DF-631
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RESEARCH ARTICLE Agricultural Science Digest, Volume Issue : ()

Barn Owls (*Tyto alba* Scopoli, 1769) in the Saharan Region of Algeria (Souf): Valuable Predators for Rodent Control in Agriculture

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10.18805/ag.DF-631

ABSTRACT

Background: Barn Owls (*Tyto alba* Scopoli, 1769), which are nocturnal birds of prey, play a crucial role in controlling rodent populations that damage crops. They are valuable allies for farmers because they can effectively hunt small rodents. In Algeria, the Barn Owl is represented by two subspecies, *Tyto alba alba* and *Tyto alba guttata*.

Methods: This study focuses on the Barn Owls′ diet in the Saharan region, specifically in the Souf region, characterized by a dry climate. The research examines the contents of the Barn Owl′s reject balls, which are regurgitated, to determine their diet.

Result: The study reveals that each reject ball contains 1 to 9 prey items. The researchers identified 23 prey species, with rodents being the most abundant, making up 88.3% of the diet. The most commonly found prey species in Barn Owl balls are *G. gerbillus*, *G. campestris*, *M. musculus*, *G. nanus* and *G. tarabuli*. Overall, the Barn Owl′s diet in the Saharan region is crucial for maintaining ecosystem balance by controlling rodent populations.

Key words: Diet Analysis, Reject Balls, Rodent Control, Souf Region, *Tyto alba*.

INTRODUCTION

Nocturnal birds of prey are considered predators par excellence; This puts them at the top of the food chain pyramid (Ramade, 2012; Dulsat-Masvidal *et al*., 2021; Dhakal *et al*., 2023). Given the nature of the selected prey, including rats and mice, which cause damage to crops in open fields and grain storage places, they are considered valuable assistants to the farmer (Giban and Haltebourg, 1965; Viteri *et al*., 2022; Choudhary *et al*., 2020; Sobhana *et al*., 2022). These predators help limit the size of prey populations, even when the harvest may seem small (Ramade, 2012; Martínez-Ruiz *et al*. 2020; Montoya *et al.,* 2021). Several studies have been carried out to clarify the diet of birds of prey around the world, including the Barn Owl in Spain (Delibes *et al.,* 1984; Sridevi *et al.,* 2020), Switzerland (Roulin, 1996), Italy (Natalini *et al.,* 1997) and Morocco (Rihane, 2005). In Algeria, on the other hand, some works are carried out in different districts of Algeria (Baziz *et al.,* 1999), in the suburbs of Algiers (Baziz *et al.,* 1999), in the Mergueb Nature Reserve (Sekour, 2010; Sekour *et al.,* 2010) and (Alia *et al.,* 2012; Alia *et al.,* 2015; Hadjoudj *et al.,* 2020) about the Barn Owl.

The family Tytonidae is represented in Algeria by a single species that includes two subspecies *Tyto alba alba* (Scopoli, 1759) and *Tyto alba guttata* (Brehm, 1831) (Heim de Balsac and Mayaud 1962; Isenmann and Moali 2000). Also known as the Barn Owl or the White Lady, it is a nocturnal bird of prey that often feeds on small mammals (Bourlière 1984; Leonardi and Dell′Arte 2006). These are generally Muridae such as Mus musculus (Linnaeus 1758), Mus spretus (Lataste 1883) and Gerbillus gerbillus (Olivier 1801) (Boukhemza, 1989; Boukhamza *et al*., 1994). Furthermore, the trophic diet of this species is largely unknown in the Saharan regions, particularly in the Souf region. To compensate for this deficiency, this study was published to complement the North Saharan (Souf) rodent database and highlight the importance of rodents-prey items in the trophic diet of this predator. For these studies, we applied the analysis of Effraie balls to make the necessary

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How to cite this article: Alia, Z., Khechekhouche, E.A., Amara, D.G., Messaoudi, M. and Sekour, M. (2024). Barn Owls (*Tyto alba* Scopoli, 1769) in the Saharan Region of Algeria (Souf): Valuable Predators for Rodent Control in Agriculture. Agricultural Science Digest. doi: 10.18805/ag.DF-631.

