Diet of the Barn Owl (*Tyto alba*) (Strigiformes: Tytonidae) in the Saharan Touggourt Area (Algeria)

Dieta de la lechuza común (*Tyto alba*) (Strigiformes: Tytonidae) en el área sahariana de Touggourt (Argelia)

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ABSTRACT

The Barn Owl, *Tyto alba* (Scopoli, 1769), is a nocturnal raptor species. Their diet includes small vertebrates, mainly rodents, and birds. To study their feeding in the desert area of Touggourt, we collected 153 pellets at the Ranou palm grove. We found 468 specimens belonging to 62 species. In terms of abundance, the item more consumed was Rodents (35.9%) followed by Insects (35.2%) and Birds (10.7%). In terms of absolute abundance, the prey more consumed was *Brachytrypes megacephalus* (21.4 %), followed by an undetermined Lacertidae species (9.2%) and *Gerbillus nanus* (8.8%). In terms of biomass, rodents contributed more to the diet of *Tyto alba* (44.66%) than birds (34.3%) and reptiles (12.06%). The highest value of biomass corresponded to *Streptopelia* sp. (15.7%), followed by *Rattus rattus* (14.1%) and an undetermined Lacertidae species (11.8%). To our knowledge, this is the first assessment of the diet composition of *Tyto alba* in the Saharan Touggourt area.

Keywords — Birds, Insects, Rodents, diet composition, predator-prey interactions.

➤ Ref. bibliográfica: Hadjoudj, M.; Benhaddya, M. L.; Souttou, K.; Doumandji, S. 2020. "Diet of the Barn Owl (*Tyto alba*) (Strigiformes: Tytonidae) in the Saharan Touggourt Area (Algeria)". *Acta zoológica lilloana* 64 (1): 30-42. Fundación Miguel Lillo, Tucumán, Argentina. D.O.I.: https://doi.org/10.30550/j.azl/2020.64.1/3
➤ Recibido: 26 de enero de 2020 – Aceptado: 12 de mayo de 2020
➤ URL de la revista: http://actazoologica.lillo.org.ar

RESUMEN

La lechuza común, *Tyto alba* (Scopoli, 1769), es una especie de rapaz nocturna. Su dieta incluye pequeños vertebrados, principalmente roedores y aves. Para estudiar su alimentación en el área desértica de Touggourt, recolectamos 153 egagrópilas en el palmeral de Ranou. Encontramos 468 especímenes pertenecientes a 62 especies. En términos de abundancia, el artículo más consumido fue Roedores (35,9%) seguido de Insectos (35,2%) y Aves (10,7%). En términos de abundancia absoluta, la presa más consumida fue *Brachytrypes megacephalus* (21.4%), seguida de una especie indeterminada de Lacertidae (9.2%) y *Gerbillus nanus* (8.8%). En términos de biomasa, los roedores contribuyeron más a la dieta de *Tyto alba* (44,66%) que las aves (34,3%) y los reptiles (12,06%). El valor más alto de biomasa correspondió a *Streptopelia* sp. (15,7%), seguido de *Rattus rattus* (14,1%) y una especie indeterminada de Lacertidae (11,8%). Hasta donde sabemos, esta es la primera evaluación de la composición de la dieta de *Tyto alba* en el área sahariana de Touggourt.

Palabras clave — Aves, insectos, roedores, composición de dieta, interacciones depredador-presa.

INTRODUCTION

In Algeria, there are thirty-three species of diurnal raptors, and seven species of nocturnal raptors; all are protected by law (Decree Number 83-509, 20 August 1983). Among them, the Barn Owl, *Tyto alba* (Scopoli, 1769), is a nocturnal raptor of the Tytonidae family. This raptor is one of the most widespread birds on the planet (Clark, Smith, Kelso, 1978). But, new molecular studies on *Tyto alba* have proposed three main clades from *Tyto alba* complex; *Tyto alba* (Africa, Europe), *Tyto furcata* (New World; including *bargei*) and *Tyto javanica* (Australasia; including *T. j. delicatula* and *T. j. stertens*) (Enríquez, Eisermann, Mikkola, Motta-Junior, 2017). This species complex has a large distribution area in the five continents and occupies mainly open areas, anthropogenic areas, and forests (Venable, 1997; Brito e*t al*., 2015).

