

# Autumn diet of Little Owls (*Athene noctua*) in southern Tunisia

Intissar SAADA<sup>1\*</sup>, Abdessalem HAMMOUDA<sup>1</sup>, Jerzy ROMANOWSKI<sup>2</sup> & Slaheddine SELMI<sup>1</sup>



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**Abstract** The Little Owl (*Athene noctua*) is a widespread nocturnal raptor whose diet has extensively been studied. In the Mediterranean, a tendency towards increased ingestion of insects has been highlighted, but this tendency still needs more empirical validation. Here, we provide data on the autumn diet of Little Owls in an arid area in southern Tunisia. We analyzed 621 pellets from 30 different territories and identified 4,267 prey items, with insects being by far the most ingested prey. However, based on biomass, the diet was more evenly distributed across the identified prey categories. Vertebrates accounted for 63% of the biomass ingested, while the remaining part of prey composition was almost equally shared between insects and arachnids. The importance of arachnids looks like a characteristic dietary trait of Little Owls in south Mediterranean deserts, where arachnids represent a main component of the community of potential prey. In summary, our findings highlight the great food opportunism of the Little Owl due to its capability of adapting its diet to the availability of potential prey.

**Keywords:** arid areas, Mediterranean, nocturnal raptors, pellet analysis, trophic ecology

**Összefoglalás** A kuvik (*Athene noctua*) széles körben elterjedt éjszakai ragadozómadár, amely táplálkozása alaposan tanulmányozott. A Mediterráneumban a faj megnövekedett rovarfogyasztását emelték ki, azonban ez további megerősítést igényel. Jelen tanulmányban a kuvik Dél-Tunézia száraz régiójában jellemző őszi étrendjéről közlünk adatokat. A 30 különböző területről származó, összesen 621 köpet elemzésével 4267 zsákmányt azonosítottunk, amelyek közül messze a rovarok jelentették a legtöbbet fogyasztott zsákmányt. A biomassza alapján azonban a zsákmánykategóriák eloszlása egyenletesebb volt az étrendben. Az elfogyasztott biomassza 63%-át a gerincesek tették ki, míg a zsákmány-összetétel fennmaradó része közel egyenlő arányban oszlott meg a rovarok és a pókfélék között. A pókfélék fontossága egy jellemző táplálkozási jelleg a dél-mediterrán sivatagokban előforduló kuvikok esetén, ahol a pókfélék a potenciális zsákmány közösség fő alkotóelemei. Összefoglalva, eredményeink rávilágítanak a kuvik nagy táplálkozási opportunizmusára, mivel képes étrendjét a potenciális zsákmány elérhetőségéhez igazítani.

**Kulcsszavak:** sivatagos terület, Mediterráneum, éjszakai ragadozómadarak, köpetelemzés, trofikus ökológia

<sup>1</sup> Laboratory “Ecology & Environment” (LR24ES17), Faculty of Sciences, Gabès University, Zrig 6072, Gabès, Tunisia

<sup>2</sup> Institute of Biological Sciences, Cardinal Stefan Wyszyński University, Wóycickiego 1/3, 01-938 Warsaw, Poland  
\* corresponding author; e-mail: intissarsaada60@gmail.com

## Introduction

As top predators, owls play important roles in ecosystem functioning and provide valuable ecological services worldwide (Donazar *et al.* 2016). For conservation purposes, profound knowledge on their trophic ecology is needed. In particular, it is essential to investigate how diet varies among local populations depending on local conditions and prey availability, as this may help assess how owls adapt to environmental changes.