Submitted: 07-06-2024 **Accepted:** 25-09-2024 **Online:** 21-10-2024

observations for a possible study of this species in the Saharan region.

MATERIALS AND METHODS

Area Study

The Souf region is located in southeast Algeria, roughly 600 kilometers from Algiers, the country's capital. It is located in the Eastern Erg's northern region (33° to 34° N; 6° to 8° E). The large Tunisian Chott El-Djérid is to the east and the Merouane, Melrhir and Rharsa Chotts are to the north. The Chott trail of Oued Righ and the Oued M'Ya forms the western and southern boundaries, respectively (Voisin 2004; Côte, 2006). Based on meteorological data from 1980 to 2022, this study area belongs to the Saharan bioclimatic stage and experiences moderate winters. The same facts point to a dry season all year long. Tyto alba ball samples were gathered in Elarfji, which is 25 kilometers northwest of El-Oued, in 2021. The Barn Owl repellent balls were gathered beneath the mosque's (Soumaa) minaret in the community. 200 *Phoenix dactylefera* (L. 1753) variation palm trees and 300 *Olea europaea* (L. 1753) type olive trees are among the famous crops grown in Elarfji. The primary food source for L'Effraie, which hunts in open areas, is tiny rodents (Bourlière, 1974; Sekour, 2010). It differs from other nocturnal birds of prey by consuming insectivores, such as bats, frogs, and birds trapped in midair.

Study of *Tyto alba* reject balls

These digestive byproducts of birds, which in some species do not follow the typical route of excretion when agglomerated, are called reject balls, according to (Taberlet 1983; Montoya *et al.,* 2021). The patient tries to escape through the mouth opening and not through the oesophagus and moves in the opposite direction. For this study, this strategy included examining the materials of scarecrow rejection balls. L'Effraie prefers to hunt in open areas. Its diet is more varied than that of other nocturnal birds of prey, which these insectivores tend to despise (Bourlière, 1974; Sekour *et al.,* 2010); It consists of 90 to 95 percent small rodents, the rest are flight-caught bats, frogs and birds (Hadjoudj *et al.,* 2020).

Tyto alba's nutritional research is divided into four parts. The first will be completed outside. This is the study station's collection of raptor-repellent balls. The second, third and fourth processes are completed in the laboratory. This includes analyzing the aqueous wet rejection balls and identifying and counting the prey species discovered in the barn owl's shelled balls.

Ball collection and experimental analysis institute

The balls of rejection were collected in the mosque's minaret at the Elarfgi station in 2021. Each ball is housed in its small paper cone, containing information about the bird of prey's name, date and collection location.

The laboratory and analytical work for this project was conducted at the Biology, Environment and Health Laboratory at the University of El Oued. The results, especially species identification, were then passed to Professor Sekour Makhlouf of the University of Ouargla to confirm and verify their scientific names. This work took place from January 2019 to March 2022.

Analysis of the rejection balls

According to (Boireau, 2009), this technique aims to extract from the ball the essential parts that provide most of the data necessary to identify the target. These parts include vertebral bones of vertebrates and sclerotinized fragments of arthropods. The ball is measured, macerated in a glass Petri dish with some water, then transported to the trituration step to remove the bone fragments, bug fragments, hair and feathers using two pliers (Libois *et al.,* 1983). Following separation, the fragments are put in a new Petri dish with the date, the location of the collection and the paddle number on it. A binocular magnifying glass and graph paper gauge the size of arthropods and bones found in the paddle to identify the prey species (Fig 1). The later parts are compared with identification keys, reference collections and keys.

