Acta fytotechn zootechn, 26, 2023(3): 263–272
http://www.acta.fapz.uniag.sk

Original Paper

Sexual dimorphism and dietary composition of the sandfish lizard *Scincus scincus* (Linnaeus, 1758) of southeastern Algeria

Laoufi Hayet[1, 2*], Mouane Aicha[1], Aouimeur Souad[3], Merabti Brahim[2], MEHAOUA Mohamed Seghir[2, 4]

[1]*University of El Oued, Faculty of Nature and Life Sciences, Department of Biology, El-Oued, Algeria*
[2]*Laboratory of Genetic, Biotechnology and Valorization of Bioresources (LGBVB), University of Biskra, Biskra, Algeria*
[3]*University of Ouargla, Faculty of Nature and Life Sciences, Department of Agronomic Sciences, Ouargla, Algeria*
[4]*Laboratory of Diversity of Ecosystems and Dynamics of Agricultural Production Systems in Arid Zones (DEDSPAZA), University of Biskra, Biskra, Algeria*

Article Details: Received: 2023-05-22 | Accepted: 2023-05-31 | Available online: 2023-09-30

https://doi.org/10.15414/afz.2023.26.03.263-272

In this study, we present the first data on the sexual dimorphism and diet of a typical desert lizard species, *Scincus scincus*, in the region of El-Oued, southeastern Algeria. The objective was to characterize the types of prey in the diet and determine whether there is a correlation between prey size and body size in males and females. The results obtained reveal that out of the 115 individuals captured (43 males and 72 females), sexual dimorphism is observed. Males tend to be larger than females, with males exhibiting relatively larger snout-vent length, head height, head length, and jaw length compared to females. However, no difference is recorded in terms of head width. The analysis of stomach contents allowed us to identify 485 prey items distributed among 9 prey categories, all attributed to insects. Coleoptera was the most commonly ingested prey category, accounting for 61.54% of stomachs, 59.79% of total prey items, and 62.41% of total volume. A similar diet was observed between females and males of *S. scincus*, with a high diet overlap ($O = 0.99$) and a low diversity of prey types ingested by both males ($Ba = 0.17$) and females ($Ba = 0.19$). Coleoptera represented the most dominant order in the skink's diet, followed by the Hymenoptera order. Generally, the remaining seven taxa were consumed in low proportions by both sexes. Additionally, we observed no significant difference between the number of prey consumed and the volume of prey between the sexes, and no correlation was found between morphometric characteristics, diet composition, and prey volume.

Keywords: *Scincus scincus*, sexual dimorphism, diet, prey size, El-Oued

1 Introduction

In the Algerian Sahara, the sandfish lizard, *Scincus scincus*, plays important ecological roles and is also valued for its dietary preferences among the local inhabitants. This reptile is highly regarded by the local population as a source of protein, serving as an alternative to meat and fish (Toumi et al., 2022). The analysis of the ecological niche and more particularly its trophic dimension constitutes an essential step in understanding the functioning of populations and ecosystems (Mori et al., 2018). In ectotherms species, digestive performance, energy budget, and energy allocation for different activities including reproduction depend on the quality of the diet (Brewster et al., 2021). Indeed the energy needs and the search for food of an animal depend according to certain intrinsic factors: behavior of search for food, the body size, the sex and the ontogeny, and the availability of food resources (Vitt, 2000; Sales et al., 2012). The quantitative and qualitative variations of the trophic resources in the environment are likely to modify the diet and the dietary strategy of individuals (Millon et al., 2009). The animal has behavioral and physiological plasticity that allows them to adjust their food search effort according to the available trophic resources to increase their chances of survival (Guariento et al., 2018), and more particularly for animals living in arid and desert areas characterized by relatively limited trophic resources (Pianka, 2017). The sandfish lizard *S. scincus* is a diurnal

***Corresponding Author:** Laoufi Hayet, Laboratory of Genetic, Biotechnology and Valorization of Bioresources (LGBVB), University of Biskra, Biskra 07000, Algeria
laoufihyt@yahoo.fr https://orcid.org/0000-0002-1709-5582

skink with a wide distribution from North Africa to the Middle East. This specie is strictly subservient to the desert environment; it makes the exception of Squamata by its ability to adapt to life subharenal, through a particular physiological mechanism (Vihar et al., 2015). However, few studies have addressed the trophic ecology and diet of Skinks *S. scincus* (Al-Sadoon et al., 1999). Our objective is to study sexual size dimorphism and diet composition in *S. scincus*, and to examine whether the observed size dimorphism can qualitatively and quantitatively influence the food spectrum of the lizards. We also aim to investigate whether there is a relationship between the size of ingested prey and the size of individuals (both males and females).

2 Material and methods

2.1 Study area

Fieldwork was conducted in the region of El Oued (33° 21′ 21.9″ N, 6° 51′ 47.5″ E), which is situated approximately 700 km southeast of Algiers (Figure 1). It is considered one of the primary oases in the northern Sahara of Algeria, located in the eastern Erg. The average annual temperature is around 26 °C, with summer temperatures reaching up to 45 °C and occasionally dropping to freezing point in winter. Precipitation is low, sporadic, and variable, with an average annual rainfall not exceeding 70 mm and rarely reaching 100 mm (Khezzani et al., 2016).

2.2 Lizards' collection and processing

The lizard specimens were collected by hand between October 2017 and November 2018, the capture process was the search for the place likely to find the lizard, through the footprints left on the surface of the ground surface to facilitate capture. The sex is determined by direct observation; the adult males differ from the females by the presence of dark spots on the back, while the females have a duller color which is similar to the juvenile livery. For this we have carried out verification through the gonads to avoid confusion. Once lizards are captured they are transported to the laboratory, where they are euthanized using formaldehyde (5%). The following measurements are taken using a digital caliper (0.01mm accuracy). The length of the nasal opening (SVL) from the tip of the nose to the anterior end of the cloacal cavity. Head length from the posterior margin of the tympanic membrane to the tip of the nose (HL). Head width (HW) at the widest part of the skull. Head height (HH) at maximum skull height. and jaw length (JL) (Figure 2).