Tyto alba hunts silently over roads, barns, buildings, and around farmlands. Many species are the prey of *Tyto alba* such as rats, mice, shrews, small birds, and arthropods (Sekour *et al*., 2010; Milchev, 2015). *Tyto alba* species also occupy agricultural areas where they specialized in predation of small mammals, but the identity of the prey species hunted vary given their accessibility (Taylor, 1994; Tores, Motro, Motro, Yom-Tov, 2005; Miltschev and Georgiev, 2009; Bernard e*t al*., 2010). They contribute to the limitation of the size of prey populations even if the sample taken may appear low (Ramade, 1984).

In the world, many researchers worked on the diet composition of the *Tyto alba*. These studies have as objective to improve our knowledge on the diet ecology of the raptor and the structure and composition of its prey, particularly micromammals (Sekour e*t al*., 2014). Faúndez, Osorio, Henríquez, Orozco, and Alvarado (2016) in Chile worked on the diet of American Barn owl (*Tyto furcata*, Temminck, 1827) at

Acatama desert. In Northern of Lebanon, Abi-Said, Shehab, Amr (2014) published a research on the diversity of small mammals consumed by *Tyto alba*. Near from Lebanon, Shehab, Daoud, Kock, Amr (2004) recorded a list of small mammals in Syria. Other researchers can be cited such as Nghipangelua and Lukubwe (2017) in Namibia; Leonardi and Dell'Arte (2006) in Tunisia; Rihane (2005) in Doukala (Morocco). In Algeria, authors concentrate their research in the north part of the country such as Boukhemza (1989) in Algiers; Baziz, Doumandji, Hamani (1999) in different areas of northern Algeria; Sekour *et al*. (2010) in Mergueb; Souttou *et al*. (2015) in Djelfa; and Ouarab and Doumandji (2017) near of Algiers; but in the southeast part of Algeria (Sahara), this information is rare or absent. For that, this study has the objective to provide a first assessment of the diet composition of *Tyto alba* in a Saharan region (Touggourt) and to establish an inventory of prey species of this area.

MATERIALS AND METHODS

Study area.— Our study was conducted within Touggourt region, in the southeast of Algeria (33°02' – 33°12' N, 5°59' – 6°14' E) (Fig.1). The study region represents the highest part of the Oued Righ area. In the south and east, Touggourt is limited by the Great Eastern Erg. At the north is bordered by the palm groves of Megarine and in the west by dunes. Touggourt region is located at an altitude of 75 m (Dubost, 2002; Hadjoudj, Souttou, Doumandji, 2018). The temperature varies between 11.7 °C in January and 35.1 °C in July. The average annual rainfall is 155.7 mm. The climate in this region is characterized by a long dry period from February to December and a rainy period in January. The wind speed varies between 10.3 m / s (37 km / h) in June and 19.5 m / s (70.2 km / h) in March.

Pellet sampling.— *Tyto alba* consumes prey whole and later regurgitates the indigestible material, including fur and bones, as a pellet (Taylor, 1994). We collected 153 pellets under the nest of one *Tyto alba* in an abandoned house located in the Ranou palm plantation (33° 03' N, 6° 03' E). The sampling was carried out for 9 months between February 2009 to January 2010. It is by the wet method that the analysis of the pellets was done (Sekour *et al*. 2014; Souttou *et al*. 2015; Ouarab and Doumandji, 2017). We dissected *Tyto alba* pellets individually by hand with a fine plier. After that, we carefully separated bones, fur, and arthropod fragments to identify the species composition of each pellet. The identification of invertebrate prey species was based on dichotomous keys and collections of the Agricultural and Forest Zoology Department (ENSA, Algiers) that were also used as a reference. With regard to vertebrates, we used also identification key if it was necessary: Cuisin (1989) for birds; Osborn and Helmy (1980), Orsini, Cassaing, Duplantier, Cruset (1982), and Barreau, Rocher, Aulagnier (1991) for rodents; Heim De Balsac and Bourlière (1955), and Aulagnier and Thevenot (1986) for insectivores.