Identification of prey species

The vertebrate prey species discovered in rejection balls fall into the following taxonomic groups: Insectivora, Rodentia and Chiroptera. (Barreau *et al.,* 1991; Chaval, 2014) state that rodent identification is based on three criteria. The first is based on the shape of the back of the lower jaw. The second concerns the calvaria's zygomatic plate and tympanic bubbles and their properties. The third method is based on the molars' wear surface layout and the quantity of dental roots' alveoli. According to Bourlière (1974; Tavernier *et al.,* 2022), the upper first molar in *Mus musculus* is roughly equivalent to the second and third molar's combined length. *Mus spretus*, however, has a tetra-lobed first lamella of the lower first molar and a consistently shaped zygomatic plate (Benamane *et al.,* 2019; Merabet *et al.,* 2022). The upper incisors of the Gerbillinae are hollow with a median groove, according to (Boukhamza *et al.,* 1994; Hamdine 1998; Rihane, 2018). Tympanic bubbles in this family's species are highly developed and have a broad skull (Le Louarn and Quéré, 2011; Masudi *et al.,* 2016).

Count of prey species

The existence of the forehead and jaws is the main factor used to count rodents. The long bones are considered in the latter's absence, particularly the femurs, pelvic bones, tibias, humerus and others.

Exploitation of results by statistical methods

The deferential indexes, which include generic, specific and average wealth, take advantage of the outcomes. Relative abundance (A.R. per cent) is the ratio of the number of individuals of a prey species (Ni) to the sum of all the individuals of all the species (N) as determined by all surveys (Zaime and Gautier, 1989; Fethia *et al.,* 2021). Occurrence frequency (FO) is the proportion of surveys (Pi) with the species I present to all surveys (P), expressed as a

