Insights on the diet of *Buthus* Leach, 1815 (Scorpiones: Buthidae) from Ouarsenis mountains of northwestern Algeria

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Abstract: This study is an empirical observation of the feeding behavior of the *Buthus* Leach, 1815, in the wild of the Ouarsenis Mountains (Tissemsilt and Tiaret regions, northwestern Algeria) during the study period (2021–2022). We have observed 29 instances of *Buthus* species eating arthropods. The identifications of this prey yielded a list of 20 species belonging to 15 families and 9 orders. We note a dominance of the Orthoptera and Coleoptera, with 3 families and 5 species for each. Gryllidae and Scarabaeidae are the most represented, with 3 and 2 species, respectively. Also, we record some insects larvae eating and many cases of cannibalism and intraguild predation. All of the *Buthus* species' prey are intermediate or smaller arthropods.
Key words: Algeria, *Buthus*, Cannibalism, Diet, intraguild, Ouarsenis.

Nota Perspectivas sobre la dieta de *Buthus* leach, 1815 (Scorpiones: Buthidae) de las montañas Ouarsenis del noroeste de Argelia
Resumen: Este estudio es una observación empírica del comportamiento alimentario de *Buthus* Leach, 1815, en la naturaleza de las montañas Ouarsenis (regiones de Tissemsilt y Tiaret, noroeste de Argelia) durante el período de estudio (2021-2022). Hemos observado 29 casos de especies de *Buthus* que comen artrópodos. Las identificaciones de esta presa arrojaron una lista de 20 especies pertenecientes a 15 familias y 9 órdenes. Observamos una dominancia de Ortópteros y Coleópteros, con 3 familias y 5 especies para cada uno. Gryllidae y Scarabaeidae son los más representados, con 3 y 2 especies, respectivamente. Además, registramos el consumo de larvas de insectos y muchos casos de canibalismo y depredación intragrupo. Todas las presas de la especie *Buthus* son artrópodos intermedios o más pequeños.
Palabras clave: Argelia, *Buthus*, Canibalismo, Dieta, Ouarsenis.

Introduction

Certainly, habitat (microhabitat) confirms foraging success for animals due to prey availability or foraging efficiency (Griffiths, 1975; Werner *et al.,* 1981). Scorpions are solitary, sedentary arthropods that are ecologically important because they influence the flow of energy in arid and semi-arid ecosystems (Polis and McCormick, 1986; Polis, 2001; Brown and Kotler, 2004; Nime *et al.,* 2016). They are efficient predators and accept a wide variety of prey such as invertebrates, small lizards, snakes, and even small mice (Vachon, 1952; Kock, 1969; Polis and McCormick, 1986; McCormick and Polis, 1990; McCormick and Polis, 1995; Teruel, 2015; Lira *et al.,* 2016; Dupré, 2015a; Sadine, 2018; Sadine and El Bouhissi, 2021; Chedad *et al.*, 2022a).

Moreover, they are stationary in nature; thus, they are often encountered in their shelter, which they only leave to feed and reproduce (Polis, 1990). Generally, during the day, they seek shelter under rocks and logs, in crevices and burrows dug in the substrate, or under the loose outer layers of shrubs and trees of many plants. Just after sunset, individuals emerge from these diurnal retreats to forage or engage in other activities (Polis, 1979; Polis, 1990).

Where scorpions enter the diet of many animals, especially vertebrates, Polis *et al*. (1981) summarized a list of approximately 150 taxa of scorpion predators, and Dupré (2015b) resumed a list of 312 species that can be considered scorpion predators, with more than 80% being vertebrates (birds, mammals, and reptiles). Among the few consumers is the wild boar, *Sus scrofa*, whose consumption of scorpions was recorded in the Ouarsenis region (west Algeria) (Chedad *et al.,* 2021).

The genus *Buthus* Leach, 1815, belongs to the most abundant and widely distributed scorpion family, Buthidae C.L. Koch, 1837, with 78 validly named species (Rein, 2022). The number of confirmed *Buthus* species in Algeria has increased to 11: two species have a wide distribution, i.e., *B. paris* and *B. tunetanus*; there are also height endemic species for Algeria such as *B. tassili* Lourenço, 2002; *B. pusillus* Lourenço, 2013; *B. saharicus* Sadine, Bissati and Lourenço, 2016; *B. aures* Lourenço and Sadine, 2016; *B. boussaadi* Lourenço, Chichi and Sadine, 2018 and *B. apiatus* Lourenço, El Bouhissi and Sadine, 2020; *B. ahaggar* Ythier, Sadine, Haddadi and Lourenço, 2021; *B. goyffoni* Abidi, Sadine and Lourenço, 2021; and a Moroccan species, *B. oudjanii* Lourenço, 2017.