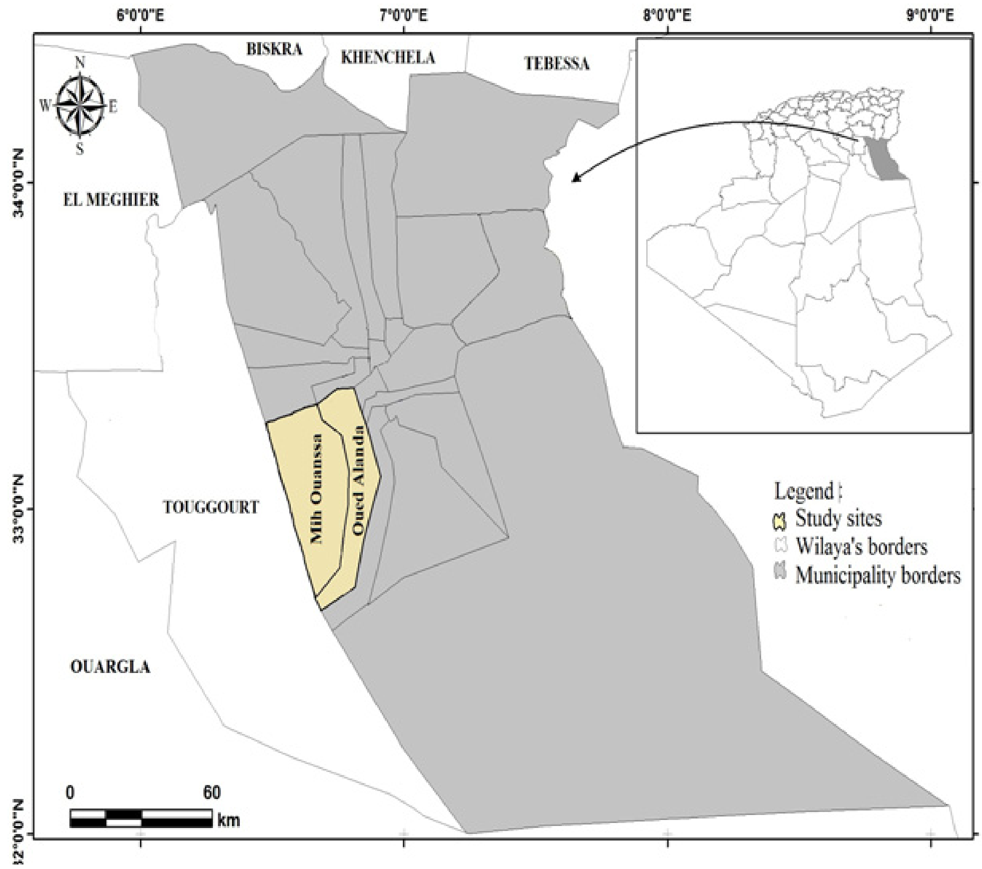

Figure 1 Carte of the study area

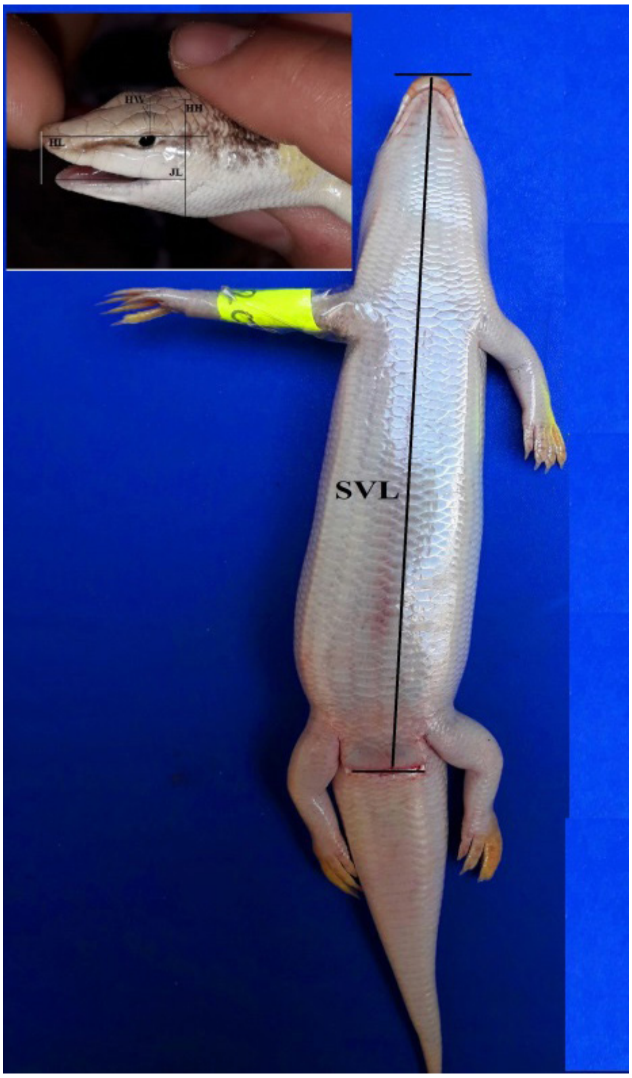

Figure 2 *Scincus scincus* measurements
(SVL) snout-vent length; (HL) head length; (HW) head width; (HH) head height; (JL) jaw length

The *S. scincus* diet is developed based on stomach content analysis, being the most accurate method (Arab & Doumandji, 2003; Paray et al., 2018). After dissection, the stomach contents of each specimen is then extracted and placed in a petri dish containing 75° alcohol. We analyzed the stomach contents under a binocular dissecting scope equipped with a micrometer eyepiece so as to, determine, count and measure the size (length and width) of the prey items so long as it is not too fragmented. Prey is identified at the low taxonomic level possible (order); the volume is estimated by the formula for a prolate spheroid:

$$V = \frac{4}{3}\left(\frac{length}{2}\right)\left(\frac{width}{2}\right)^2$$

Three parameters are calculated: percentage of occurrence (%*F*), numerical percentage (%*N*) and volumetric percentage (%*V*) of each prey category (*i*), defined as follows:

$$\%F = \left(\frac{fi}{F}\right) \times 100$$

where: *fi* – the number of stomachs containing the prey category (*i*); (*F*) – the total number of stomachs non-empty stomachs

$$\%N = \left(\frac{ni}{N}\right) \times 100$$

where: *ni* – the number of prey of categories (*i*); (*N*) – the total number of prey

$$\%V = \left(\frac{vi}{V}\right) \times 100$$

where: *vi* – the volume of prey of categories (*i*); (*V*) – the total volume of prey

The contribution of each prey category to the diet is quantified using the Relative Importance Index (% *IRI*) calculated by the following equation for males, females, and the total sample (Mesquita & Colli, 2003):

$$IRI = \frac{(\%F + \%N + \%V)}{3}$$

Trophic niche diversity is calculated by the standardized Levin's index (*Ba*):

$$Ba = \frac{(B-1)}{(n-1)}$$

where: (*n*) – the number of prey categories; (*B*) – the Levin's index of niche breadth:

$$B = \frac{1}{\sum pi2}$$

where: *pi* – the proportion of each category (*i*)

This index describes the breadth of the trophic niche where a value of '1' indicates a generalized diet and a value of '0' indicates a specialized tendency (Krebs, 1999).