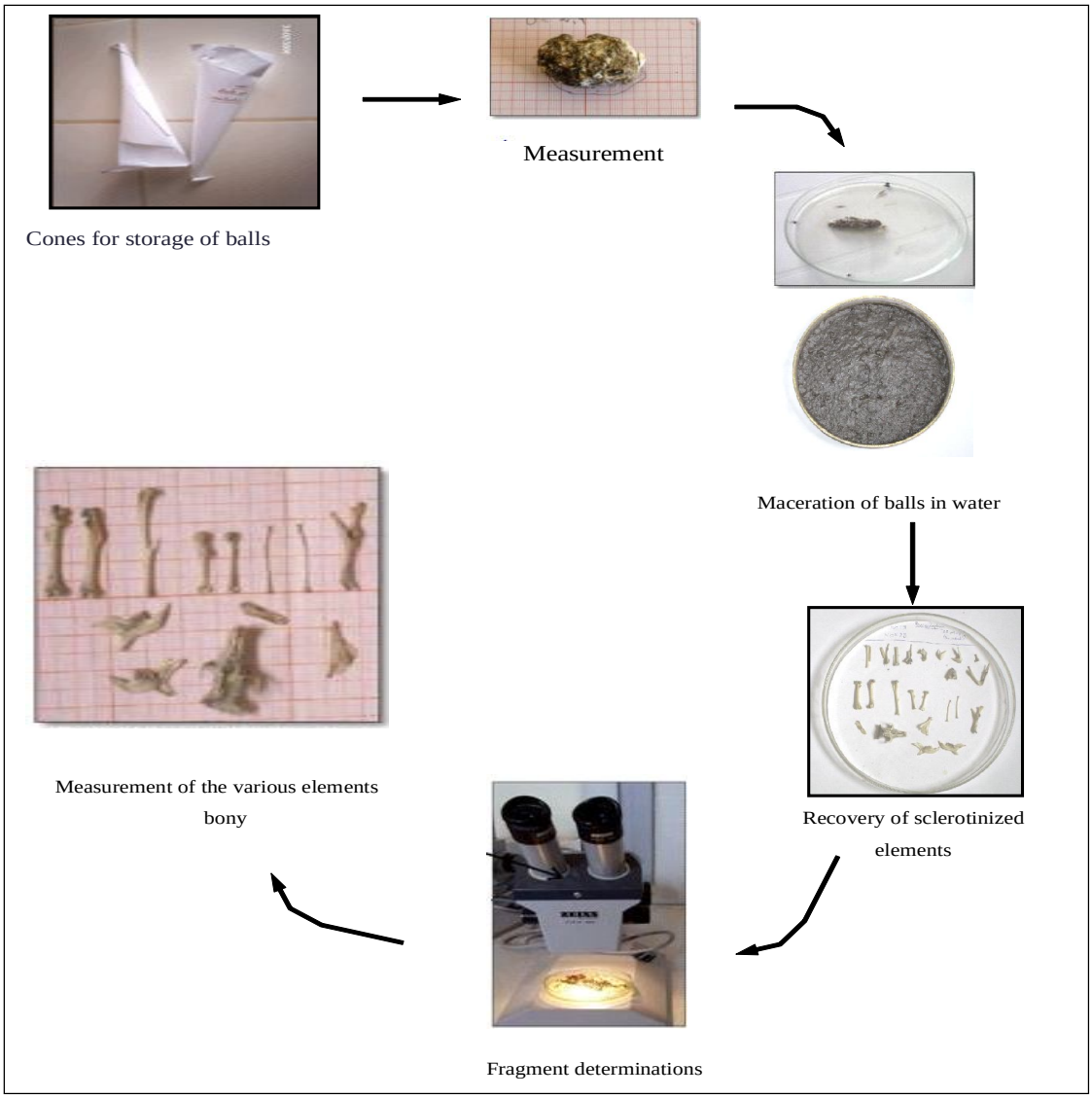

Fig 1: Stages of analysis of Barn Worm rejection balls (Original).

percentage (Dajoz, 2000; Faurie, 2011; Serge and Figuié, 2016). The link between the natural diversity (H') and the maximal theoretical diversity is known as equitability (E), which is also employed (H max).

RESULTS AND DISCUSSION

Rodent inventory by random trapping is a separate study from the Tyto alba rejection balls analysis. The findings on the Barn Owl's feeding system are presented in this section. The primary aim of the rodent study is to analyze 133 balls of rejects from the later raptor found in the mosque's minaret in Elarfgi.

Characteristics of the balls of the Barn Owl

As for the peculiarities of the regurgitates of this raptor, it is helpful to focus on the dimensions of the balls and their weights. Then, variations in the number of preys per paddle are considered.

Dimensions of Barn Owl reject balls

The average measurements of the length, large diameter and weight of the *Tyto alba* balls analyzed are grouped in Table 1. *Tyto alba* rejected 133 balls, 23 of which were fractured. The remnants (110 balls) have a length of 24 to

Table 1: Dimensions (mm) and weight (g) of Barn Owl balls harvested in the Souf region.

Parameters	Large diameter	Length	Weight
Maximum	40	97	22.5
Minimum	12	24	1
Average	24.84	39.73	4.16
Ecart-Error	3.76	8.61	2.06

97 mm (average: 39.7±8.61 mm; Table 1). The large paddle sizes of this raptor range from 12 to 40 mm (average: 24.8±3.76 mm). These paddles have weights ranging from 1 to 22.5 g (average: 4.16±2.06 g) (Table 1). They come in 39.7 mm and 8.61 mm average lengths. According to ALIA *et al.* (2012), the average size of the gathered pellets is 38.75 mm and 11.68 mm. In contrast, SEKOUR *et al.* (2010) claim that the M'Sila region has high mean length values. These writers noted 48.10 mm as the average length. This raptor's huge balls have a diameter of 24.8 mm and 3.76 mm. Additionally, these balls weigh an average of 4.16 mm and 2.06 g each. According to alia *et al.* (2012), this raptor's huge balls have a diameter of 24.7 mm and 2.9 mm. Similarly, SHEHAB (2005) records readings in Syria ranging from 18 to 32 mm. Barn Owl rejection balls with huge diameters of 26 mm were reported by Switzerland MEBS in 1994.

