

Field study on scorpions and scorpionism in the southeast of El Jadida, Morocco

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Abstract. Morocco has a rich and diverse fauna of scorpions. However, certain regions such as Boulaouane remain underdocumented despite their importance for public health. Against this backdrop, our research aims to describe the local fauna of scorpions and evaluate the potential risks of envenomation. Systematic surveys were conducted in four distinct habitats, combining nocturnal UV detection with diurnal manual collection. The collected specimens were taxonomically identified, and their distribution analyzed in relation to environmental factors.

A total of 56 specimens belonging to the families Scorpionidae and Buthidae were collected. *Scorpio maurus* (36%) was the most commonly reported species in the region, with limited medical significance, while *Buthus occitanus* (16%) and *Androctonus mauritanicus* (12%) were unevenly distributed but were known to be responsible for the most serious cases of envenomation, particularly in children. These results provide essential reference data for assessing localized risks, developing antivenom production strategies, and guiding public health management in Morocco.

Keywords.

Scorpion biodiversity ; Boulaouane ; Morocco ; envenomation risk ; *Androctonus mauretanicus* ; *Buthus occitanus* ; *Scorpio maurus* ; venom variability ; public health

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1. Introduction

Scorpion stings are a significant public health issue, particularly in tropical and subtropical regions [1], causing serious clinical symptoms that can lead to death. There are an estimated 1,500,000 cases worldwide each year, with 2,600 deaths [2]. Due to differences in venom composition, clinical manifestations, and severity, Old World and New World scorpions are generally contrasted, and therefore therapeutic approaches differ [3].

North Africa is one of the regions with the highest incidence of envenomation. Morocco, Algeria, and Tunisia are among the most affected countries. The prevalence of scorpionism in these regions is closely linked to the geographical distribution of species, particularly between latitudes 50° N and 50° [4]. Environmental parameters, which vary with altitude, such as temperature and humidity, can significantly influence the composition of scorpion communities [5]. This variation is also associated with the geological complexity, climatic conditions, and topographical diversity of Morocco [6]. As a result, Morocco is one of the richest countries in the world in terms of scorpion diversity. This exceptional richness is attributed to its varied geomorphology, strategic geographical position, and unique climatic conditions. The diversity of Morocco's scorpion fauna considered the most significant in North Africa and the Mediterranean region. Moroccan scorpions belong to two families, Scorpionidae and Buthidae [5].

In Morocco, there are an estimated 30,000 to 50,000 cases of scorpion stings each year, mainly affecting children under the age of 15 years [7]. These cases of envenomation are mainly concentrated in the central and southern regions of the country, where the species *Androctonus mauretanicus* and *Buthus occitanus* are widely found [8]. According to the Poison Control and Pharmacovigilance Center, scorpionism is the leading cause of envenomation in the country [9].

Furthermore, [10] observed interspecific variations in venom composition between species of the same family, and even between individuals of the same species from different habitats. The wide range of clinical symptoms associated with scorpion envenomation is a major challenge for medical teams, particularly in the absence of targeted treatments. [11]

The molecular variability of venom remains insufficiently characterized in many species. Controlling scorpion envenomation depends on understanding the diversity of scorpions and the variability of their venoms. Fieldwork is therefore crucial in assessing this diversity and its impact on human health, especially as in Morocco, a single region can present a great variety of climatic and ecological conditions, as our study area illustrates. Each scorpion species develops a unique venom, influenced by the environment in which it evolves. For example, the venom of *Buthus stockmanni* from Zagora differs from that of specimens from Tan-Tan [12].

Since the first studies on scorpions, in particular Vachon's monograph, which remains the only comprehensive reference on the systematics and distribution of scorpions in North Africa, including Morocco, species identification has been largely underestimated. Apart from a few studies carried out in specific Moroccan regions, taxonomic knowledge is still insufficient, although it is crucial for understanding the toxicity of venoms and their impact on human health; In addition, the evolution of ecosystems and current environmental changes require a re-evaluation of the species recorded, some of which may be endemic or recently identified by needed to fill these gaps, allowing better management of public health risks [11].