To compare dietary overlap between females and male, we used the formula:

$$O = \frac{\sum pij \times pik}{\left(\sum pij^2 \times \sum pik^2\right)^{1/2}}$$

where: *pij* – the male proportion prey category (*i*); *pik* – the female proportion prey category (*i*), which has a range value from 0 (no similarity) to 1 (complete similarity

For each lizard, we determine maximum and minimum prey size by considering the items with the largest and smallest volumes in each stomach, respectively. Lizards that ingested less than two prey items are excluded from the prey size analysis because estimates of the maximum and minimum prey sizes were inconsistent (Palmeira et al., 2021).

2.3 Data analyses

Firstly, we applied the Shapiro-wilk test to confirm the normality of all data (the Gaussian distribution) of all measurement parameters. Student's test (*t*-test) is used to verify the presence of differences between males and females in (SVL, HH, HL, and JL). The Mann-Whitney U test is applied to verify the existence of sexual differences in HW, diet for the number of food items ingested (Nprey) and the volumetric sum of all prey items inside the stomach (Vprey), and the minimum and maximum prey volume (Preymin and Preymax). The Person's correlation was useful to verify the existence of sexual correlation between SVL and HH, Hl, and JL. The correlation of Spearman is also to verify the existence of sexual correlation between the measurement of the body and the width of the head of *S. scincus* with the number and volume of prey consumed (SVL, HW, Nprey,Vprey, Prey max and Prey min). Statistical test and graphs are performed using SPSS 19.0 for Windows. Mean values are expressed as mean ±SE and $P < 0.05$ is considered as statistically significant.

3 Results and discussion

3.1 Morphometric parameters and Sexual size dimorphism

The application of the normality test is done on all the parameters studied in both sexes to know the normality of the natural distribution, by applying the test of Shapiro-Wilk. The four SVL, JL, HH and HL parameters have a *p*-value greater than 0.05 ($p > 0.05$), which shows the significance of the normality of these parameters, whereas, the HW, Nprey, Vprey, Prey min and Prey max indicate a *p*-value less than 0.05 ($p < 0.000$), with outlier values and non-normal distribution. So we apply the non-parametric tests according to this normality test.

A total of 115 adults of *S. scincus* (43 males and 72 females) are measured in this study. The largest male and female are 119.27 mm and 109.70 mm, respectively. However the smallest male and female are 74.82 and 66.44 mm, respectively. Males are significantly larger than females, the mean SVL is different between sexes (males: 101.69 ±11.33 mm, females: 90.77 ±10.62 mm; $t = 5.19$, $df =$

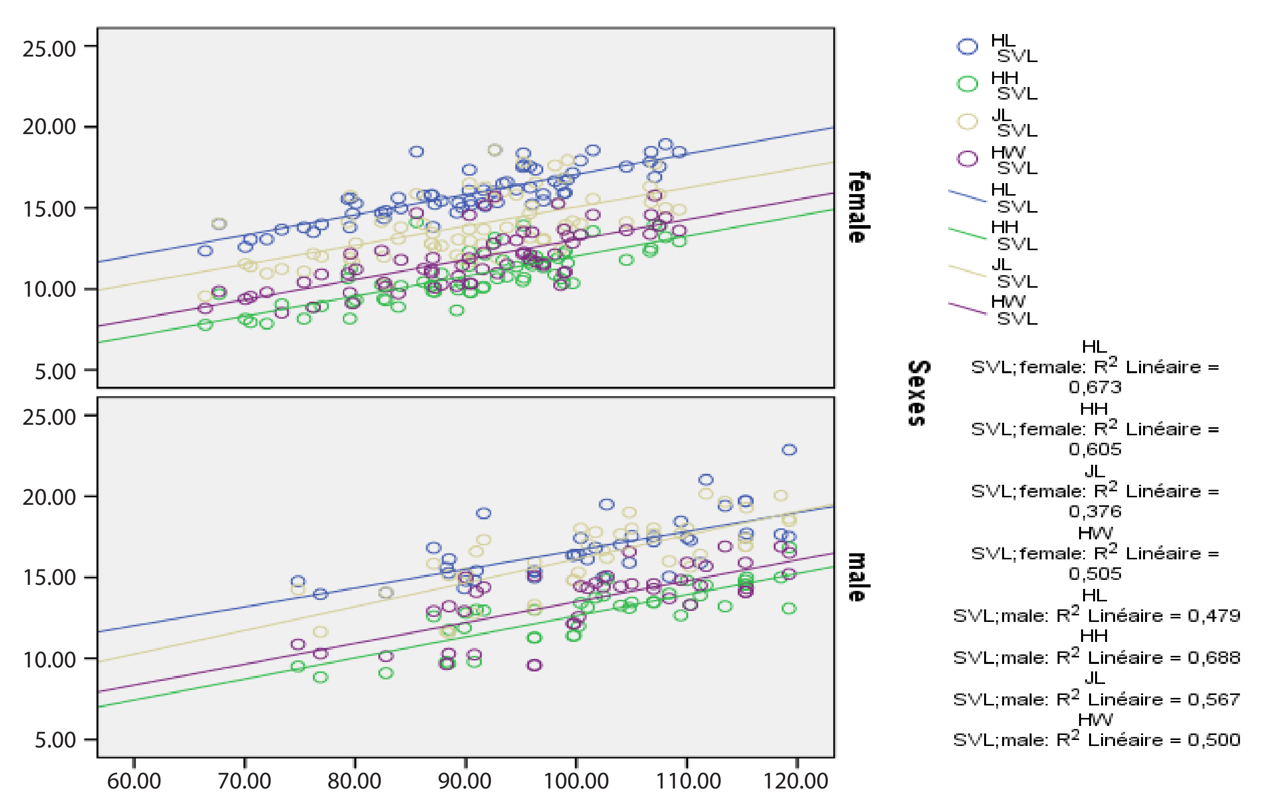

Figure 3 Linear regressions of head length (HL), head higher (HH), and jaw length (JL): abdomen length (d) on snout-vent length (SVL) in *S. scincus* of 43 males and 72 females