Variation of the number of preys per ball in *Tyto alba*

Fig 2 depicts variations in the number of preys per paddle in the investigated Barn in the Souf region. In this piece, there are somewhere between 1 and 9 preys on each paddle (Fig 2). The most common type of ball, with a rate of 27.8%, has two preys in it. They are followed by those that have three preys (25.6%) and those that have one prey (18.0%). (Fig 2). Similarly, Alia *et al.* (2015b) report an even number of preys per paddle, ranging from 1 to 9. Balls with two preys are the most prevalent, accounting for 31.7% of all balls. Presents balls of the barn in Cote d'Or (France), distinguished by a variety of prey, ranging from 1 to 13 prey (Baudvin, 1986). However, Sekour *et al.* (2010) report that there are only 1 to 4 prey per skein in the highlands of Mergueb. The same scientists report that balls with only one prey are most frequently observed (69.1 per cent), followed by balls with two prey (25.5%). Therefore, it can be claimed that the Barn Owl often only feeds on one to three preys, which suggests that its prey is significant in size and biomass, as is the case for rodents.

Study of the diet of the *Tyto alba* by ecological indices of composition

The study of the data on *Tyto alba*'s food by ecological composition indices is covered in the following section.

Generic, specific richness of the prey identified in the reject balls of the Barn Owl

Table 2 lists the general and specific prey richness of *Tyto alba* regurgitations.

Tyto alba rejections from 133 balls were analyzed, and the results revealed 23 prey species (Sm = 1.9±0.63 species) in 17 genera (all taxa combined, Table 2). When it comes to rodents, there are 7 genera, 13 species (Sm = 1.65±0.67 species) and 341 individuals (Table 2). According to Alia *et al.* (2015b), 170 individuals were found after analyzing the rejection balls and they were grouped into 17 genera and 23 prey species (Sm=1.83±0.93 species). In Bouclans (France), Michelat and Giraudoux (1993) found a total species richness of 13 species. Roulin (1996) noted the same amount in the Swiss canton of Broye. The total richness (39 species) Baziz *et al.* (2002) mentioned is higher than ours. In the balls of *Tyto alba*, Aulanginer *et al.* (1999) recorded 32 prey species in Morocco.

Relative abundance applied to prey categories

Fig 3 displays the relative quantity of prey categories discovered in *Tyto alba* reject balls. There seem to be 5 categories listed (Fig 3). Rodentia (88.3%%) has the highest population density, followed by Aves (20%, 5.2%), Insects (15 individuals, 3.4%), Reptilia (1.8%) and Chiroptera (1.3 %, Fig 3). In the exact study location, Alia *et al.* (2012) discovered that rodents are the tiny trophic *Tyto alba*'s most prevalent prey type (88.2%). Similarly, Sekour *et al.* (2005) in the M'Sila region report that rodents predominate all prey by examining rejection balls with 89.6% and even for the remnants at the

Table 2: Generic, prey-specific richness of *Tyto alba* reject balls and importance of rodents.

	Prey species	Rodentia prey
Ni	386	341
Sg	17	7
Ss	23	13
Sm	1.92	1.65
Ecart-Error	0.63	0.67

Ni: Number of rodent individuals; Sg: Generic wealth; Ss: Specific wealth; Sm: Average wealth.