In addition to advance scientific knowledge, these field studies play an essential role in raising public awareness of the dangers of scorpion stings. By involving local communities and informing them about the risks and preventive measures, this work can help reduce the incidence and severity of scorpion stings, thereby improving public health [13].

The aim of our study is to characterize the diversity of scorpion fauna in the southeast of the city of El Jadida, in the municipality of Boulaouane. This region is known for its ecological diversity, but remains underdocumented to date. This area, rich in varied habitats,

has a high potential for scorpion biodiversity, the composition and distribution of which have not yet been systematically explored. Given this ecological diversity, our research aims to fill this gap by providing a detailed study of the species present, in order to contribute to a better understanding of the richness of scorpions in this region of Morocco.

2. Materials and methods

2.1 Study area

Boulaouane is a small town and rural commune in the province of El Jadida, in the Casablanca-Settat region of Morocco. It is located approximately 120 km southeast of Casablanca, 70km from El Jadida, and 50 km from Settat. It sits on a hill overlooking the *Oued Oum Er-Rbia* valley and is surrounded by fertile farmland. The region is characterized by a varied landscape, with small mountains and river valleys forming a mosaic of diverse biotopes. This ecological heterogeneity was a determining factor in the choice of study sites, as it promotes rich biodiversity.

Boulaouane's strategic location ensures good connectivity with the surrounding provinces, particularly Settat to the northeast and Marrakech-Safi to the south. Its population was estimated at 14,740 inhabitants according to the 2024 national census. The municipality's altitude is approximately 179 meters above sea level [14].

The region has a Csa Mediterranean climate according to the Köppen-Geiger classification, with hot, dry summers and mild, wet winters. The average annual temperature is around 17.4°C, and average annual precipitation is around 343 mm [15].

Figure 1 illustrates the four areas of the Boulaouane region selected for this study. Each area was chosen based on its ecological characteristics and biotope diversity, which allowed for a thorough assessment of scorpion diversity and distribution.



Figure 1: Geographic location of the Boulaouane study area (El Jadida Province, Morocco). The four study sites are marked with circles.

2.2 Scorpion Collection

The field study, conducted over a period of 15 days in September 2023, focused on four sites with diverse ecology along the *Oued Oum Er-Rbia* (33° 19' 12.00" N, 8° 20' 16.80" W). These sites were strategically selected due to the heterogeneity of their habitats, including rocky outcrops, agricultural areas, and semi-arid zones, as well as their proximity to inhabited areas. This ecological diversity reflects the environmental richness characteristic of the Boulaouane region, which influences the diversity and distribution of scorpions [16].

Scorpion specimens were collected during diurnal and nocturnal surveys following established protocols (Figure 2) [17]. Daytime searches consisted of manual exploration under rocks, in burrows, and across open plains; potential refuges were carefully excavated using shovels to ensure complete sampling. Nighttime collections were carried out using ultraviolet lamps, due to the fluorescence of the scorpions' exoskeletons, which improved the efficiency of their detection [18]. Specimens were carefully captured by grasping the metasoma with long-handled forceps to minimize harm and risk.

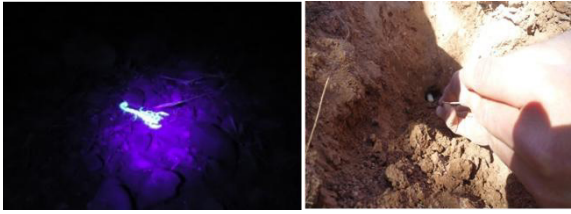


Figure 2: Day and night scorpion survey methods

2.3 Scorpion Identification

Captured scorpions were maintained alive and transported to the laboratory for morphological identification using authoritative taxonomic keys [19,20]. Identification was based on key morphological characters such as the cephalothorax, carinae, pedipalp shape and venom vesicle. In the Scorpionidae family, particularly in the genus *Scorpio*, the cephalothoracic carinae are well developed. In the Buthidae family, however, which includes the genera *Androctonus*, *Buthus* and *Hottentotta*, specific criteria are used to differentiate between genera. For instance, the venom vesicle of the *Androctonus* genus is generally broad and flattened, whereas that of the *Buthus* genus is more elongated. Additionally, the shape and carination of the chelae offer valuable identification clues (Figure 3). All specimens were subsequently curated and deposited at the Venoms and Toxins Laboratory of the Pasteur Institute of Morocco for future reference and further analyses.