This study aims to provide a contribution to the diet of the *Buthus* species from the Ouarsenis Mountains (northwestern Algeria), based on an empirical observation in the wild environment that includes various events of cannibalism and intraguild predation**.**

Material and methods

Study area

Our research area is in the Ouarsenis massif, in the Tissemsilt and Tiaret regions (northwestern Algeria) (Fig. 1). This forest massif is characterized by a semi-arid to humid climate at altitudes between 400 and 1985 m, several biotopes with distinct plant covers, and a slope of up to 50% (BNEDER, 2009; Chedad *et al*., 2022b).



Fig. 1. Map of Algeria, showing the study area (Tissemsilt and Tiaret regions).

For two years (2021–2022), the onset of high temperatures coincides with the beginning of the exit of scorpions from hibernation (the end of April until the end of October). We searched for scorpions with an average rate of once every 10 days, during predation under stones and straws, in burrows and crevices, and we also searched for food scraps, on which we concentrated our outings, especially in the early morning (two to three hours) and the period before sunset (one hour).

The study area (Ouarsenis massif) exhibits a very high level of scorpion-specific diversity, with more than 62% of the species being *Buthus* (Chedad *et al*., 2022b). The following table summarizes the *Buthus* species that can be found in this region (Table I).

Results and discussion

During the study period (2021–2022), in the wild of the Ouarsenis region (Tissemsilt and Tiaret), we observed 29 cases of *Buthus* species eating arthropods. Morphological identification of this prey yielded a list of 20 species belonging to 15 families and nine orders (Table II).

Our results show the dominance of the Orthoptera and the Coleoptera, with three families and five species for each. Gryllidae and Scarabaeidae are the most represented, with three and two species, respectively (Fig. 1, Tab. II). *Buthus* sp. 1 has the highest abundance (13,79%), while *Messor* sp. has the second highest (10,34%). We also recorded some insects larvae, which are considered fast to digest.

One Sample T-Test (df = 19,0; p< 0,001): The p-value for the test is < 0,001, which is less than the alpha = 0,05 significance level. It can be concluded that the consumption by *Buthus* species varies according to the type of prey. (fig. 2)

Scorpions are characterized by an external digestion that remains very slow (Quinlan et *al*., 1995). Their diet is very diverse and tends to be insectivorous. It contains important arthropods abundant in their biotope, such as insects (small beetles, butterflies, locusts, grasshoppers, and ants), crustaceans (woodlice), and arachnids (scorpions, spiders, opiliones, etc.) (Williams, 1987; Sánchez Piñeroet *al.,* 2013; Sadine, 2018; Toprak et *al.,* 2022). In our study, the *Buthus* spp. diet is composed of more than 75% of insects from its biotope. However, the scorpions consumed represent more than 20.5% of *Buthus*' diet (Fig. 3). Nevertheless, *Buthus* species, like other scorpions, can feed on small vertebrates (reptiles and rodents) (McCormick & Polis, 1990; Sadine & El Bouhissi, 2021).

Many authors reported that the foraging success of scorpions may be associated with seasonal changes in prey availability (Polis 1980; Polis & McCormick, 1986). In general, it can be summarized into two types of prey capture strategies. First, most species hunt prey by waiting for passages near or just in front of their burrows/hiding places. The second is to actively hunt away from hiding places. (McCormick & Polis, 1990).

Table I. *Buthus* species than can be found in the Ouarsenis region.

No.	Species	References
1	*B. apiatus* Lourenço, El Bouhissi and Sadine, 2020	Benali and Feghoul, 2022; Chedad et *al*., 2022b
2	*B. aures* Lourenço and Sadine 2016	Benali and Feghoul, 2022; Chedad et *al*., 2022b
3	*B. boussaadi* Lourenço, Chichi and Sadine, 2018	Benali and Feghoul, 2022
4	*B. oudjanii* Lourenço, 2017	Benali and Feghoul, 2022
5	*B. paris* (C.L. Koch, 1839)	Benali and Feghoul, 2022; Chedad et *al*., 2022b
6	*B. tunetanus* (Herbst, 1800)	Benali and Feghoul, 2022; Chedad et *al*., 2022b
7	*Buthus sp.*	Chedad et *al.,* 2022b

Table II. Prey of the *Buthus* species in the Ouarsenis region, Algeria.