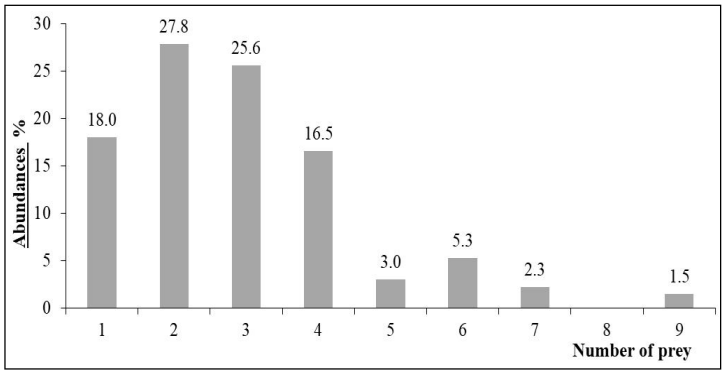

Fig 2: Prey rate per ball for *T. alba* in the Souf region.

nest of this raptor (62.6%). Even though rats make up 63.8 per cent of the trophic menu of the Barn *et al.* (2000) emphasize the significance of microorganisms (68.4%). After analyzing barn pellets, Staouéli *et al.* (2002) confirmed the dominance of rodents (67.0%). Rihane (2005) reveals the significance of rodents in *Tyto alba* rejection balls with a rate of 50.8 per cent in the semi-arid plains of Morocco. Similarly, Leonardi and Dell'arte (2006) demonstrate the predominance of rodents in the diet of the Barn Owl in a steppe setting in Tunisia. According to Amat and Soriguer (1981), mammals make up 72.7% of the land area in western Spain. According to Sorgo (1992), micro-mammals are the source of 96.5 per cent of *Tyto alba*'s prey in Slovenia.

Table 3: Shannon-Weaver diversity index, maximum diversity and equitability applied to prey species from *Tyto alba* to Souf.

Parameters	All species combined	Rodentia
H′	3.25	2.68
H′ max	4.52	3.70
E	0.72	0.73

H′: Shannon-Weaver Diversity; H′ max: Maximum diversity; E : Equitability.

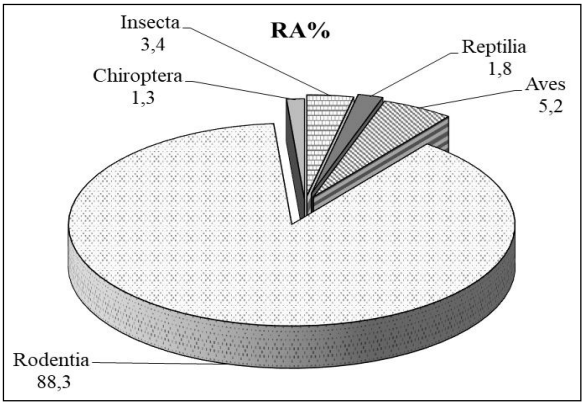

Fig 3: Relative abundance of prey categories noted in *Tyto alba* balls.

Relative abundance of prey species sampled in Barn Owl regurgitates

The importance of all prey species ingested by Barn Owls is shown in Fig 4.

G. gerbillus is the prey species found in Barn Owl balls at a rate of 36.8%. *M. musculus* (10.6 per cent), *G. nanus* (9.8 percent), *G. tarabuli* (11.1 per cent) and *G. campestris* were the following most common species (8.3 %). With rates that don't go above 3.5 per cent, other species, including insects, reptiles, birds and bats are only marginally represented (Fig 4). The two species that souf encounters the Barn Owl the most frequently are *G. gerbillus* (44.0%) and *G. compestris* (13.3%). (Alia *et al.,* 2015b). While in the highlands, *Meriones shawii* is the most consumed prey by the barn in Ain El-Hadjel (87%) (Sekour *et al.*, 2010).

Occurrence frequency of prey species noted in Barn Owl reject balls

Results for the frequency of occurrence of all prey species ingested by the Barn Owl are shown in Fig 5. Based on the frequency of occurrence values, *G. gerbillus* (OF = 54.1%) is a regular prey item in the Barn Owl trophic menu (Fig 5). By contrast, the species that are considered accidental prey in the diet of this raptor are *G.nanus* (OF = 23.1%), *G. campestris* (OF = 20.3%), *G. tarabuli* (OF = 19.5%), *M. musculus* (OF = 17.3%), *D. simoni* (OF = 7.5%), *J. jaculus* (FO = 7.3%), *Passer* sp. (OF = 6.0%) and Lacertidae sp. ind (FO = 5.3%, Fig 5).