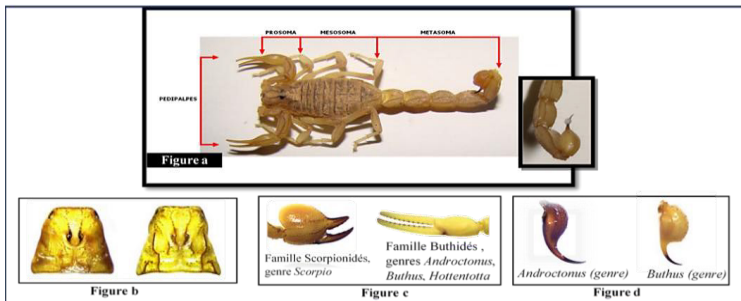


Figure 3: Distinctive morphological features of the main scorpion genera.

Fig a: External anatomy of a scorpion, fig b: Cephalothoracic carinae, fig c: Pedipalp shape, fig d: Venom vesicle

2.4 Euthanasia and Preservation

2.4.1 Euthanasia

Collected scorpions were euthanized immediately after capture in order to minimize any potential suffering, by exposure to carbon dioxide (CO₂) in a closed container, a method commonly used for arthropods and considered to be quick and humane [21,22].

2.4.2 Preservation

After euthanasia, the specimens were fixed in 70% ethanol to preserve them for long-term storage and safe transport to the laboratory. This method maintains the morphological integrity necessary for taxonomic identification and morpho-toxicological analyses, while complying with safety and biosafety standards [23,24].

3. Results

The current study provides a detailed description of scorpion biodiversity in the Boulaouane region of Morocco and highlights three important medical species: *Scorpio maurus*, *Buthus occitanus*, and *Androctonus mauretanicus* (figure 4). Species identification was based on precise morphological criteria according to previously published identification keys.



Figure 4: Spatial localisation of captured scorpions in Boulaoune

3.1 *Scorpio maurus*

Size: Total length 7–9 cm; metasoma robust and granulated.

Coloration: Variable from dark brown to black, lighter ventral segments.

Morphological features: Massive pedipalps with broad, heavily granulated pincers. Telson moderately curved, vesicle bulbous with a sharp aculeus.

Identification key: Presence of five pairs of eyes; trichobothrial pattern typical of the genus *Scorpio*; absence of dark dorsal markings seen in other species of the genus [25,26].

3.2 *Buthus occitanus*

Size: Total length 6–8 cm; metasoma elongated and annulated.

Coloration: Pale yellow to light brown, with darker segments on telson and pedipalps.

Morphological features: Relatively long and slender pedipalps with fine granulations. Telson elongated with a sharp aculeus, capable of delivering potent neurotoxic venom.

Identification key: Lack of dark dorsal markings typical of other *Buthus* species; metasomal segment proportions and trichobothrial pattern consistent with the genus [27].

3.3 *Androctonus mauretanicus*

Size: Adult length 8–10 cm; metasoma thick and robust.

Coloration: Black to dark brown, lighter ventral segments.

Morphology: Morphology: the pedipalps are thick, the claws relatively short but powerful, and the telson is robust, with an elongated vesicle and a thick, sharp aculeus.

Identification key: genus-specific trichobothrial pattern, distinctive number of pectinate teeth, dark coloration, and robust metasoma characteristic of *Androctonus* [28].

3.4 Zone 1 – Riparian and Rocky Habitats Adjacent to the Oued Oum Er-Rbia

Zone 1 had the highest abundance of scorpions (32.14% of the sample), and was mainly made up of the endemic species *Scorpio maurus* (figure 5). *Scorpio maurus* is very ecologically plastic, able to occupy a wide variety of microhabitats (i.e., soils) of different substrate types (i.e., riverbanks, rocky crevices, and burrows) where there is typically high stability and temperature fluctuation. Burrows may be dug into steady, dry soil where diurnally fluctuating temperatures can be buffered. Burrow construction and burrowing to transport by road are facilitated by the discontinuous nature of the vegetation of most habitats of *Scorpio maurus* (Figure 6).