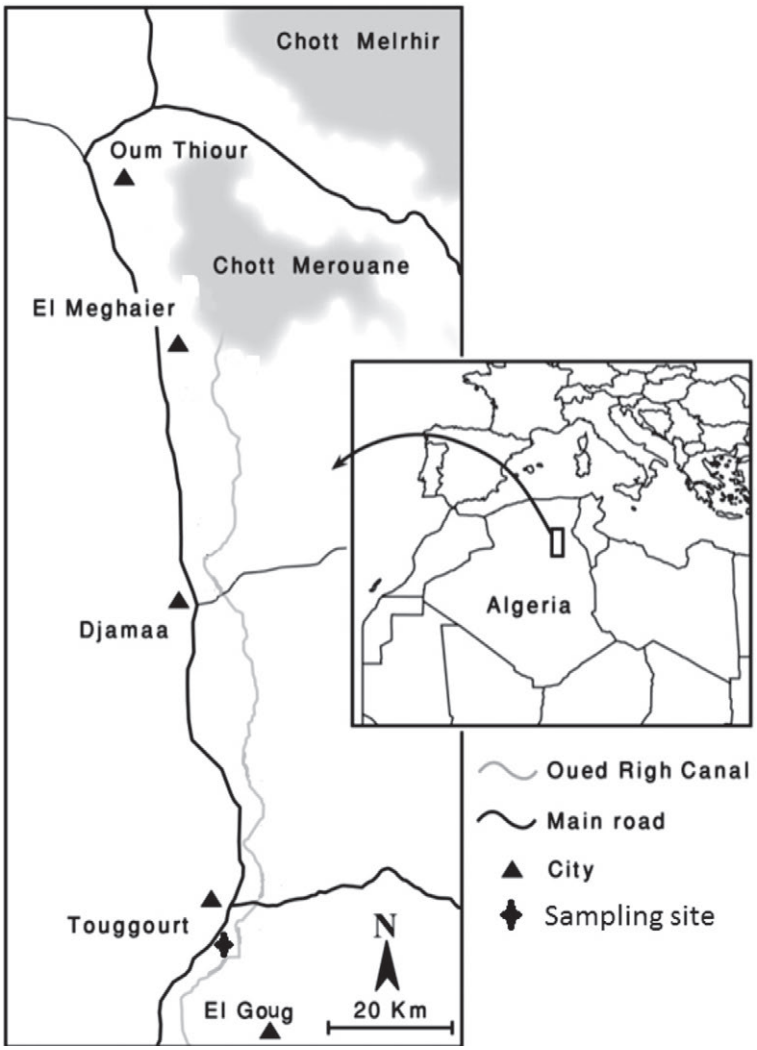

Figure 1. Geographic situation of the sampling area (Touggourt, Southeast Algeria).

Figura 1. Situación geográfica del área de muestreo (Touggourt, Sudeste de Algeria).

Data analysis.— The analysis of our research was based on the total number of species (total richness, S) identified in all Barn Owl pellets (Blondel, 1975; Horn, McMillan, Clair, 2012). The relative abundance (RA%) is the ratio of the number of individuals from a prey species (n) to the total number of individuals of all prey species (N) (Hamdine, Khammar, Gernigon, 2006; Hadjoudj, Souttou, Doumandji, 2015). A biomass index was estimated using the mean weight of each species. Biomass was calculated by the ratio between the weight of individuals of a determined prey and the total weight of all prey (Vivien, 1973). We also used the Shannon-Weaver Index (H = -Pi * log2 Pi; where Pi = ni / N; [ni: number of individuals for each species; N: total number of individuals]) (Sekour e*t al*., 2010; Stoetzel *et al*., 2016). The evenness index (E) indicated the species distribution in the community (E = H / Hmax; where Hmax= log2 S; [S = total species richness]) (Faurie, Ferra, Médori, Dévaux, Hemptinne, 2006; Hadjoudj e*t al*., 2018). The values vary from 0 (one dominant species) to 1 (all species equally represented in the community).

