DIET OF THE BARN OWL (*Tyto alba* SCOPOLI 1769) FROM THE COPIAPÓ VALLEY, ATACAMA DESERT, CHILE

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SUMMARY

*The Barn Owl (*Tyto alba*) is a nocturnal raptor species distributed from Arica to Tierra del Fuego in Chile. The diet of this bird is the best known of any raptor of Chile; it is based on small vertebrates, particularly rodents and birds. We studied the diet of the Barn Owl, by analyzing of pellets collected in Copiapó valley, located in the hyper-arid Atacama Desert. This information was compared to available data from Chile and neighboring countries. Because of the environmental conditions of extreme aridity a low diversity of prey, typical of raptors from arid ecosystems, was expected. In the case of* Tyto alba *populations from the Atacama region, the most consumed species were rodents (76.7%), specially* Eligmodontia dunaris *(27.3%),* Phyllotis darwini *(24%) and* Abrocoma bennetti *(12.4%). Other preys corresponded to birds (17.8%) and coleopterans (3.3%). There was no significant correlation between frequency of prey and their body mass (r^2= 0.229, p= 0.497) and between frequency of prey and their habitat (r^2= 0.538, p= 0.088), indicating that this raptor does not select its preys by either body size or habitat. Regarding biomass, rodents contributed more significantly (95.3%) than birds (3.5%), with the largest individual contribution given by* A. bennetti *(60.1%) and* P. darwini *(26.8%). Both the Simpson (SI = 0.1683) and Shannon (H'= 0.8958) indices indicate that this species consumes a low diversity of prey, which is consistent with the observations for others raptors inhabiting on arid environments.*

Introduction

The nocturnal raptor *Tyto alba* (Scopoli, 1769) is a member of the Strigidae family, a raptor species which is one of the most widespread of all birds in the world (Clark *et al*., 1978). In Chile, this raptor is found across the entire country, inhabiting a large diversity of environments (Carmona and Rivadeneira, 2006).

There are many dietary studies of the Barn Owl in South America, for example in Argentina (Noriega, 1993, Solaro, 2012; Gómez, 2012; Bellocq and Kravetz, 1994; Donadio, 2009; Nanni *et al*., 2012; Sahores and Trejo, 2004; Fernández *et al*., 2009; Travaini *et al*., 1997), Bolivia (Vargas *et al*., 2002; Reboledo and Lartigau, 1998; Aliaga-Rossel and Tarifa, 2005), Brazil (Bonvicino and Bezerra, 2003; Rocha *et al*., 2011; Moura de Faria and Passamani, 2013), Colombia (Delgado and Ramirez, 2007, 2009), Cuba (López Ricardo, 2012; Hernández-Muñoz and Mancina, 2011), Perú (Ramírez *et al*., 2000) and Venezuela (Araujo and Molinari, 2000). In the rest of the world, many others studies have been published, for example in Australia (Debus *et al*., 2004), France (Bernard *et al*., 2010), India (Patki *et al*., 2014), Italy (Catalisano and Massa, 1987; Pezzo and Morimando, 1995), Netherlands (De Bruijn, 1994), Pakistan (Khan *et al*., 2014), Poland (Kitowski, 2013; Kopij, 2012), Spain (Braña, 1974; Herrera, 1973; Sans-Coma, 1974; Siverio *et al*., 2010; Zamorano *et al*., 1986; Sommer *et al*., 2005), Syria (Shehab and Al Sharabi, 2006) and USA (Michel, 2009; Colvin and McLean, 1986; Marti, 2010).

In Chile, the dietary habits of the Barn Owl are considered the best known among all the raptors inhabiting the territory (Raimilla *et al*., 2012) although many other biological variables remain poorly understood or unknown.

In general, the diet of the Chilean population of Barn Owl is composed mainly of small mammals, particularly nocturnal rodents (Jaksic and Yáñez, 1979; Cerpa and Yáñez, 1981, Jaksic *et al*., 1981), although other important items are marsupials, birds and arthropods. The diet of this raptor has been studied in many Chilean locations, such as Chiu-Chiu, Antofagasta region (Jaksic *et al*., 1999), La Dehesa, Metropolitana region (Reise, 1970); Fray Jorge, Coquimbo region (Schamberger and Fulk, 1974); Puchuncaví (Cerda and Yáñez, 1981) and La Campana (Zunino and Arcos, 1989) both in Valparaíso region; Lastarria, Araucanía region (Rau *et al*., 1985); Termas del Flaco, Libertador Bernardo O'Higgins region (Torres-Mura and Contreras, 1989); Burca, Concepción region (Muñoz and Murúa, 1990); Torres del Paine, Magallanes region (Iriarte *et al*., 1990);