Although the venom is not very toxic, the species' proximity to inhabited areas highlights the need for ecological surveillance in order to properly assess the potential risks.



Figure 5: Spatial distribution of scorpions caught in zone 1



Figure 6: Microhabitat characteristic of *Scorpio maurus*

3.5 Zone 2 – Agricultural Landscapes and Rocky Outcrops

In the second zone, 25% of catches consisted mainly of *Buthus occitanus* (Figure 7). This species was recorded on the dry, rocky upper slopes, well exposed to sun and marked by erosion (Figure 8). It was also found under rocks and across plains, indicating its presence in semi-disturbed habitats, including agricultural areas



Figure 7: Geographical distribution of scorpion occurrences in zone 2



Figure 8: Biotope characteristic of the genera *Buthus* and *Scorpio*

3.6 Zone 3 – Semi-Arid Plains and Scrubland Mosaic

Zone 3, representing semi-arid plains and scrubland, accounted for 23.22% of the specimens and was notable for the coexistence of *Scorpio maurus* and *Androctonus mauretanicus* (Figure 9). The latter was represented by 10 specimens, primarily occupying burrows. It is a mobile species observed in sunny areas with compact, stony soil, as well as in modified environments such as adobe walls, ruins, and the outskirts of rural dwellings (Figure 10).

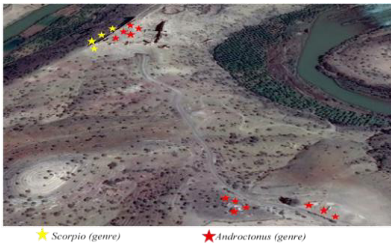


Figure 9: Spatial distribution of scorpion specimens collected in Zone 3.



Figure 10: Area of co-occurrence of the genera *Scorpio* and *Androctonus*.

3.7 Zone 4 – Dry, Rocky Terrain with High Medical Significance

Although Zone 4 had the lowest overall scorpion abundance (19.64%), it harbored the two most dangerous genera, *Buthus* and *Androctonus* (figure 11). The environment is rugged and rocky, characterized by compact to slightly loose soil, poor vegetation and high exposure to solar radiation. Figure 12 illustrates an open, dry landscape dotted with surface stones, rocky debris and a few anthropogenic elements (ruined walls, remains of structures), offering potential micro-refuges.

In this type of environment, *Buthus occitanus* is often observed under stones or in cracks in the ground, exploiting the interstices to protect itself from the daytime heat. This species has also been observed in areas disturbed by human activity. *A. mauretanicus*, a more robust species, has adapted well to these conditions, occupying dry, stony substrates where it takes refuge under large rocks or in deep crevices. Its presence in this area confirms its affinity for open, rocky environments with little vegetation.

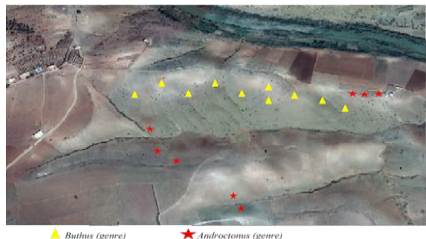





Figure 11: location of scorpion collection points in Zone 4.



Figure 12: Characteristic environment of *Androctonus* and *Buthus* habitats.

Table 1. Summary of Scorpion Diversity and Medical Relevance by Zone

Zone	% of Total Specimens	Dominant Genera	Medically Relevant Species	Specimen image
1	32.14%	<i>Scorpio</i>	<i>Scorpio maurus</i>	 Adapted from Itamar Ofer, Animalia.bio, licensed under CC BY-SA 3.0
2	25%	<i>Scorpio</i> , <i>Buthus</i>	<i>Buthus occitanus</i>	 Photograph by the first author
3	23.22%	<i>Scorpio</i> , <i>Androctonus</i>	<i>Androctonus mauretanicus</i>	 Photograph by the first author
4	19.64%	<i>Buthus</i> , <i>Androctonus</i>	<i>Buthus occitanus</i> , <i>A. mauretanicus</i>	

4. Discussion

The Mediterranean region is home to a wide variety of scorpions, particularly in Morocco, which has a highly diverse scorpion fauna due to its varied ecological landscapes. Although scorpion venom is known to cause significant health problems in many regions, particularly in Boulaouane, no epidemiological surveys have been conducted to assess the safety or health risks associated with scorpions in this region. In addition, data from surrounding provinces, such as El Kelaâ des Sraghna, indicate an annual incidence of 3.2 scorpion stings per 1,000 inhabitants, with a venomous sting rate of 12% and a fatality rate of 0.7% [29]. This gap

highlights the importance of the present study, which is the first systematic study of scorpion biodiversity and public health risks in this locality.