RESULTS

The average length (± SD) of the pellets was 43.35 ± 12.65 mm and the average diameter was 26.03 ± 5.82 mm. We identify 468 individual preys. The total richness was 62 prey species; distributed among six categories: Mammals, Aves, Reptilia, Insecta, Malacostraca, and Arachnida. Within Mammals, we recorded the categories Rodentia, Chiroptera, and Soricomorpha (Table 1). The highest relative abundance (RA%) corresponded to Rodents (35.9%), and Insects (35.25%). The abundance of Birds and Reptiles was 10.68% and 9.61%, respectively. Chiroptera represented 7.48% of the abundance. The other categories were poorly abundant. In terms of biomass, Rodentia was first with 44.23% followed by Birds (34.3%), Reptiles (12.06%), and Chiroptera (6.38%) (Table 1).

Among the prey species, *Brachytrypes megacephalus* was dominant with a relative abundance of 21.4%; followed by an undetermined Lacertidae species (9.2%), and *Gerbillus nanus* (8.8%) (Table 1). Mus spretus was fourth with 7.7% of relative abundance; followed by an undetermined species of Chiroptera (7.3%), and *Gerbillus gerbillus* (6.6%). Other species have lower values of relative abundance, ranging between 0.2% and 3.9%. The biomass values of prey species showed that *Streptopelia* sp. had the highest percentage (15.71%); followed by *Rattus rattus* (14.14%) (Table 1). An undetermined Lacertidae species occupied the third position with value biomass of 11.8%; followed by *Columba livia* (10.2%). *Gerbillus gerbillus*, *Gerbillus nanus*, *Mus spretus* and *Mus musculus* had values varying between 2.5% and 7.1%. The Shannon-Weaver index of diversity H' was 4.5 bits; the Hmax was 6 bits; and the Evenness index was 0.8, meaning a tendency towards a balance among the prey species of *Tyto alba*.

DISCUSSION

The size of pellets correlates with the size of the predators because pellet size is proportional to spout width, esophagus diameter, and gizzard size, which directly affect the ability of *Tyto alba* to capture larger prey (Guérin, 1928; Alivizatos, Goutner, Zogaris, 2005; Sekour e*t al*., 2010). Many studies in Algeria are focused on the *Tyto alba* diet. To identify and confirm the species studied, we compared the size of our pellets with other Algerian studies and we found them similar. We found similar results to Baziz (2002) from different Algerian sites, and Manaa, Souttou, Sekour, Guezoul, Doumandji (2015) in Ouargla near to Touggourt; from where they have reported pellet sizes 41.1 ± 11.9 mm, 26.0 ± 6.4 mm, 40.21 ± 5.34, and 26.1 ± 3.29 mm; respectively.

In our study, invertebrates were more represented (S = 34) than vertebrates (S = 27). Rocha, Ferreira, Leite, Fonseca, Costa (2011) reported 16 vertebrate items in the diet of *Tyto furcata* from Central Brazil. In South Bulgaria, Milchev (2015) reported 7 invertebrate and 33 vertebrate species. Stoetzel *et al*. (2016) analyzed 57 pellets of *Tyto furcata* in Dominica and mentioned a higher total richness of vertebrates (S = 37) than invertebrates (S = 7). According to Nghipangela and Lukubwe (2017),

Table 1. Prey items consumed by *Tyto alba* in the Touggourt area. N, number of individuals; RA %, relative abundance; B %, biomass; RAc %, relative abundance of categories; Bc %, biomass of categories.

Tabla 1. Presas consumidas por *Tyto alba* en el área de Touggourt. N, número de individuos; RA%, abundancia relativa; B%, biomasa; % RAc, abundancia relativa de categorías; Bc%, biomasa de categorías.