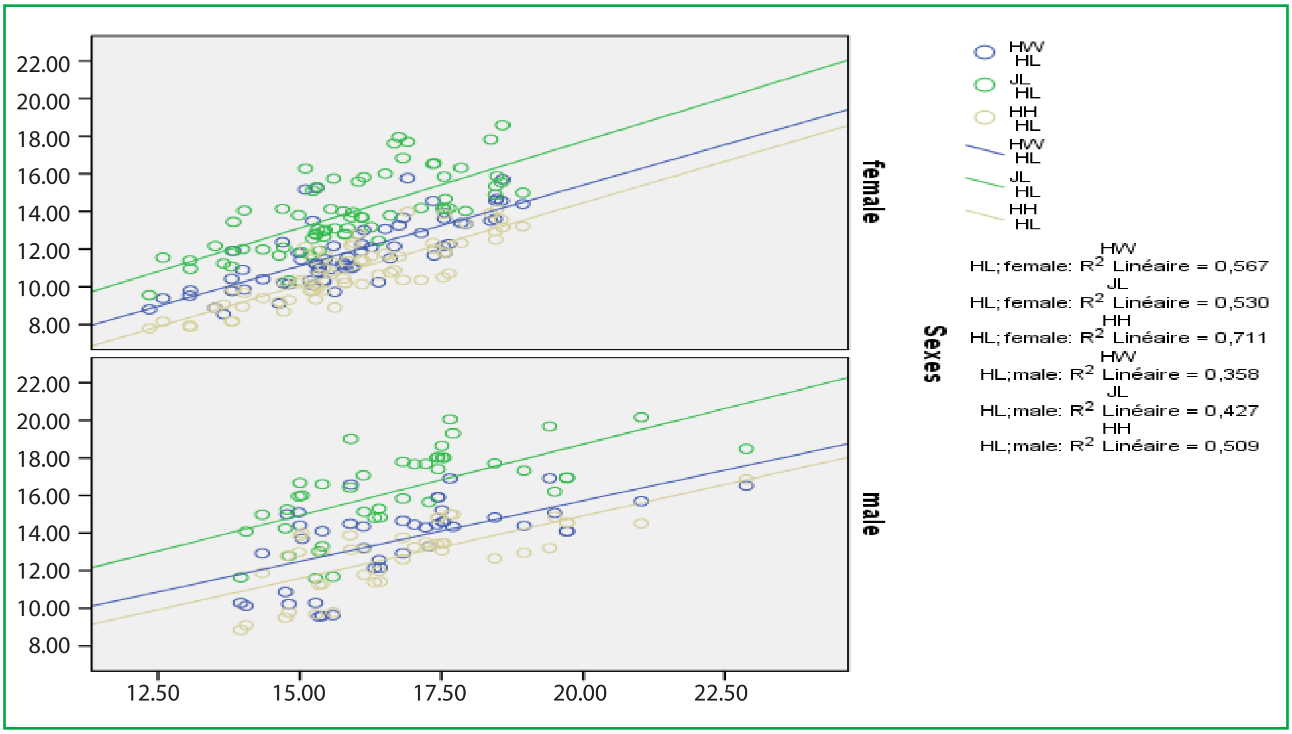

Figure 4 Linear regressions of head width (HW), jaw length (JL), and head higher (HH), on head length (HL), in *S. scincus* of 43 males and 72 females

116, p = 0.000). With the T-test, the difference is clearly significant between the two sexes (p = 0.000) for the three parameters HH, HL and JL. Table 1 illustrates the corresponding data.

A nonparametric Mann-Whitney test is used for the parameter HW and it revealed that the difference between the two sexes is well reported for this parameters (p = 0.000) but the five parameters HW, Nprey, Vprey, Prey min and prey max revealed that only the difference between the two sexes is well signaled in the HW parameters (p = 0.000). However, the four parameters (Nprey, Vprey, Preymin and Preymax) related to the diet studied in both sexes, the differences are not significantly apparent according to Table 1.

The linear regression between SVL and HH, HL and JL shows a well determined correlation between these four parameters, according to the calculated significance (P = 0.000). In males, the strongest correlation is reported between SVL and HH with correlation coefficient of Pearson (R^2 = 68.80%), followed by SVL/JL, SVL/HW, SVL/HL with a correlation coefficient of Pearson respectively (56.7%; 50%; and 47.9%) (Figure 3 and 4). In females, a correlation coefficient R^2 of 67.3% between the SVL and HL considered to be the most important and shows a positive correlation between body length and head width (HW). About SVL/HH, SVL/HW and SVL/JL are also correlated respectively with the correlation coefficient of R^2 60.5%, 50.5% and 37.6%.

3.2 *Food composition*

The comparison between the volume and the number of prey consumed by males and females of *S. scincus* according to the Mann-Whitney U test shown that there is no significant difference (p >0.05) for these parameters, and the same remark about the minimum and maximum volume of prey consumed of both sexes and SVL (Table 1).

A weak correlation is recorded between the SVL with the number and volume of prey consumed for both sexes, males and females, with a correlation coefficient (R^2) not exceeding 10%.

The food spectrum of *S. scincus* was composed mainly of Arthropods (Table 2). The analysis of 115 stomachs revealed 485 prey items distributed in 09 prey categories, averaging 4.21 items/stomach, and as indicated by the the proportion of occurrence (%F), Coleoptera are the most frequent prey found in the stomachs of lizards with (61.54%) represents (59.79%) of all the prey ingested, and a ratio of 62.41% of the total volume. Its abvious that importance index compared to other prey categories, shows a contribution of (I = 61.24%) of Coleoptera in the diet of scincus lizard.