The identification of 56 specimens in four distinct ecological zones confirms that environmental heterogeneity is a key variable in the distribution of scorpions. The three species collected, *Scorpio maurus*, *Buthus occitanus*, and *Androctonus mauretanicus*, belong to two families known for their medical importance: Scorpionidae and Buthidae. This taxonomic composition is consistent with previous studies conducted in Morocco [30], which also highlight the ecological plasticity and clinical importance of these taxa.

The predominance of *Scorpio maurus* (36% of total specimens) is particularly striking. This predominance confirms observations made in other semi-arid regions of North Africa, where this burrowing species is known to thrive in various microhabitats [31]. Its wide distribution in zone 1 demonstrates its ability to adapt to a variety of biotopes and highlights its remarkable ecological resilience [31]. Its low medical relevance, due to its discreet lifestyle and mild venom, underscores the importance of ecological knowledge in distinguishing high-risk species from more benign ones. Finally, its presence in three of the four zones studied confirms its great ecological polyvalence, particularly in riverine and rocky areas.

In contrast, *B. occitanus* and *A. mauretanicus*, which together account for 28% of the specimens collected, are two species of medical importance, distributed unevenly. In zone 2, *B. occitanus* is mainly found on dry rocky slopes and in semi-disturbed agricultural areas, confirming the conclusions drawn from similar Mediterranean agroecosystems [32]. Its ability to adapt to habitats influenced by human activity explains its proximity to inhabited areas.

Similarly, zone 3, which corresponds to semi-arid plains and scrubland areas, is characterized by the joint presence of *S. maurus* and *A. mauretanicus*. The latter, known for its neurotoxic venom and its tendency to regularly appear near human dwellings, makes this zone a high-risk area for envenomation.

Although zone 4 has the lowest abundance of scorpions, it is home to species of the genera *Buthus* and *Androctonus*, whose highly potent venoms are responsible for the most serious cases of envenomation in Morocco [33]. Observations have confirmed that *B. occitanus* and *A. mauretanicus* tolerate human disturbance very well and prefer open, rocky environments with little vegetation. The spatial segregation and habitat specificity observed in this zone confirm previous reports on the ecological partitioning between these genera and highlight the need to map species distribution for health planning purposes.

The spatial heterogeneity observed between the areas studied highlights the need for local ecological monitoring. From a broader perspective, this study underscores the urgent need to integrate small-scale ecological data into national antivenom development strategies. In Morocco, there are no region-specific antivenoms capable of effectively neutralizing the venom of the dominant local species [34]. The establishment of scorpion mapping in the field, such as that proposed here, enables targeted toxicological analyses to be carried out and more specific and effective therapeutic tools to be developed.

Finally, the ecological richness of Boulaouane, revealed by this preliminary study, suggests the potential existence of other species in as yet unexplored microhabitats. Future work should broaden both the temporal and spatial scope of collections, combine molecular identification techniques, and study the variability of venom between different populations, an approach that is gaining popularity in the international literature [35].

These results highlight Boulaouane as a hotspot for scorpion biodiversity, with a complex spatial distribution influenced by habitat heterogeneity. The dominance of *S. maurus* in more mesic and structured environments contrasts sharply with the uneven but high-risk distribution of *A. mauretanicus* and *B. occitanus* in more challenging habitats. This ecological partitioning informs both biological and conservation research and the

prioritization of medical resources and the manufacture of region-specific antivenoms. By correlating ecological field data with public safety priorities, this study fills an important knowledge gap and lays a solid foundation for further toxicological and epidemiological research, which is essential for reducing morbidity and mortality associated with scorpion envenomation in Morocco.

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