Class	Species	N	RA %	B %	RAc %	Bc %
Arachnida	Solifugea und. sp.	1	0.21	0.03	0.64	
	Galeodes sp.	2	0.43	0.05		0.03
Malacostraca	*Oniscus* sp.	1	0.21	0	0.21	0.00
Insecta	Mantis religiosa	1	0.21	0		
	Hodotermes sp.	1	0.21	0		
	Platycleis griseus	1	0.21	0		
	Tropidopola cylindrica	1	0.21	0.01		
	Acrididae und. sp.	1	0.21	0.02		
	Gryllus sp.	3	0.64	0.01		
	Brachytrypes megacephalus	100	21.37	2.36		
	Gryllotalpa gryllotalpa	2	0.43	0.05		
	Labidura riparia	1	0.21	0		
	Scutelleridae und. sp.	1	0.21	0		
	Coleoptera sp.	2	0.43	0.01		
	Cicindela flexuosa	2	0.43	0	35.25	2.51
	Hydrophilus sp.	1	0.21	0		
	Ateuchus sacer	1	0.21	0.02		
	Pentodon sp.	1	0.21	0.01		
	Tenebrionidae und. sp.	5	1.07	0.01		
	Pachychila sp.	1	0.21	0		
	Mesostena angustata	2	0.43	0.01		
	Larinus sp.	2	0.43	0		
	Cyphocleonus sp.	1	0.21	0		
	Rhytirrhinae und. sp.	2	0.43	0		
	Hypera sp.	1	0.21	0		
	Prionus pectinicornis	2	0.43	0		
	Scoliidae und. sp.	1	0.21	0		
	Formicidae und. sp.	1	0.21	0		
	Messor capitatus	4	0.85	0		
	Camponotus sp.	17	3.63	0		
	Cataglyphis sp.	1	0.21	0		
	Pheidole sp.	3	0.64	0		
	Pheidole pallidula	1	0.21	0		
	Tetramorium biskrense	2	0.43	0		
Reptilia	Lacertidae und. sp.	43	9.19	11.82		
	Agamidae und. sp.	2	0.43	0.24	9.61	12.06
Aves	Aves und. sp.	2	0.43	1.57		
	Columbidae und. sp.	1	0.21	1.02		
	Columba livia	10	2.14	10.21	10.68	34.3
	Streptopelia sp.	16	3.42	15.71		
	Hirundinidae und. sp.	1	0.21	0.15		
	Sylviidae und. sp.	7	1.5	0.99		
	Lanius excubitor	6	1.28	3.3		
	Passer sp.	5	1.07	0.16		
	Passeriforme und. sp. 1	1	0.21	0.16		
	Passeriforme und. sp. 2	1	0.21	1.03		
Chiroptera	Chiroptera und. sp.	34	7.26	6.14		
	Rhinolophidae und. sp.	1	0.21	0.24	7.48	6.38
Rodentia	*Gerbillus* sp.	3	0.64	0.6		
	Gerbillus campestris	5	1.07	0.9		
	Gerbillus gerbillus	31	6.62	7.13		
	Gerbillus nanus	41	8.76	5.41		
	Gerbillus tarabuli	3	0.64	0.8		
	Mus musculus	17	3.63	2.54		
	Mus spretus	36	7.69	5.37		
	Rattus sp.	5	1.07	3.93		
	Rattus rattus	18	3.85	14.14		
	Eliomys quercinus	2	0.43	0.82		
	Jaculus sp.	1	0.21	0.43		
	Jaculus jaculus	6	1.28	2.59	35.9	44.66
Soricomorpha	Suncus etruscus	1	0.21	0.02	0.21	0.00

Tyto alba pellets in Namibia had 18 of vertebrates species and 8 invertebrates ones. In two Algerian steppe regions (M'Sila and Djelfa), Sekour *et al*. (2014) avowed the equality between invertebrates and vertebrates, with 38 species for each group. We founded a result different from that reported by Ouarab and Doumandji (2017) for the Reghaïa wetland (Algiers), where vertebrates (S = 13) were the only prey species of the diet of *Tyto alba*.

The prey species diversity was greater in our study than other studies cited in our discussion. This richness suggests a potential of *Tyto alba* hunting in palm groves, dunes, and at the level of the houses closest to its nest in our study area. *Tyto alba* hunting range estimates are very diverse and range from 0.45 to 6 km (Smith, Wilson, Frost, 1974; Glutz von Blotzheim, 1980; Taberlet, 1983). Of the twelve species of Rodentia, the *Gerbillus* genus prefers the sandy soils with the presence of Saharan plantation (*Zygophyllum album* and *Traganum nudatum*) (Hamdine e*t al*., 2006; Hadjoudj e*t al*., 2015). In previous work, *Mus* and *Rattus* genera were described in 5 palm groves of the Touggourt region (Bebba, Hadjoudj, Baziz, Sekour, Souttou, 2008; Bebba and Baziz, 2009; Hadjoudj e*t al*., 2015).