Study of the diet of the Barn Owl by ecological indices of structure

The Shannon-Weaver Diversity Index uses the Barn Owl regurgitation ball analysis results, the Maximum Diversity Index and equitability. They are set out in Table 3.

The H' value is 3.25 bits for all prey species compared to 2.68 bits for rodents exclusively (Table 3). Therefore, the rodent category is particularly diversified compared to the other animal types stated in the balls of the Barn. H' max values 4.52 bits for all prey species, compared to 3.70 bits

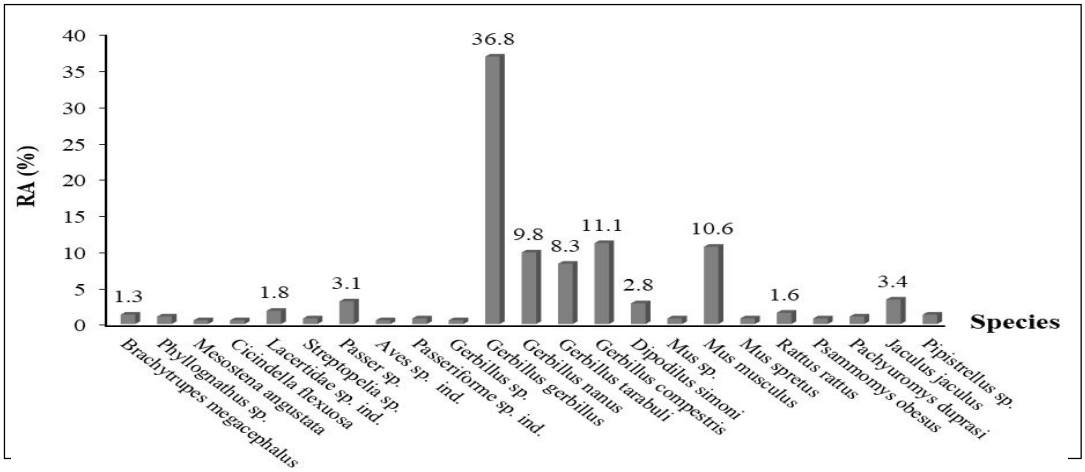

Fig 4: Relative abundance of prey species noted in *Tyto alba* balls.

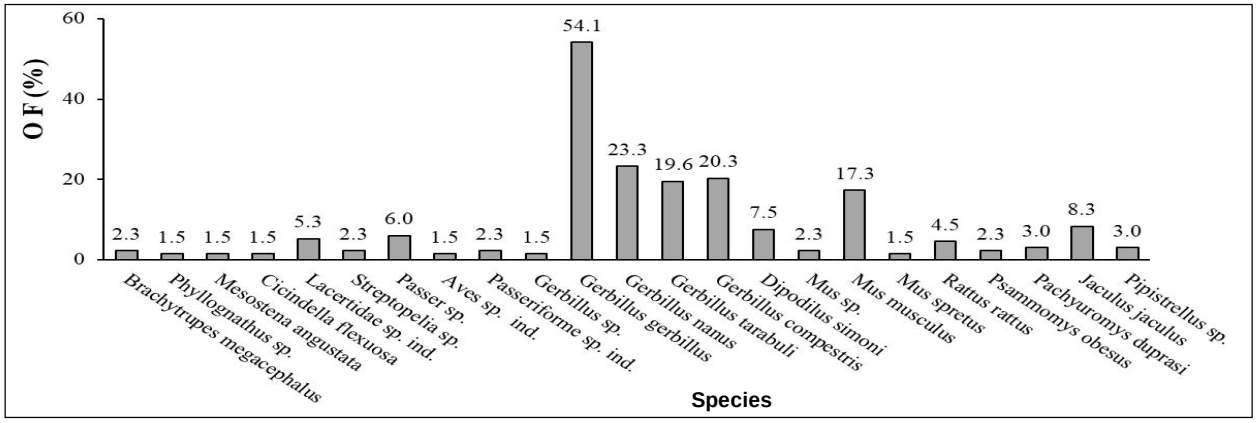

Fig 5: Occurrence frequency of species prey in Barn Owl rejection balls.