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DIETA DE LA LECHUZA BLANCA (*Tyto alba* SCOPOLI 1769) EN EL VALLE DE COPIAPÓ, DESIERTO DE ATACAMA, CHILE

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RESUMEN

*La Lechuza Blanca (*Tyto alba*) es una especie rapaz nocturna que en Chile se distribuye desde Arica a Tierra del Fuego. Su dieta es la mejor conocida de las rapaces del país. La misma se basa particularmente de pequeños vertebrados, particularmente roedores y aves. La dieta de la Lechuza Blanca fue evaluada por medio de egagrópilas recolectadas en valles aledaños a Copiapó, localidad del hiperárido Desierto de Atacama. Los resultados fueron comparados con datos disponibles de Chile y países vecinos. Debido a las condiciones de extrema aridez, se esperaba una baja diversidad de presas, característica de las rapaces que habitan ecosistemas áridos. En el caso de la población de* Tyto alba *en la Región de Atacama, las especies más consumida fueron roedores (76,7%), particularmente* Eligmodontia dunaris *(27,3%),* Phyllotis darwini *(24%) y* Abrocoma bennetti *(12,4%). Otras presas correspondieron a aves (17,8%) y coleópteros (3,3%). No hubo una correlación significativa entre la frecuencia de presas y sus masas corporales (r^2= 0,229; p= 0,497) y ni entre frecuencia y hábitat (r^2= 0,538, p= 0,088), lo que indica que estas rapaces no seleccionan a sus presas por el tamaño o por el hábitat. La biomasa de los roedores en la dieta (95,3%) fue considerablemente mayor que la de las aves (3,5%), teniendo la mayor contribución* A. bennetti *(60,1%) y* P. darwini *con 26,8%. Los índices de Simpson (SI= 0.1683) y de Shannon (H'= 0.8958) indicaron que las lechuzas consumen una baja diversidad de presas, lo que es consistente con otras rapaces que habitan zonas áridas.*

DIETA DA CORUJA-DAS-TORRES (*Tyto alba* SCOPOLI 1769) NO VALE DE COPIAPÓ, DESERTO DE ATACAMA, CHILE

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RESUMO

*A Coruja-das-torres (*Tyto alba*) é uma espécie rapina noturna que no Chile se espalha desde Arica até Tierra del Fuego. Sua dieta é a melhor conhecida das rapinas do país. A mesma se baseia particularmente de pequenos vertebrados, particularmente roedores e aves. A dieta da Coruja-das-torres foi avaliada por meio de egagrópilas coletadas em vales circundantes a Copiapó, localidade do hiper-árido Deserto de Atacama. Os resultados foram comparados com dados disponíveis no Chile e países vizinhos. Devido às condições de extrema aridez, se esperava uma baixa diversidade de presas, característica das rapinas que habitam ecossistemas áridos. No caso da população de* Tyto alba *na Região de Atacama, as espécies mais consumidas foram roedores (76,7%), particularmente* Eligmodontia dunaris *(27,3%),* Phyllotis darwini *(24%) e* Abrocoma bennetti *(12,4%). Outras presas corresponderam a aves (17,8%) e coleópteros (3,3%). Não houve uma correlação significativa entre a frequência de presas e suas massas corporais (r^2= 0,229; p= 0,497) e nem entre frequência e hábitat (r^2= 0,538, p= 0,088), o que indica que estas rapinas não selecionam a suas presas pelo tamanho ou pelo hábitat. A biomassa dos roedores na dieta (95,3%) foi consideravelmente maior do que a das aves (3,5%), tendo a maior contribuição* A. bennetti *(60,1%) e* P. darwini *com 26,8%. Os índices de Simpson (SI= 0.1683) e de Shannon (H'= 0.8958) indicaram que as corujas consomem uma baixa diversidade de presas, o que é consistente com outras rapinas que habitam zonas áridas.*

and Pampa del Tamarugal, Tarapacá region (Carmona and Rivadeneira, 2006). The diet of the Barn Owl has been studied in almost all regions of Chile, the Atacama region being an exception. For this reason, the aim of the present study is to analyze the diet of the Barn Owl from the Atacama region, specifically in the Copiapó valley. This valley is located in close ecological relationship to a hyper-arid area, where sporadic rainfall triggers the blossoming of a large diversity of endemic plants and flowers. This phenomenon is known as 'flowering desert' and the areas where it occurs are considered a Priority Conservation Site *Desierto Florido* (Squeo *et al*., 2008).