Bird species were present in the pellets of *Tyto alba* with *Streptopelia* sp., *Columba livia*, *Lanius excubitor*, and *Passer* sp. Reptiles (Lacertidae and Agamidae) and Chiroptera were also presented in the list of species consumed in the current research. Hamani (2006) noted that in the absence or rarity of large prey such as *Meriones shawi*, *Psammomys obesus*, and *Jaculus orientalis*; *Tyto alba* attacks smaller prey suggesting varying ecological roles. *Brachytrupes megacephalus* also was a replacement prey in the palm grove. Chopard (1943) reported the abundance of this desert cricket in southern Algeria and Tunisia. Lakhdari e*t al*. (2015a) and Lakhdari *et al*. (2015b), mentioned the presence of this cricket in the oasis of Sidi Mehdi (Touggourt) associated to crops and suggest that it causes crop damages. For the rest of insect species present in the pellets, we assume that they could have been consumed by *Tyto alba*'s prey (i.e., rodents, bats, birds, reptiles) because they had very small sizes.

Generally, in arid regions, *Tyto alba* consumes different categories, such as Gastropoda, Arachnida, Insecta, Batrachia, Reptilia, Aves, Rodentia, Soricomorpha, and Chiroptera (Sekour e*t al*., 2014). In Chile, the diet of *Tyto furcata* was composed principally of rodents, although also by other categories such as marsupials, birds, and arthropods (Faúndez e*t al*., 2016). Our results were different from those founded by Alia, Sekour, Ould El Hadj (2012) in Oued Souf (Southeast Algeria) where rodents dominated the diet with 88.2% of abundance. Our observations are also different from those of Sekour *et al*. (2010) in Ain El Hadjel (Steppe region, Algeria) when they indicated that rodents are the most frequent prey (66.7%) followed by the insects (1.02%) and birds (0.85%). On contrary, farther in the south of Touggourt in Ouargla, Manaa *et al*. (2015) reported variations in the diet of the Barn Owl by ingesting more birds in Mekhadma (64.6%) and Tazgraret (64.5%) compared to the rodents. Therefore, the current work disagrees with that of Manaa *et al*. (2015) realized in Ouargla. Here we found similar values to a study carried out in Morocco, where the diet of *Tyto alba* was composed of 50.8% of rodents, 29.4% of birds, and 15.7% of insects Rihane (2005).

The biomass index showed that rodents were the most important part of biomass (44.66%) followed by birds (34.3%). This finding agrees with many previous studies. Stoetzel *et al*. (2016) mentioned that prey biomass was 76.2% for rodents and 12.2% for birds from pellets of *Tyto furcata* in Dominica. In the Atacama desert in Chile, Faúndez e*t al*. (2016) estimated that rodents contributed more significantly (95.3%) than birds (3.5%) to the diet of *Tyto furcata*. Our results are similar to the study of Farhi *et al*. (2016) in Ziban (Biskra, Algeria) when they found higher biomass for rodents (52.95%) than birds (43.43%). The high biomass value registered in our study also is similar to the results of Souttou *et al*. (2015) in a steppe environment in Algeria, where the biomass of rodents in the diet of *Tyto alba* was 80.09%.

On the other hand, our results about the abundance of prey species differed from those of Boukhemza (1989) at the National Agronomic Institute of El Harrach (Algeria), who noted that the abundance of insects in the pellets of *Tyto alba* was modest (1.7%). Also in Oued Souf (Southeast Algeria), Alia *et al*. (2012) reported a low presence of insects (3.3%) while *Gerbillus gerbillus* (44%) dominated followed by *Gerbillus campestris* (13.3%). Similarly, in Tunisia, Leonardi and Dell 'Arte (2006) noted that *Jaculus jaculus* constitutes the main prey with 50.2% in the diet of *Tyto alba*. According to a large group of authors such as Bontzorlos, Peris, Vlachos, Bakaloudis (2005) in Greece; Charter, Izhaki, Meyrom, Motro, Leshemy (2009) in Jordan and Palestine; and Milchev (2015) in Bulgaria; the presence of insects in the pellets of *Tyto alba* is very low. This variation may be attributed to the type of environment. Manaa *et al*. (2015) worked in two sites in Ouargla (Southeast Algeria) and they recorded the dominance of *Streptopelia* sp. in Mekhadma (32.9%) and Tazgraret (30.3%), and *Passer* sp. in Mekhadma (21.9%) and Tazgraret (27.6%). For his part, Hadj Benamane (2015) in Ouargla, noted that *Streptopelia* sp. was the most consumed prey followed by *Passer* sp. The results of the current work disagree with those of Manaa *et al*. (2015) and Hadj Benamane (2015) in Ouargla.