No.	Orders	Families	Species	Relative abundance (RA%)
01	Araneae	Lycosidae	*Hogna* sp.	3,45
02	Coleoptera	Tenebrionidae	*Pimelia* sp.	6.90
			Scaurus sp.	3.45
		Scarabaeidae	*Oxythyrea* sp.	3.45
			Amphimallon sp.	3.45
		Staphylinidae	*Ocypus* sp.	3.45
03	Dermaptera	Forficulidae	*Forficula* sp.	3.45
04	Hymenoptera	Apidae	*Xylocopa* sp.	3.45
		Formicidae	*Messor* sp.	10.34
05	Isopoda	Porcellionidae	*Porcellio* sp.	3.45
06	Mantodea	Mantidae	*Mantis religiosa*	6.90
07	Orthoptera	Gryllidae	*Gryllus* sp.	6.90
			Sciobia sp. 1	6.90
			Sciobia sp. 2	3.45
		Acrididae	*Schistocerca* sp.	3.45
		Tettigoniidae	*Tettigonia* sp.	3.45
08	Scolopendromorpha	Scolopendridae	*Scolopendra cingulata*	3.45
09	Scorpiones	Buthidae	*Buthus* sp. 1	13.79
			Buthus sp. 2	3.45
		Scorpionidae	*Scorpio* sp.	3.45
Total	09	15	20	100

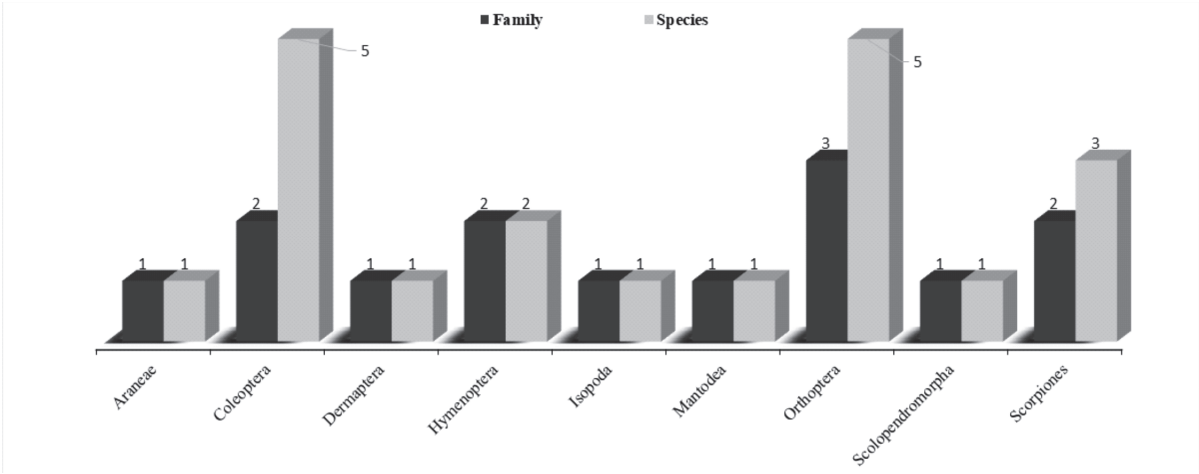


Fig. 2. Distribution of families of arthropod species identified as prey of *Buthus* spp. in the Ouarsenis region, Algeria.



Fig. 3. Prey of *Buthus* species from Algeria**. A:** *Mantis religiosa,* **B:** *Gryllus* sp., **C:** Larva 1, **D:** Larva 2, **E:** *Scolopendra cingulata*, **F:** *Schistocerca* sp., **G**: *Porcellio* sp., **H:** *Ocypus* sp.



Fig. 4. **A**. Cases of cannibalism *Buthus*/*Buthus*; **B**. Case of intraguild predation *Buthus*/*Scorpio*

This study shows cases of cannibalism in *Buthus/Buthus* and intraguild predation in *Buthus/Scorpio* (Fig. 4), where scorpions are considered very voracious predators and cannibals.

For some predators, such as scorpions, cannibalism is an important factor in mortality that determines ecology and behavior (Sánchez-Piñero and Urbano-Tenorio, 2016), and it is usually the key interaction that shapes the distribution, behavior, and population structure of these species (Polis, 1981; Leonardsson, 1991; Rudolf, 2006). Predator threat therefore becomes a key factor in determining where animals can safely forage and influencing trophic interactions, population, and community structure (Hawlena and Schmitz, 2010; Cresswell and Quinn, 2013). This phenomenon is an asymmetrical interaction, with larger predators usually feeding on smaller conspecifics (Polis, 1981); this is what we have noted through this study and has also been reported by Chedad et *al.* (2022a).

Conclusions

This work constitutes the first study that shows an overview of the trophic diet of the *Buthus* species in Northwestern Algeria, where we have observed a remarkable diversity of the trophic menu of these species. Therefore, it becomes necessary to conduct a deep study in this field in order to learn more about the trophic diet and preferences of the scorpions and generalize them to other regions. As scorpions are nocturnal species, it is desirable to monitor their feeding behavior carefully, whether to follow them in captivity or in the wild.

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