Methods

The study was conducted in the Copiapó valley (35°15'47''S, 69°78'10''W, 221masl), in the Atacama Desert, Northern Chile. The ecological conditions of the Atacama Desert region correspond to a hyper-arid area (Juliá *et al*., 2008) known as 'flowering desert of the plains' (Gajardo, 1994), with a transitional desert climate (Novoa *et al*., 2008; Juliá *et al*., 2008) and geo-morphologically named transitional Pampa (Novoa *et al*., 2008). In terms of eco-geographical landscape, the study area includes two areas denominated Pampa and Serrano, with the lowest rainfall in the region (<0.5mm in normal conditions).

Pellets were collected under the higher trees, particularly palms from the localities of Piedra Colgada (n= 107) and San Pedro (n= 42) in May-October 2011 and June-December 2012, near Copiapo city, Atacama region. Both localities correspond to a transversal valley with agricultural systems. Collected pellets were stored in paper bags with a label indicating date of collection, a unique numeric code and the number of pellets found in the particular location. The pellets were transported to the Laboratory of Integrative Zoology, Universidad de Tarapacá, Arica, Chile. The pellets were individually hydrated for 3h. Subsequently, the pellets were disaggregated and all remains were identified to the highest possible taxonomic level. The analysis of bones (skulls and jaws) and exoskeleton fragments was performed under a

stereomicroscope (Olympus XTL-2310). For the recognition of the prey species, we used skull and jaw as reference keys for rodents and lizards that inhabit the Atacama region. These references are in the Zoological Collection of Arid and Andean Zones, Universidad de Tarapacá (CZZA-UTA). Identification of arthropods was achieved by applying the methodology described by Cepeda-Pizarro *et al*. (2005).

Each identified prey item was recorded in a database, and frequency and abundance in each pellet were calculated. The number of vertebrate individuals in each pellet was determined using either skulls or maximum count of jaws. On the other hand, the number of insect preys was established using heads or pairs of elytra. To analyze the contribution of each prey in biomass consumption the number of individuals in each pellet was multiplied by the average mass (g) of each species. This mass value was obtained from previous studies carried out by Cortes *et al*. (1992) for lizards, Spotorno *et al*. (1998) for *Oligoryzomys*, *Abrothrix* and *Abrocoma*, Spotorno *et al*. (2013) for *Eligmodontia* and by Cepeda-Pizarro *et al*. (2005) for arthropods. Subsequently, in order to assess dietary preference for body size or habitat preference of the prey, a linear Pearson correlation analysis was performed between the frequencies for prey and body mass, and between number of prey and type of habitat. Finally Simpson and Shannon indices were calculated to assess the richness of preys (Muñoz-Pedreros and Rau, 2004). Statistical analyzes were performed using SPSS 10.0 software.

Results

One hundred forty nine pellets were analyzed, resulting in a total of 275 prey items identified (Table I). The group mostly consumed was rodents, with an abundance of 76.7%. Of these, the largest prey item (27.3%) corresponds to species of small animals such as *Eligmodontia dunaris* (Spotorno *et al*., 2013), and other median and large rodents such as *Phyllotis darwini* (Waterhouse, 1837) (24%) and *Abrocoma bennetti* Waterhouse, 1837 (12.4%). Other species were birds (17.8%), including *Zonotrichia capensis* (Müller, 1776) (2.9%), *Troglodytes aedon* Vieillot, 1809 (3.3%) and *Diuca diuca* (Molina, 1782) (3.3%). Occasional items found were coleopterans (3.3%) and lizards from the *Liolaemus* genus (0.4%).

The group that contributes most to the total biomass is that of mammals (96.4%), particularly *A. bennetti* (60.1%), and secondarily *P. darwini* (26.8%) and *E. dunaris* (6.3%). Contributions of others species were not significant, for example birds (3.5%), coleopterans (0.1%) and lizards (0.1%) (Table II). There was no significant correlation between frequency of prey and their body mass (r^2= 0.229, p= 0.497) and between frequency and their habitat (r^2= 0.538, p= 0.088), both indicating that this raptor does not select their prey by body size or habitat. Finally, both the Simpson index (SI= 0.1683) and the Shannon index (H'= 0.8958) indicate a low diversity of prey, which is consistent with the others raptors that inhabit on arid environments.