Table 4: Age variation of rodents-prey found in barn owl rejection balls.

Age category → Species ↓	Juvenile	Subadult	Adult	Elderly
Gerbillus sp.	-	50.0	50.0	-
Gerbillus gerbillus	9.2	62.7	20.4	7.7
Gerbillus nanus	5.3	60.5	26.3	7.9
Gerbillus tarabuli	9.4	53.1	31.3	6.3
Gerbillus compestris	14.0	55.8	18.6	11.6
Dipodilus simoni	9.1	27.3	45.5	18.2
Mus sp.	-	-	66.7	33.3
Mus musculus	14.6	46.3	31.7	7.3
Mus spretus	-	66.7		33.3
Rattus rattus	-	66.7	16.7	16.7
Psammomys obesus	-	33.3	66.7	-
Pachyuromys duprasi	-	25.0	50.0	25.0
Jaculus jaculus	15.4	53.8	23.1	7.7

for rodents only (Table 3). At the same time, the obtained equitability values for both groups tend to be equal to 1, whether it is for all prey species (E = 0.72) or simply for rodent prey species (E = 0.73) (Table 3). This indicates that the quantity of prey species included in this raptor's rejection balls tends to be balanced.

Study of the age categories of rodents-prey found in the Barn Owl balls in the Souf region

The age categories of rodent-prey species noted in the regurgitations of *Tyto alba* are given in Table 4.

Most of the prey rodent species, as shown in Table 4, are adults and sub adults. The four age groups correspond to the species *G. gerbillus*, *G. nanus*, *G. tarabuli* and *G. campestris*, as well as *D. simoni*, *M. musculus* and *J. jacullus*. *R. rattus* and *P. duprasi*, however, each have three age groups (subadult, adult and elderly). *G. gerbillus* (62.7%), *G. nanus* (60.5%), *G. tarabuli* (53.1%), G. *campestris* (55.8%), *M. musculus* (46.3%) and *J. jacullus* all have high populations in the subadult age class (53.8 %, Table 4). However, *Mus spretus* (subadult and elderly) and *P. obesus* are two species that have two age categories (sub adult and adult).

CONCLUSION

The analysis of the waste pellets, used as a complementary method alongside rodent trapping, revealed important information. The rodent prey found in the pellets of Tyto alba are classified into two families: Muridae and Dipodidae. The species identified include G. gerbillus, G. nanus, G. tarabuli, G. campestris, D. simoni, P. duprasi, P. obesus, M. musculus, M. spretus, R. rattus, and J. jaculus. Among these, gerbils are the preferred prey for the Barn Owl, particularly G. gerbillus and G. campestris. In terms of prey diversity, the Barn Owl's regurgitated pellets exhibit a notable variety of environments utilized by this raptor, indicating a balanced distribution in prey numbers. Furthermore, the age categories most frequently chosen by the Barn Owl in the Souf region are subadults and adults, suggesting these age groups are the most actively hunted.

Conflict of interest

On behalf of all the authors of the aforementioned manuscript, I am writing to confirm that we have no conflicts of interest related to the research, authorship, and publication of this article. None of the authors have any financial, personal, or institutional interests that could be perceived as influencing the outcomes or interpretations presented in the manuscript.

The findings and conclusions in our study are based solely on objective scientific data and analysis. We assure you that this work was conducted without any bias or external influence that could compromise its integrity.

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