The Hymenoptra, is the order represented in the second position with (29.28%) of the diet. The proportions of the other categories of prey, namely: Arenae, Isopoda, Blattoptera, Dermaptera, Diptera, Orthoptera and Lepidoptera, do not exceed (5.36%). Additionally,

Table 1 Descriptive statistics of morphological traits and consumed prey for females (n = 73) and males (n = 43) of 115 specimens of *S. scincus*

Traits	Males	Females	*T*-test/Mann-Whitney *U* test
SVL	96.68 ±23.33	90.77 ±10.62	t = 5.19, df = 116, p = 0.000
HL	16.77 ±2.15	15.96 ±1.62	t = 2.81, df = 116, p = 0.006
HW	13.54 ±2.26	11.95 ±1.86	Mann-Whitney U = 867.0, p = 0.000
HH	12.72 ±2.02	10.88 ±1.67	t = 5.97, df = 116, p = 0.000
JL	16.22 ±2.35	14.00 ±2.06	t = 5.78, df = 116, p = 0.000
Nprey	5.00 ±2.83	4.85 ±2.25	Mann-Whitney U = 1,374.0, p = 0.178
Vprey	419.21 ±840.86	719.65 ±436.91	Mann-Whitney U = 1,503.0, p = 0.542
Preymin	6.70 ±47.15	6.70 ±40.38	Mann-Whitney U = 744.0, p = 0.698
Preymax	327.25 ±537.06	512.65 ±1601.46	Mann-Whitney U = 699.0, p = 0.408

SVL – snout-vent length; HL – head length; HW – head with; HH – head higher; JL – jaw length; Nprey – number of prey; Vprey – volume of prey; Preymin –minimum prey voluem, Preymax – maximum prey volume

Table 2 Descriptors parameters of the taxonomic diet of *S. scincus*

Prey category	%*F*	%*N*	%*V*	IT	IM	IF
Araneae	5 (1.60)	10 (2.06)	27.1 (0.30)	1.32	0.67	1.72
Isopoda	3 (0.96)	3 (0.62)	476.8 (5.24)	2.27	2.55	2.70
Blattoptera	8 (2.56)	9 (1.86)	1342.3 (14.76)	6.39	7.43	2.78
Coleoptera	192 (61.54)	290 (59.79)	5676.5 (62.41)	61.24	57	65.74
Dermaptera	1(0.32)	2 (0.41)	235.5(2.59)	1.1	1.62	–
Diptera	16 (5.13)	26 (5.36)	47.2 (0.52)	3.67	4.12	3.35
Hymenoptera	85 (27.24)	142 (29.28)	1205.5 (13.25)	23.25	26.1	22.59
Lepidoptera	1(0.32)	2 (0.41)	66.2 (0,73)	0.48	0.48	–
Orthoptera	1(0.32)	1(0.21)	18.5 (0.20)	0.24	–	0.72

%*F* – frequency of occurrence; %*N* – relative abundance; %*V* – volumetric percentage; I – index of relative Importance; T – total sample; M – sample of adult males; F – sample of adult female; – Indicates no individuals of that prey category were found)

the presence of fragments of two scorpion species: *Anthroctunus* sp and *Buthidae* sp, and two plant species: *Spartidium saharae* and *Retama retam* are diagnosed in the stomach contents. The analysis of diet between both sexes shows that, males consumed 08 prey categories, and females 07. In addition, the Levi's index indicated a low diversity of ingested prey types in males (Ba = 0.17) and for females it is (Ba = 0.19). Pianka's indices showed high similarity between the two nutrient spectra (O = 0.99). The strong contribution of Coleoptera in their food spectrum is clearly visible (IM = 57% and IF = 65.74%) respectively in male and female, several identifiable genera and species, they are essentially represented in the male by *Pimilia* sp (12.60%) and *Ptinus* sp (10.08%).The same species of this prey category with approximately the same proportion is found in the diet of females, which is further distinguished by the consumption of a species of *Cymindis* sp with (17.54%) while only 3.36% which is represented in the diet of males. The Hymenoptera present a food supply in the lizards of (IM = 26.1%, IF = 22.59%) respectively in males and females. The dominant families of this order are: Formicidea, which is exclusively represented by many ant species,of which Messor sp is the most consumed ant species in females with (32.90%), against (8.7%) quantified in male, meanwhile, there is a slight consumption trend of *Pheidole pallidula* in females which is (11.11%) compared to males (28.98%).

It has been reported that the order of Lipidoptera does not appear in the food composition of males, also the order of Dermaptera and Orthoptera are absent from the food menu of females.

From the previous observations it is known that males generally have relatively larger body size and head dimensions than do females in many Lacertid lizards, as in other lizard families (Cox et al., 2003; Kaliontzopoulou et al., 2007; Zhao &Liu, 2013; Liang et al., 2021) This pattern is also confirmed in this study, in which a significant difference is observed between male and female of *S. scincus* which affects body size (SVL) and also in favors