The Little Owl (*Athene noctua*) is a widespread owl species that occurs in different habitats across the Palearctic, preying on a diverse pool of small vertebrates and invertebrates (del Hoyo *et al.* 1992, Nieuwenhuyse *et al.* 2008). Although its diet has been the subject of many investigations in different regions of its geographical range in Europe (e.g. Capizzi & Luiselli 1995, Fattorini *et al.* 1999, Goutner & Alivizatos 2003, Romanowski *et al.* 2013, Hámori *et al.* 2017, 2019), Asia (e.g. Shao & Liu 2008, Zhao 2011), the Middle East (e.g. Al-Melhim *et al.* 1997, Obuch & Krištín 2004, Charter *et al.* 2006) and North Africa (e.g. Alaya & Nouria 2007, Chenchouni 2014), this subject still attracts the interest of ornithologists who continue to provide new data (e.g. Kolendrianou *et al.* 2022, Fallahi Akhlamad *et al.* 2023). These studies contribute greatly to the identification and understanding of the spatial patterns of the trophic ecology in this species. In this context, a north-south dietary gradient has been highlighted, with a decrease in small mammals and an increase in insects from continental Europe towards the Mediterranean (del Hoyo *et al.* 1992, Nieuwenhuyse *et al.* 2008). Although an insect-based diet has been accepted as a typically Mediterranean dietary trait, strong empirical evidence from southern Mediterranean populations is still lacking. Indeed, there is a huge asymmetry between the northern and southern borders of the Mediterranean concerning the knowledge on Little Owl diet because of incomparable research efforts dedicated to this subject.

In this paper, we provide detailed data on the diet of Little Owls inhabiting an arid area along the Gulf of Gabès, in southeast Tunisia. Our main goals were to describe the diversity of consumed prey and to assess whether southern Tunisian Little Owls had a typical Mediterranean diet.

## Materials and Methods

### Data collection

The study area is an arid desert plain close to Gabès city (33°53'N-10°05'E), in southeast Tunisia. The landscape corresponds to a mixture of sparsely-vegetated steppes, farmlands, including oases and dry fruit tree groves, and urban areas. In this area, the Little Owl is a common resident breeder that often uses piles of stone abandoned by people as roosting and nesting sites (Saada *et al.* 2024).

In October and November 2022, we collected Little Owl pellets in thirty territories that we previously located (Figure 1). Pellets were searched for around piles of stones assembled by people and used by Little Owls as daytime roosting and nesting sites. Collected pellets were

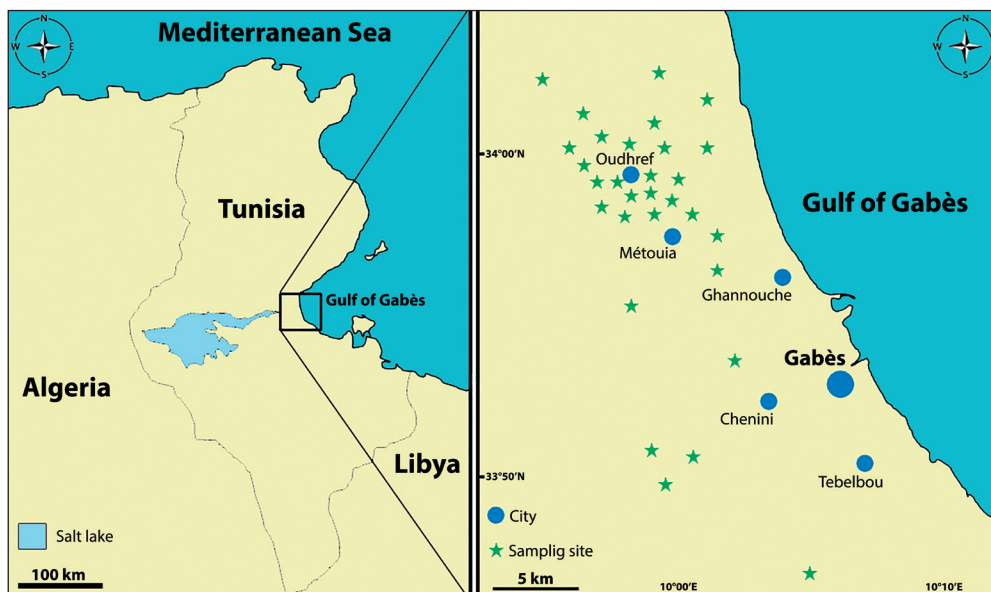


Figure 1. Map of the study area showing the locations of sampled Little Owl territories  
 1. ábra A vizsgált terület térképe, amelyen látható a mintavételi helyek elhelyezkedése

brought to the laboratory where they were soaked separately in water for at least 30 minutes. Prey remains, including bones, hair and feathers from preyed vertebrates, and chitinous pieces (jaws, mandibles, heads and chelicerae) from invertebrates, were separated and dried on filter paper. Subsequently, the remains were carefully observed using a stereo-microscope for prey identification and count following Romanowski *et al.* (2013). We tried to identify the prey to the species level by referring to the guides and reference works available in the Zoology laboratory at the Faculty of Biology and Environmental Sciences, Cardinal Stefan Wyszyński University, Warsaw, Poland. For each pellet, the pieces belonging to each category of prey were collected together and counted so that the minimum number of individuals was retained (Rey-Rodríguez *et al.* 2019).