In terms of biomass, *Streptopelia* sp. (15.7%) occupied the first rank followed by *Rattus rattus* (14.1%). The results of the current study confirm that reported by Manaa *et al*. (2015) in Ouargla. These authors report that the highest biomass was provided by *Streptopelia* sp. with 43% at Mekhadma and 62.8% at Tazgraret. The same authors emphasize that *Columba livia* came in second place with 15.7% in Tazgraret and with 35% in Mekhadma. On the contrary, our observations disagree with those noted in Mâalba (Steppe, Algeria) by Souttou *et al*. (2015) and of Sekour *et al*. (2010) in Ain El Hadjel (Steppe, Algeria). Souttou *et al*. (2015) noted that *Meriones shawii* and *Meriones lybicus* represented 40.3% and 18.8% of the prey biomass, respectively. Sekour *et al*. (2010) mentioned that *Meriones shawii* and *Gerbillus* sp. represented 85.8% and 9.5% of the prey biomass, respectively. According to these latter authors, the biomass of birds was negligible. In Tunisia, Leonardi and Dell 'Arte (2006) registered the highest value of biomass for *Jaculus jaculus* (50.2%) followed by *Meriones lybicus* (19.5%). Also, these latest authors mentioned that birds are poorly represented as *Galerida cristata* (0.7%) and *Oenanthe* sp. (0.7%). The current research results are different from those of Charter *et al*. (2009) in Jordan and Palestine when they report that prey biomass was composed exclusively by *Meriones* sp.

Based on the results of the Shannon-Weaver and Evenness indexes, we noted that our values are different from those noted by Manaa *et al.* (2015) in the steppe and Saharan regions. These authors estimated a diversity H' = 2.7 bits (H' max = 3.46 bits) at Ain El Ibel site and an H' = 2.43 bits (H'max = 3.32 bits) in El Mesrane site. The same authors reported an H' = 2.87 bits (H'max = 4.32 bits) at Mekhadma and an H' = 2.49 bits (H 'max = 3.58 bits) at Tazgraret. Stoetzel *et al*. (2016) registered low values compared to our observations. These authors mention an H' = 2.21 bits (H'max = 4.74 bits) and a weak equitability (0.47). At the Atacama Desert in Chile, Faúndez e*t al*. (2016) report that *Tyto furcata* consumed a low diversity of prey (H' = 0.89 bits), which differs from the result obtained at Touggourt. In contrast, our values were very close to those of Farhi *et al.* (2016) in Algeria (H' = 4.24 bits, H'max = 5.39 bits and E = 0.78).

CONCLUSION

In the present study, the analysis of 153 pellets reveals a high richness of prey species. We found more invertebrate than vertebrate prey species. Among the six categories of prey, rodents and insects were dominant. The prey species found in the diet suggest that *Tyto alba* hunts in palm groves, dunes, and near to the houses. The prey more frequent was *Brachytrypes megacephalus* ("djendeb"). Previous studies report a low presence of insects in the Barn Owl diet. Our study suggests that insectivory in Barn Owl is high in Touggourt. Also, the Barn Owl diet presents high diversity. So, it is important to protect *Tyto alba*, because this raptor contributes to the reduction of harmful species for crops (Souttou *et al*., 2015; Ouarab and Doumandji, 2017).

ACKNOWLEDGEMENTS

We are very thankful to the corresponding author's father, Hadjoudj Mohammed Mahmoud for his help during the sampling process.

FUNDING

No funding sources.

PARTICIPATION

All authors participated in the study.

CONFLICTS OF INTEREST

No conflicts of interest.

LITERATURE CITED

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