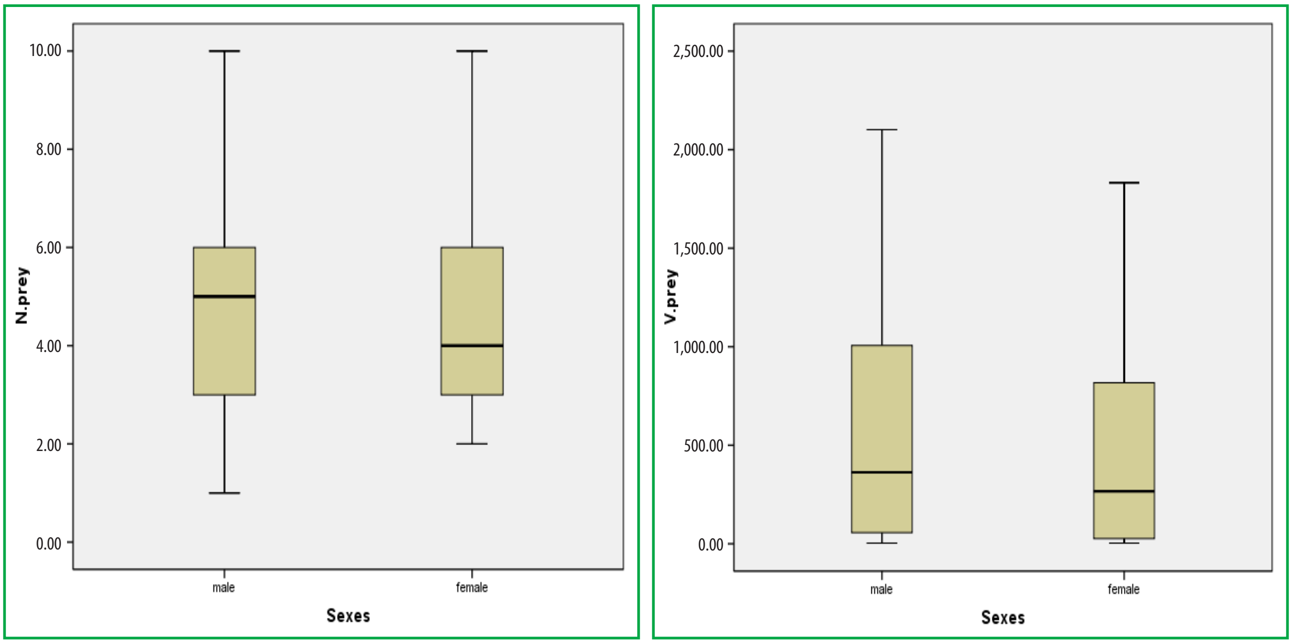

Figure 5 Difference in Prey number (Nprey) (left) and Volume of Prey (Vprey) (right) in both sexes

of the males with a larger snout vent length (SVL) of 94.75 mm. Hence, these results are in agreement with the results obtained by Babelhadj et al. (Babelhadj et al., 2021), though an average of (122 mm ±4.4) is mentioned by Toumi et al. (Toumi et al., 2022). It is under the effect of sexual selection that favors a large size for the male which confers an advantage in intrasexual behavior (Cox et al., 2003), and natural selection for large female size is related to a fecundity advantage of larger females (Cox et al., 2003; Du et al., 2005; Pincheira Donoso & Hunt, 2017). Indeed, the dimension of the head which affects the length, the height of the head also the length of the jaw is relatively more important in the males than that of the females *Scincus*, our results are confirmed by those obtained by Babelhadj et al. (Babelhadj et al., 2021). In fact, the studies carried out in this direction clearly show this intersexual differentiation, in many lizard families for exemple Agamidae (Withers &Thompson, 2005); Lacertidae (Kaliontzopoulou et al., 2008) and Scincidae (Ciracì et al., 2022). According to Brannelly et al. this is maybe due to sexual selection because larger head in males allows for higher bite force than that in females, which is important during intersexual competition (Brannelly et al., 2019). Moreover, because of larger bite forces, animals with larger heads can attack larger and harder prey (Arcos et al., 2017). feeding behavior in male reptiles depends on jaw length (JL) (Pianka & Vitt, 2003).

For example the food spectrum of *S. scincus* is very broad and consists primarily of terrestrial wide variety of invertebrates available in the study area, most of which are arthropods, especially insects. These diets have been documented in most lizard species, some herbivorous has been noted (Rastegar-Pouyani & Mohammad, 2016). However, food selectivity is noticed in our lizards specimens, this agrees with other previous study on the diet of *Scincus* genus (Al-Sadoon et al., 1999; Paray et al., 2018; Kadry, 2019). Indeed, some of the invertebrate preys are not used as a food source by *S. scincus*, the study by (Paray et al., 2018). Some studies have shown that Coleoptera and Hymenoptera are two of the most common orders of insects in the stomach contents of some lizards species (Puga & Colmenares et al., 2019). The strong representation of Coleoptera in the diet of *S. scincus* observed is 60%, this predominant consumption of this order has also been observed in sandfish lizards from arid zones, such as *S. scincus* from Egypt (Kadry, 2019), *S. hemprichii* and *S. mitranus* of Saudi Arabia (Al-Sadoon et al., 1999; Paray et al., 2018). The contribution of ants diet is in second position in the menu of *Scincus* but a low consumption, results also mentioned in the same species in Egypt (Kadry, 2019). Carretero reports that myrmecophagy is associated with poor environments with few nutritional resources (Carretero, 2004) like in arid and desert areas (Zhao & Liu, 2013). According to Pianka, desert habitats are characterized by low and changeable product, Coleoptera, Formicidae and Isoptera become the main prey of this ecosystem (Pianka, 2017). Therefore, it seems that these predators tend to prefer catching easier prey such as ants and beetles, and avoid relatively agile prey such as spiders and flies and consquently they are found in small proportions in the sampled stomachs of the *Scincus*. However, some studies, which that have focused on the diet of lizards, have revealed that their choice of prey is affected by the availability of such prey and also by the edaphic characteristics of the surrounding environment (de Fraga et al., 2022).Unfortunately, we did not sample potential prey in the habitat to verify whether their abundance in this lizard's diet reflected their abundance in the environment. This would have made it possible to highlight any selection phenomena. The results obtained reveal the presence of scorpion fragments in the stomach contents of the *Scincus*, which has not been mentioned before for the *Scincus* of the same family (Al-Sadoon et al., 1999; Paray et al., 2018), especially for the same species of lizards (Kadry, 2019), with the exception of the study by (Mouane et al., 2022). According to several authors (Pianka, 2017) the diet can be varied in the same genus of lizards even they cohabit the same habitat.

Plant consumption is also negligible. This can be explained by the fact that compared to animal prey, plant material is generally less energetic and difficult to assimilate (Cooper Jr &Vitt, 2002; Bombi et al., 2005). Regarding the trophic diet of males and females of sand fish, there is a similarity in the composition, quantity of different categories of prey ingested, mainly Coleoptera order followed by Hymenopteran, like the case of the Agama, *Phrynocephalus przewalskii* of the Tengger desert of China, in which both sexes consumed similar prey types and ingested a similar amount of food items, while a size discrepancy is observed in males and females (Zhao & Liu, 2013). Sexual differences in the diet composition are usually attributed to sexual dimorphism in the body and the head dimensions that allows a differential consumption of prey between sexes, with the larger sex having the potential to consume larger prey (Shine et al., 2002), in addition, the head divergence between males and females could reduce both intraspecific and interspecific competition for food resources (Nel et al., 2015). The sexual dimorphism in *S. scincus* is well established, and depends on the size of the body and the different dimensions of the head, however, no relationship is observed between, the quantity and the size of the prey (volume). Taverne et al. and Zhao and Liu have found that prey size does not correlate with the degree of head dimorphism (Zhao & Liu, 2013; Taverne et al., 2019).