Abundance data were converted into biomass using body weight data available in the literature, in particular Tobias *et al.* (2022) for birds, Amor *et al.* (2010) for amphibians, Murariu and Chișamera (2007) for small mammals, Jelaska *et al.* (2011), Heatwole and Muir (1989) and Byers (2015) for insects, and Zaafour *et al.* (2014) for gastropoda. With regard to scorpions and solifuges, body weight data were not available in the literature, so we calculated the mean weight of individuals that we caught on the field. In each group, the average body weight of the most commonly recorded species was used for converting prey numbers into biomass. In summary, the following conversion coefficients were used: scorpions and solifuges (3 g), Coleoptera (0.28 g), ants (0.007 g), wasps (1 g), Orthoptera (0.77 g), Dermaptera (0.27 g), Gastropoda (3 g), amphibians (30 g), birds (30 g), small mammals (18 g). We emphasize here that these conversion coefficients were determined for use in the particular case of our study system, and we recognize that they may lack precision.

## Data analyses

For a given prey class  $i$ , we calculated the frequency of occurrence (1) in the pellets (i.e., the number of pellets where that prey class was recorded by the total number of pellets sampled), and (2) in the studied territories (i.e. the number of territories where that prey class was recorded in the diet by the total number of territories sampled). We also determined its contribution to the Little Owl's diet, by calculating its frequency ( $p_i$ ) relative to the total prey ingested. Calculations were made in terms of abundance and biomass, and the obtained frequencies were subsequently used to assess the diet breadth, using the Levin's index:  $B = 1/Sp_i^2$  (Magurran 2004). Values were standardized on a scale of 0 (specialist diet) to 1 (generalist diet), by calculating evenness:  $E = (B-1)/(N-1)$ , with  $N$  being the number of prey classes (Magurran 2004).

Furthermore, we drew abundance-frequency and biomass-frequency curves by ranking the prey classes from the most to the least important based on either abundance or biomass along the  $x$ -axis, and their cumulative frequencies on the  $y$ -axis (Magurran 2004). The differences between the two curves were then assessed by means of a Kolmogorov–Smirnov two-sample test, using the `npair1way` procedure in SAS (SAS Institute 2008). Finally, the prey classes were ranked according to their importance in the diet by using a modified formula of the Index of Relative Importance (Martin *et al.* 1996):  $IRI = (N+W) \times F$ , with  $N$ ,  $W$  and  $F$  are the frequencies (expressed in %) of abundance, biomass and occurrence (relative to total pellets sampled), respectively.

## Results

From the 621 pellets analyzed, we recorded 4,267 prey items belonging to 10 main categories (Table 1). All prey categories were commonly ingested, as each of them occurred in the diet of at least 40% of the territories sampled (Table 2). The smallest prey identified were ants, weighing approximately 7 mg, while the largest prey was the Sand Rat (*Psmammomys obseus*) with a weight exceeding 100 g. Based on abundance data, coleopterans were the most often caught prey, as they accounted for 69% of identified prey items (Table 2), leading to a low value of the Levin's index evenness ( $E = 0.112$ ).

Among coleopterans, the specimens belonging to the Tenebrionidae family were the most commonly consumed, occurring in 91% (563/621) of pellets and accounting for 23% (685/2957) of the coleopterans ingested (16% of identified prey; 685/4267).