TABLE I
BARN OWL (*Tyto alba*) PREY RECORDED IN COPIAPÓ VALLEY, ATACAMA REGION

Item prey	Abundance		Frequency	
Rodentia	N	%	Nf	%
Abrothrix olivaceus	4	1.5	4	2.7
Phyllotis darwini	66	24.0	45	30.2
Oligorysomys longicaudatus	6	2.2	6	4.0
Eligmodontia dunaris	75	27.3	43	28.9
Abrocoma bennetti	34	12.4	32	21.5
Non identified rodents	26	9.5	26	17.4
		76.7		
Didelphimorphia				
Thylamys elegans	5	1.8	4	2.7
Passeriformes				
Zonotrichia capensis	8	2.9	8	5.4
Troglodytes aedon	9	3.3	9	6.0
Diuca diuca	9	3.3	8	5.4
Non identified birds	23	8.4	22	14.8
		17.8		
Coleoptera				
Gyriosomus sp.	9	3.3	9	6.0
Squamata				
Liolaemus sp.	1	0.4	1	0.7
Total	275	194.5		

TABLE II
BIOMASS PROVIDED BY EACH PREY ITEMS IN THE DIET OF BARN OWL*

	Nº of ítems	Mass/sp (gr)	Total biomass (gr)	% Biomass
Mammalia				
Abrothrix olivaceus	4	35	140	0.5
Phyllotis darwini	66	57.5	3795	26.8
Oligorysomys longicaudatus	6	27.8	166.8	1.2
Eligmodontia dunaris	75	11.9	892.5	6.3
Abrocoma bennetti	34	250.5	8517	60.1
Non identified rodents	26			
			13511.3	95.3
Didelphimorphia				
Thylamys elegans	5	30	150	1.1
Passeriformes				
Zonotrichia capensis	8	22.7	181.6	1.3
Troglodytes aedon	9	11.3	101.7	0.7
Diuca diuca	9	24.2	217.8	1.5
Non identified birds	23			
			501.1	3.5
Coleoptera				
Gyriosomus sp.	9	0.8	7.2	0.1
Squamata				
Liolaemus sp.	1	13.3	13.3	0.1

* Average body mass by species collected from Mann (1978), Cofré and Marquet (1999), Muñoz-Pedreros and Yáñez (2009) and Iriarte (2008) for mammals; Anderson *et al*., (2002) and Salvador and Bodrati (2013) from birds. Reptiles and arthropods own data.

Discussion

Our work corresponds to first record of the diet of the Barn Owl from the Atacama region, Chile. The diet of this raptor in the Atacama Desert is primarily composed of smaller mammals of the genus *Eligmodontia*, followed by *Phyllotys darwini* and *Abrocoma bennetti*. These data are in agreement with those found in the literature, where

the preference is mammals, values ranging from 76.2% in Tamarugal, northern Chile, to 99.8% in the Torres del Paine, Southern Chile (Carmona and Rivadeneira, 2006). In other studies similar results are found in the consumption of birds: 3.4% in Tamarugal and 0.2% in Torres del Paine (range 0.2-10%), those of reptiles and amphibians are not significant, and arthropods are more important than in the present our study (range 2-16.4%). The smaller marsupial *Thylamys elegans* (Waterhouse, 1839) was less consumed in Atacama than *T. pallidior* (Thomas, 1902) in Tamarugal (range 6.7-25.9%).

On the other hand, *A. bennetti* and *Oligoryzomys longicaudatus* (Bennett, 1832) inhabit the valleys of the Atacama region (Valladares and Campo, 2012) with vegetation cover, scrub and farm fields. *P. darwini* lives in arid hills and ravines (Valladares, 2012) and *E. dunaris* is a small rodent which inhabits in the arid dunes under small scrubs, where they dig their burrows (Spotorno *et al*., 2013). Despite the fact that the Barn Owl build their nests in the valley of Copiapo, their prey is principally captured from desert and ravines (53.1%), whereas prey from the valleys constitute only 16%. Especially interesting is the complete absence of *Rattus* sp. in the diet of the Barn Owl from the Copiapo valley, despite the abundance of this species in these areas and in the city. The differences in the proportions of mammals and birds consumed may be related to the coincidence in daily activity, since most species of rodents have crepuscular or nocturnal rather than diurnal activities (Iriarte, 2008).

The Shannon and Simpson indices indicate a low diversity of prey in the population of *T. alba* from the Atacama region, compared with populations of southern Chile and Argentina, where the number of prey increases to more than double. Considering indirect variables such as the wider distribution range and its fundamental trophic niche, displayed on the large number of prey registered, it could be indicating an ecologically generalist species (Futuyma and Moreno, 1988; Kassen, 2002; Calenge and Basille, 2008), and these results indicate a functional response to prey availability (Jaksic *et al*., 1992; Farías and Jaksic, 2007).

This study is of relevance since the population of Barn Owl inhabit the Priority Conservation Site *Desierto Florido* (Squeo *et al*., 2008). When the El Niño phenomenon (ENSO) takes place, rainfall increases and the area blooms, with subsequent changes in populations of all the species that live there. The present data were obtained when rainfall was very low. Therefore this work constitutes a first diagnosis of the dietary biology of the Barn Owl in the Atacama region, which must be also assessed when an ENSO phenomenon occurs, allowing a clearer idea of the consequences of this phenomenon on the biological communities of the Atacama Desert.

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