4 Conclusion

In conclusion, lizards play a significant role in the food chain of arid ecosystems. Our study on *S. scincus* has revealed morphological differences between males and females, with males being larger and having wider jaws. There is a strong correlation between body size, head size, and jaw size. However, we did not find a correlation between body size and the prey consumed by *S. scincus* in terms of number and volume. Interestingly, both males and females exhibited a similar diet composition, showing a preference for consuming Coleoptera and Hymenoptera. For future research, it is important to further investigate why this species favors certain prey over others and to delve deeper into the feeding behavior of this lizard. Understanding whether this variability in diet is influenced by the natural distribution of prey, selective preferences, or other factors will contribute to a more comprehensive understanding of *S. scincus* and its ecological role in arid ecosystems. Advancing our knowledge of *S. scincus* and its ecological dynamics in arid ecosystems will provide valuable insights into population dynamics and interactions within these specific habitats. This information can contribute to improved conservation and management strategies for arid ecosystems, highlighting the importance of lizards in these fragile environments.

Acknowledgments

The authors would like to express their sincere appreciation to all people who contribute directly or indirectly for the realization of this modest work. Pedagogic laboratory of the Biology Department of Hamma Lakhdhar University of El-Oued. The scientific staff of team of Laboratory of Genetic, Biotechnology and Valorization of Bioresources (LGBVB), University of Biskra.

References

Al-Sadoon, M., Al-Johany, A., & Al-Farraj, S. (1999). Food and feeding habits of the sand fish lizard *Scincus mitranus*. *Saudi Journal of Biological Sciences*, 6(1), 91–100. https://10.1016/j.sjbs.2017.11.004

Arab, K., & Doumandji, S.E. (2003). Etude du régime alimentaire de la Tarente de Mauritanie *Tarentola mauritanica* (Linné. 1758) (Gekkonidae) et le psammodrome algire *Psammodromus algirus* (Linné. 1758) (Lacertidae) dans un milieu sub-urbain près d'Alger. *Bulletin de la Société herpétologique de France,* (106), 10–16.

Arcos, V.H., Sanabria Urbán, S., & Cueva del Castillo, R. (2017). The interplay between natural and sexual selection in the evolution of sexual size dimorphism in *Sceloporus lizards* (Squamata: Phrynosomatidae). *Ecology and Evolution*, 7(3), 905–917. https://doi:10.1002/ece3.2572

Babelhadj, B., Thorin, C., Benaïssa, A., & Guintard, C. (2021). Etude biométrique du Scinque officinal ou «poisson de sable» *Scincus scincus* (Linnaeus, 1758): analyse du dimorphisme sexuel de la sous-espèce *S. scincus* (Linnaeus, 1758) de la région d'El Oued Souf (Algérie). *Revue suisse de Zoologie*, 128(1), 85–92. https://doi.org/10.35929/RSZ.0037

Bombi, P., Scalera, R., Bologna, M., & Vignoli, L. (2005). Food habits of *Podarcis filfolensis* (Reptilia, Lacertidae) on a small Mediterranean island during the dry season. *Amphibia-Reptilia*, 26(3), 412–417. https://doi:10.1163/156853805774408694

Brannelly, L.A., Ohmer, M.E., Saenz, V., & Richards-Zawacki, C.L. (2019). Effects of hydroperiod on growth, development, survival and immune defences in a temperate amphibian. *Functional Ecology*, 33(10), 1952–1961. https://doi.org/10.1111/1365-2435.13419

Brewster, C.L., Gifford, M., Ortega, J., & Beaupre, S.J. (2021). Analyzing Time-Energy Constraints to Understand the Links between Environmental Change and Local Extinctions in Terrestrial Ectotherms. *The American Naturalist*, 198(6), 719–733. https://doi.org/10.1086/716725

Carretero, M.A. (2004). From set menu to a la carte. Linking issues in trophic ecology of *Mediterranean lacertids*. *Italian Journal of Zoology*, 71(S2), 121–133. https://doi.org/10.1080/11250000409356621

Ciracì, A., Razzetti, E., Pavesi, M., & Pellitteri-Rosa, D. (2022). Preliminary data on the diet of *Chalcides chalcides* (Squamata: Scincidae) from Northern Italy. *Acta Herpetologica*, 17(1), 71–76.

Cooper, Jr W.E., & Vitt, L.J. (2002). Distribution, extent, and evolution of plant consumption by lizards. *Journal of Zoology*, 257(4), 487–517. https://doi.org/10.1017/S0952836902001085

Cox, R.M., Skelly, S.L., & John-Alder, H.B. (2003). A comparative test of adaptive hypotheses for sexual size dimorphism in lizards. *Evolution*, 57(7), 1653–1669. https://10.1111/j.0014-3820.2003.tb00371.x

de Fraga, R., P. Santos, Jr A., P. Werneck, F., C. Costa, H., T. Guimarães, J., Perez, R., Graboski Mendes, R., Mott, T., Vaz-Silva, W., & Ribeiro, S. (2022). The overlooked underground diversity: physical and chemical edaphic structure predict morphological variation in South American amphisbaenians (Squamata: Amphisbaenidae). *Studies on Neotropical Fauna and Environment*, 1–13. https://doi.org/10.1080/01650521.2022.2147046

Du, W.-G., Ji, X., Zhang, Y.-P., Xu, X.-F., & Shine, R. (2005). Identifying sources of variation in reproductive and life-history traits among five populations of a Chinese lizard (*Takydromus septentrionalis*, Lacertidae). *Biological Journal of the Linnean Society*, 85(4), 443–453. https://doi.org/10.1111/j.1095-8312.2005.00508

Guariento, R.D., Luttbeg, B., Carneiro, L.S., & Caliman, A. (2018). Prey adaptive behaviour under predation risk modify stoichiometry predictions of predator-induced stress paradigms. *Functional Ecology*, 32(6), 1631–1643. https://doi.org/10.1111/1365-2435.13089

Kadry, M.A.M. (2019). Morphological, genetic and feeding habits diversity of the common sand fish, *Scincus scincus* in two different habitats in egypt. *ciencia-e-tecnica*, 34(8), 151–178.