However, using biomass data, the diet seemed more evenly distributed across the identified prey categories (Table 2;  $E = 0.521$ ). Actually, vertebrates, whose contribution did not exceed 5% of recorded prey, accounted for 63% of the biomass ingested, while the remaining 37% of prey biomass was almost equally shared between insects and arachnids (Table 2). This distribution is also visible when looking to the abundance and biomass curves (Figure 2). Indeed, there was a tendency of the biomass curve to be below and steeper than the abundance curve, but this difference was still non-significant (Kolmogorov–Smirnov two-sample test:  $D = 0.400$ ;  $P = 0.401$ ). Finally, when data on occurrence, abundance and biomass were

Table 1. List of prey taxa recorded in the Little Owl diet and their frequency of occurrence in pellets

1. táblázat A kúvik táplálék-összetételében azonosított zsákmányok listája és előfordulásuk gyakorisága a köpetekben

| Class      | Order           | Family        | Species                      | Pellets (%) |
|------------|-----------------|---------------|------------------------------|-------------|
| Arachnida  | Scorpiones      | Scorpionidae  | <i>Scorpio maurus</i>        | 12 (2%)     |
|            |                 | Buthidae      | <i>Buthus tunetanus</i>      | 112 (18%)   |
|            |                 |               | <i>Androctonus australis</i> | 20 (3%)     |
|            | Solifugae       | Galeodidae    | Undetermined                 | 124 (20%)   |
| Insecta    | Coleoptera      | Tenebrionidae | <i>Pimelia</i> sp.           | 413 (67%)   |
|            |                 |               | <i>Blaps</i> sp.             | 96 (15%)    |
|            |                 |               | <i>Akis</i> sp.              | 49 (8%)     |
|            |                 |               | <i>Sepedium</i> sp.          | 4 (1%)      |
|            |                 |               | Undetermined                 | 138 (22%)   |
|            |                 | Scarabaeidae  | <i>Scarabaeus sacer</i>      | 7 (1%)      |
|            |                 |               | Undetermined                 | 78 (13%)    |
|            |                 | Carabidae     | Undetermined                 | 32 (5%)     |
|            |                 | Curculionidae | Undetermined                 | 57 (9%)     |
|            |                 | Buprestidae   | Undetermined                 | 2 (<1%)     |
|            |                 | Undetermined  | Undetermined                 | 103 (17%)   |
|            | Hymenoptera     | Formicidae    | <i>Messor arenarius</i>      | 28 (5%)     |
|            |                 | Vespidae      | Undetermined                 | 19 (3%)     |
|            | Orthoptera      | Acrididae     | <i>Heteracris annulosa</i>   | 5 (1%)      |
|            |                 |               | Undetermined                 | 236 (38%)   |
|            | Dermaptera      | Labiduridae   | <i>Labidura riparia</i>      | 4 (1%)      |
|            |                 | Forficulidae  | Undetermined                 | 55 (9%)     |
| Gastropoda | Stylommatophora | Helicidae     | Undetermined                 | 17 (3%)     |
| Amphibia   | Anura           | Ranidae       | <i>Pelophylax aharicus</i>   | 14 (2%)     |
|            |                 | Undetermined  | Undetermined                 | 12 (2%)     |
| Aves       | Passeriformes   | Alaudidae     | <i>Galerida cristata</i>     | 1 (<1%)     |
|            |                 | Sylviidae     | <i>Curruca</i> sp.           | 2 (<1%)     |
|            |                 | Passeridae    | <i>Passer domesticus</i>     | 1 (<1%)     |
|            |                 | Undetermined  | Undetermined                 | 27 (4%)     |
| Mammalia   | Insectivora     | Soricidae     | <i>Crocidura</i> sp.         | 7 (1%)      |
|            | Rodentia        | Muridae       | <i>Mus musculus</i>          | 30 (5%)     |
|            |                 |               | <i>Mus spretus</i>           | 35 (6%)     |
|            |                 |               | <i>Apodemus sylvaticus</i>   | 2 (<1%)     |
|            |                 |               | <i>Meriones shawi</i>        | 9 (1%)      |
|            |                 |               | <i>Psammomys obesus</i>      | 3 (<1%)     |
|            |                 |               | <i>Gerbillus simoni</i>      | 3 (<1%)     |
|            |                 |               | Undetermined                 | 41 (7%)     |

**Table 2.** The occurrence frequency and relative proportion, the abundance and biomass frequency and their relative proportion, as well as the Index of Relative Importance (IRI) of the prey categories identified in the food of the Little Owl

