.2	1.2			< 0.1	0.3	0.3	6.4	0.3	9.4
Subtotal Mammalia	761.1	350	4.8	10.0	1.6	1.4	1.7	3.1	10.1	55.7	5.4	60.7
Total prey (no.)			7272		1258		2249		1861		1904	
Total Biomass (g)			153069		77030		53784		12269		9986	
Total pellets (no.)			989		219		240		288		242	
Total prey remains (no.)			507		309		150		18		30	
FNB			9. 50		8.50		6.77		4.00		4.90	
FNB_S			0. 15		0.19		0.16		0.07		0.11	

cies followed by rats (*Rattus* spp) and a guano bat (*Tadarida brasiliensis*; Table 1*)*.

Crabs constituted 88.5% of preyed crustaceans, being represented by burrowing crab (*Chasmagnathus granulata*; 71.5%) as well as rock crab (*Cyrtograpsus angulatus*; 16.6%).

At the class level, diet composition of Burrowing Owls showed significant differences among seasons (G = 1622, d.f. = 18, P < 0.0001). Insects, amphibians, mammals, and crustaceans were all present in the diet throughout the year, whereas spiders, false spiders, birds, and reptiles were present only in some particular seasons (Table 1). Thus, insects constituted the most abundant prey throughout all seasons, followed in numerical importance by amphibians in spring and summer, mammals in autumn, and crustaceans in winter.

In spite of the high number of insects consumed by owls, insects only represented 3.7% of the total prey biomass, whereas amphibians and mammals represented 84.6% and 10.2%, respectively. Amphibians made the highest contribution to the biomass consumed by Burrowing Owls during spring and summer, whereas mammals made the highest contribution in autumn and winter.

Mean body weight of consumed prey ranged between 1 and 200 g, whereas the most consumed prey (84.5%) ranged between 0 and 20g. Mean weight of prey was 2.3 g (± 0.6) when considering all prey types, but was in the order of 41 g (± 88.6) when considering only vertebrates.

For the whole sampling period, food-niche breadth was 9.5 (FNB) and 0.15 (FNB_s) (N = 57 prey categories). At the seasonal level, highest values were observed during spring (FNB = 8.5; FNB_s = 0.2) and summer (FNB) = 6.8; FNB_s = 0.2). Maximum trophic similarities were registered between autumn and winter (O = 0.8), whereas similarities among other seasons were low (0.2–0.4).

DISCUSSION

The trophic generalism evidenced by Burrowing Owls from urban areas of Mar Chiquita Biosphere Reserve is clearly associated with the high diversity of consumed prey directly related to the habitat heterogeneity found at the study area and its surroundings, as shown by prey items not reported before in the diet of this raptor in Argentina. This result differs from those from homogeneous pampean agrosystems and wild areas that show a lower prey diversity (Coccia 1984, Bellocq 1988b, Bellocq & Kravetz 1994, Andrade *et al*. 2004).

Low food-niche breadth values (both annual and seasonal) were related to a preponderance of insects in the raptors diet, thus indicating the species is an opportunistic forager preying on the most abundant prey.

On the other hand, the high values of trophic overlap at the class level indicate a similar representation of prey throughout the year whereas, at the species level, low values would be reflecting seasonal trophic replacements, also evidencing the opportunism of the Burrowing Owl. Preponderance of carabid and scarabid insects has been also reported for the same species by other authors (Jacksic & Carothers 1985, Bellocq 1988a, Jaksic *et al.* 1992, Schlatter *et al.* 1992, Torres Contreras *et al.* 1994, Silva *et al*. 1995).

Trirramathus striatulus , *Argutoriduis bonariensis* and *Calendra* sp. were the prey consumed in higher numbers by Burrowing Owls. These species are characteristic of urban habitats (Cichino 2003). They were captured at night using excavation tactics under city lights.

Although amphibians were consumed throughout the year, they were more heavily preyed during their spring and summer peak abundances (Vega 2001). This particularity would be related to the availability of ponds in the urban settlement and contrasted with other reports where amphibians occurrence was markedly lower, the rodents being the main food resources (Torres Contreras *et al.* 1994, Silva *et al.* 1995, Bellocq 1997).

Juvenile amphibians are eaten as a whole by owls, whereas body parts of adults like the skin and head are discarded by owls. Amphibians are also brought to nestlings. As stated by Bellocq (1993), amphibians would be a key trophic item for owls reproductive success.

The highest consumption of rodents would be related to their higher abundance in the study area (Malizia 1984, Canepuccia 2005). Although pampas rice rats and vesper mice occurred in low numbers, they were more predated by Burrowing Owls than field mice, the dominant species in natural halophytic grasslands surrounding the study area (Malizia 1984, Canepuccia 2005). Differences between rodents representation in owl´s diet and their abundances in the field would be related both to a differential utilization of these particular microhabitats by prey, and to predators hunting strategy (Bellocq 1987, Bellocq & Kravetz 1994).

Although in low proportions, *Tadarida brasiliensis*, which is associated with urban areas in Argentina (Barquez *et al.* 1993), is in this study reported in the Burrowing Owl´s diet for the first time in the Buenos Aires Province.

This is also the first report of crustaceans in this Burrowing Owls diet for Argentina. Both *Chasmagnathus granulata* and *Cyrtograpsus angulatus* are eaten as a whole by owls; they are abundant in the salt marshes (dominated by *Spartina densiflora*) of the study site. Taken their spatial distributional patterns (Spivak *et al.* 2001), burrowing crabs would potentially be more preyed by Burrowing Owls. At seasonal level, the higher consumption of these crabs during winter would be explained by the remarkable decrease in the study area of other important prey items such as amphibians and mammals. Furthermore, the high abundance of rock crabs in the owls diet during spring would be associated to a higher availability and vulnerability of this prey at the study area, as a result of their dense groupings during mating periods (Spivak *et al.* 1996).

At the biomass level, the seasonal trophic replacement between amphibians in spring and summer vs mammals in autumn and winter supports evidence towards the opportunistic hunting strategy of Burrowing Owls.

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