Kaliontzopoulou, A., Carretero, M.A., & Llorente, G.A. (2007). Multivariate and geometric morphometrics in the analysis of sexual dimorphism variation in *Podarcis lizards*. *Journal of morphology*, 268(2), 152–165. https://doi:10.1002/jmor.10494

Kaliontzopoulou, A., Carretero, M.A., & Llorente, G.A. (2008). Head shape allometry and proximate causes of head sexual dimorphism in *Podarcis lizards*: joining linear and geometric morphometrics. *Biological Journal of the Linnean Society*, 93(1), 111–124. https://doi.org/10.1111/j.1095-8312.2007.00921.x

Khezzani, B., Bouchemal, S., & Halis, Y. (2016). Some agricultural techniques to cope with the fluctuation of the groundwater level in arid environments: Case of the Souf Oasis (Algerian Sahara). *Journal of Aridland Agriculture*, 2(2016), 26–30. https://doi.org/10.19071/jaa.2016.v2.3060

Krebs, C. (1999). Ecological Methodology. 2nd ed. Addison Welsey educational Publishers Inc. under the Benjamin/Cummings imprint, Menlo Park (California).

Liang, T., Shi, L., Bempah, G., & Lu, C.-h. (2021). Sexual size dimorphism and its allometry in Chinese lizards. *Evolutionary Ecology*, 35, 323–335. https://doi.org/10.1007/s10682-021-10104-1

Mesquita, D.O., & Colli, G.R. (2003). The ecology of *Cnemidophorus ocellifer* (Squamata, Teiidae) in a neotropical savanna. *Journal of Herpetology*, 37(3), 498–509. https://www.jstor.org/stable/1566053

Millon, A., Nielsen, J.T., Bretagnolle, V., & Møller, A.P. (2009). Predator–prey relationships in a changing environment: the case of the sparrowhawk and its avian prey community in a rural area. *Journal of Animal Ecology*, 78(5), 1086–1095. https://www.jstor.org/stable/40405844

Mori, A.S., Isbell, F., & Seidl, R. (2018). β-diversity, community assembly, and ecosystem functioning. *Trends in ecology & evolution*, 33(7), 549–564. https://doi.org/10.1016/j.tree.2018.04.012

Mouane, A., Laoufi, H., Aouimeur, S., Harrouchi, A., Bekkar, C., & Sadine, S.E. (2022). First record of scorpion in the diet of the common skink *Scincus scincus* (Linnaeus, 1758) in the northern Sahara of Algeria (Squamata: Scincidae). *Revista ibérica de aracnología,* (40), 222–224.

Nel, K., Rimbach, R., & Pillay, N. (2015). Dietary protein influences the life-history characteristics across generations in the African striped mouse Rhabdomys. *Journal of Experimental Zoology Part A: Ecological Genetics and Physiology*, 323(2), 97–108. https://doi.org/10.1002/jez.1903

Palmeira, C.N.S., Gonçalves, U., Sales, R.F.D., & Freire, E.M.X. (2021). Foraging behavior and diet composition of the gecko *Phyllopezus periosus* (Squamata: Phyllodactylidae) in the Brazilian semiarid Caatinga. *Cuadernos de Herpetología*, 35(2), 261–272. https://doi:10.31017/CdH.2021.(2021-017

Paray, B.A., Al-Mfarij, A.R., & Al-Sadoon, M.K. (2018). Food habits of the Arabian skink, *Scincus hemprichii* Wiegmann, 1837, (Sauria: Scincidae), in the Southwest Saudi Arabia. *Saudi Journal of Biological Sciences*, 25(1), 90–93. https://doi.org/10.1016/j.sjbs.2017.11.004

Pianka, E.R. (2017). *Ecology and natural history of desert lizards: analyses of the ecological niche and community structure*. Princeton University Press.

Pianka, E.R., & Vitt, L.J. (2003). *Lizards: windows to the evolution of diversity*. Univ of California Press.

Pincheira Donoso, D., & Hunt, J. (2017). Fecundity selection theory: concepts and evidence. *Biological Reviews*, 92(1), 341–356. https://doi:10.1111/brv.12232

Puga y Colmenares, M.C., Ramírez-Bautista, A., Cruz-Elizalde, R., García-Rosales, A., & Hernández-Salinas, U. (2019). Feeding ecology and its relationship with head structures in two populations of the lizard *Sceloporus minor* (Squamata: Phrynosomatidae) from Northern Mexico. *Copeia*, 107(3), 542–549. https://doi.org/10.1643/CH-19-182

Rastegar-Pouyani, N., & Mohammad, R.G. (2016). Study of the Lizard Fauna of Central and Southern Iraq with. Special Reference on *Trapelus ruderatus* (Sauria: Agamidae).

Sales, R.F., Ribeiro, L.B., Jorge, J.S., & Freire, E.M. (2012). Feeding habits and predator-prey size relationships in the whiptail lizard *Cnemidophorus ocellifer* (Teiidae) in the semiarid region of Brazil. *South American Journal of herpetology*, 7(2), 149–156. https://doi.org/10.2994/057.007.0204

Shine, R., Reed, R., Shetty, S., & Cogger, H. (2002). Relationships between sexual dimorphism and niche partitioning within a clade of sea-snakes (Laticaudinae). *Oecologia*, 133, 45–53.

Taverne, M., Fabre, A.C., King-Gillies, N., Krajnović, M., Lisičić, D., Martin, L., Michal, L., Petricioli, D., Štambuk, A., & Tadić, Z. (2019). Diet variability among insular populations of *Podarcis lizards* reveals diverse strategies to face resource-limited environments. *Ecology and Evolution*, 9(22), 12408–12420. https://doi.org/10.1002/ece3.5626

Toumi, I., Medila, I., & Bendif, H. (2022). Effect of Drying Method on Biochemical Composition and Nutritional Quality of Sandfish (*Scincus scincus*) Consumed in South-East Algeria. *Journal of Bioresource Management*, 9(3), 7.

Vihar, B., Wolf, C., Boehme, W., Fiedler, F., & Baumgartner, W. (2015). Respiratory physiology of the sandfish (Squamata: Scincidae: *Scincus scincus*) with special reference to subharenal breathing. *Salamandra*, 51(4), 326–334.

Vitt, L.J. (2000). Ecological consequences of body size in neonatal and small-bodied lizards in the neotropics. *Herpetological Monographs*, 14(2000), 388–400. https://doi.org/10.2307/1467053

Withers, P., & Thompson, G. (2005). Size-free shape differences between male and female Western Australian dragon lizards (Agamidae). *Amphibia-Reptilia*, 26(1), 55–63.

Zhao, W., & Liu, N. (2013). Sexual dimorphism of head size in *Phrynocephalus przewalskii*: testing the food niche divergence hypothesis. *Asian Herpetological Research*, 4, 242–247. https://doi:10.3724/SP.J.1245.2013.000242