**2. táblázat** A kúvik táplálékában azonosított zsákmánykategóriák előfordulásának frekvenciája és gyakorisága, abundancia és biomassza frekvenciájuk és ezek relatív aránya, valamint a relatív fontossági index (IRI)

| Prey category | Occurrence/territories | Occurrence/pellets | Abundance   | Biomass        | IRI     |      |
|---------------|------------------------|--------------------|-------------|----------------|---------|------|
|               | (%)                    | (%)                | (%)         | (%)            | Value   | Rank |
| Coleoptera    | 30 (100%)              | 599 (96%)          | 2957 (69%)  | 827.96 (12%)   | 7861.07 | 1    |
| Mammalia      | 24 (80%)               | 125 (20%)          | 139 (3%)    | 2502.00 (37%)  | 814.25  | 2    |
| Orthoptera    | 29 (97%)               | 240 (39%)          | 452 (11%)   | 348.04 (5%)    | 608.72  | 3    |
| Scorpiones    | 26 (87%)               | 135 (22%)          | 223 (5%)    | 669.00 (10%)   | 329.66  | 4    |
| Solifugae     | 25 (83%)               | 119 (19%)          | 182 (4%)    | 546.00 (8%)    | 237.16  | 5    |
| Aves          | 14 (47%)               | 30 (5%)            | 31 (1%)     | 930.00 (14%)   | 70.30   | 6    |
| Amphibia      | 12 (40%)               | 24 (4%)            | 26 (1%)     | 780.00 (12%)   | 47.17   | 7    |
| Dermaptera    | 17 (57%)               | 53 (9%)            | 152 (4%)    | 41.65 (1%)     | 35.64   | 8    |
| Hymenoptera   | 18 (60%)               | 45 (7%)            | 88 (2%)     | 19.46 (<1%)    | 17.02   | 9    |
| Gastropoda    | 12 (40%)               | 17 (3%)            | 17 (<1%)    | 51.00 (1%)     | 3.16    | 10   |
| Total         | -                      | -                  | 4267 (100%) | 6715.10 (100%) | -       | -    |

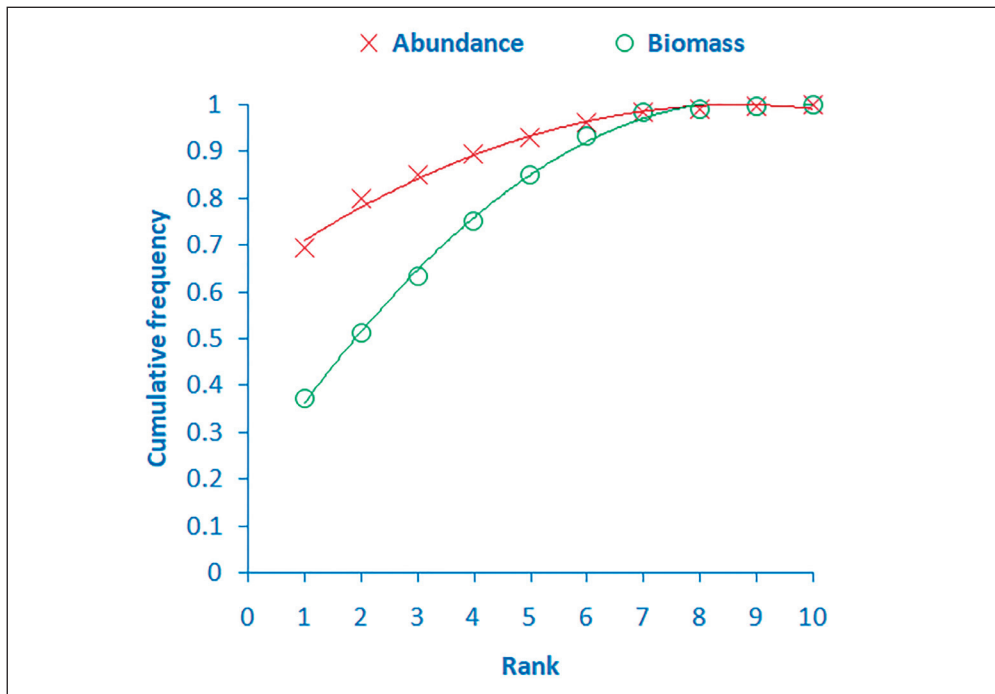


**Figure 2.** Abundance and biomass curves for prey taxa recorded in Little Owl pellets

**2. ábra** A kúvik köpetekből kimutatott zsákmány taxonok abundancia és biomassza görbéje

combined together, through the calculation of the IRI, there was a strong evidence of a coleopteran-based diet in our studied Little Owl population. Indeed, coleopterans were ranked first, far ahead of mammals, orthopterans, scorpions and solifugae (Table 2). The other classes were clearly much less important (Table 2).

## Discussion

Using pellet data, we aimed to describe the diversity of prey consumed by Little Owls inhabiting an arid southern Tunisian area. We identified ten common prey categories that contributed differently to the Little Owl's diet. We also noticed that the captured prey covered a wide range of sizes, from ants (around 7 mg) to sand rats whose weight exceeds 100 g. We admit here that we were actually surprised by the observation of sand rat skulls in some pellets. This rodent is normally large for a small owl species whose mammalian prey are often shrews and other small rodents (e.g. Capizzi & Luiselli 1995, Goutner & Alivizatos 2003, Kolendrianou *et al.* 2022). However, the consumption of rodents exceeding 100 g, such as the Black Rat (*Rattus rattus*) has also been reported by some authors (e.g. Charter *et al.* 2006). It is also remarkable that amphibians were part of the diet of Little Owls in our desert area. In fact, frogs were only eaten in some territories near wadis (river valleys) and waterholes where these prey were available.

When prey number and biomass were taken into account together, we found that small prey (i.e., insects and arachnids) were caught in higher numbers, providing significant energy intake, compared to the largest prey (i.e. vertebrates). This suggests that Little Owls have directed their hunting efforts to small prey that are likely more easily catchable than the largest prey available, in accordance with the optimal foraging theory (Stephens & Krebs 1986). Among insects, coleopterans had the most important contribution to the diet of the Little Owls studied, as they were detected in all the pellets sampled and alone accounted for 69% of the items identified and 12% of the total biomass ingested. Although five families of coleopterans were identified, the specimens belonging to Tenebrionidae were the most commonly consumed. This finding is in accordance with those reported in other Mediterranean populations. For example, Fattorini *et al.* (1999) highlighted beetles, including Tenebrionids, as major prey for Little Owls in the Rome urban area. Angelici *et al.* (1997) also noted that the most ingested beetles by Little Owls on the island of Astipalaia (Greece), during summer, were Tenebrionidae (8.80% of the total number of prey eaten). Orthopterans also provided significant diet items, consistent with what was observed in other Mediterranean populations. In particular, the study of Obuch and Kristín (2004) showed that grasshoppers and crickets took a significant place (5.7–16.4%) in the diet of Little Owls in Egypt, Syria and Iran. Orthopterans have also been reported as the main prey of Little Owls inhabiting wetlands in northeastern Greece (Goutner & Alivizatos 2003).

Our results also revealed arachnids as important prey of Little Owls in our arid study area. Indeed, scorpions and solifuges represented together almost 10% of identified prey and accounted for 18% of the biomass ingested. This importance of arachnids actually seems to be a characteristic dietary trait of Little Owls in south Mediterranean deserts,

where arachnids may indeed represent a main component of the community of nocturnal invertebrates. For example, Obuch and Kristín (2004) reported that solifuges and scorpions represented significant components (up to 11%) of the diet of Little Owls in some arid areas in Egypt, Syria and Iran. Overall, these findings suggest that the Little Owl may provide an important public health service to humans living in the desert of south Mediterranean areas, where scorpionism is a major health concern (Chippaux & Goyffon 2008), especially as this nocturnal raptor has synanthropic habits (Saada *et al.* 2024).

In conclusion, our study shows the Mediterranean character of the diet of Little Owls inhabiting the desert plain along the Gulf of Gabès in southern Tunisia. We also note a remarkable enrichment of arachnids, most likely associated with their high availability in this desert area. Overall, these findings stress that the Little Owl has a great capacity of adapting its diet to the availability of potential prey, highlighting the great food opportunism of this species.

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