
**EPIDEMIOLOGICAL STUDY OF SCORPION ENVENOMATION IN THE SOUSS-
MASSA REGION (MOROCCO)**

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ABSTRACT

Scorpion envenomation is a serious health problem around the globe, and a major health concern for many Moroccans. The high rate of scorpionism is caused by a rich and diverse scorpion fauna, characterized by abundance of dangerous species with toxic and sometimes deadly venom. In Morocco, the Souss-Massa region is one of the regions that are mostly affected by this problem. Furthermore, it experienced a high rate of incidence and lethality, particularly during the summer season.

This work seeks to provide an update of the inventory and distribution of the scorpion fauna. The envenomation's epidemiology is reviewed through gathering both retrospective and field survey. To locate scorpions, the ground was examined through searching under the rocks and in burrows. The scorpions were afterward identified in the laboratory. Epidemiological data was obtained from the Regional Health Department of Souss-Massa and from the survey results Maps that were produced for envenomation and lethality in each province of the studied area.

Five scorpion species were inventoried, divided into four genera and two families. The distribution maps of each of these species have been compiled. The retrospective epidemiological study based on the health data recorded between 2013 and 2017 used to establish impact maps and lethality in the different provinces of the region. The highest incidence was observed in the province of Tiznit while the province of Agadir IdaOutanane records the highest lethality during the same period.

Keywords: Envenomation, Souss-Massa, Morocco, Epidemiology, Inventory, Distribution.

1. INTRODUCTION

Morocco has one of the richest and most diverse scorpion fauna in North Africa. The monograph of Vachon (1952) [1] is the only synthetic and global work on the systematic and distribution of scorpions in North Africa, including those in Morocco. Following the work of Vachon, other studies have contributed considerably to the improvement of knowledge on this fauna (Toulon, 1997; 2004; Toulon, *et al.* 2001, 2002, 2008, 2010, 2012 ; Lourenço, 1999, 2002, 2003 ; Lourenço & Geniez, 2005 ; Lourenço *et al.* 2009; El Hidan, 2016)

The Souss-Massa region is considered among the areas that are mostly affected by scorpionism (El Hidan, 2016). Indeed, it records every year significant incidences and lethalties related to scorpion envenomation. This high scorpionism must be linked to a rich and diverse scorpion fauna. This work seeks to:

- Update the data related to the inventory and distribution of scorpion fauna.
- Examine the epidemiological situation of scorpion envenomation in the studied region.

2. MATERIAL AND METHODS

Study area

The Souss-Massa region is located in the center of Morocco. It covers an area of 53,789 km², equivalent to 7.6% of the national territory. The region of Souss-Massa has two prefectures: Agadir Ida Outanane and InezganeAitMelloul and four provinces: ChtoukaAitBaha, Tiznit, Taroudannt and Tata. It contains 175 municipalities, including 21 urban and 154 rural (HCP, 2016).

The inhabitants of the Souss-Massa region represent 2.67 million, meaning 7.9% of the national population (RGPH, 2014). A density of 49.8 inhabitants per km² (RGPH, 2014). Urban population represents 1,588,434 and rural population represents 1,152,790 (HCP, 2016).

The region is characterized by an arid to semi-arid climate. The intensity of aridity increases from west to east and from north to south.

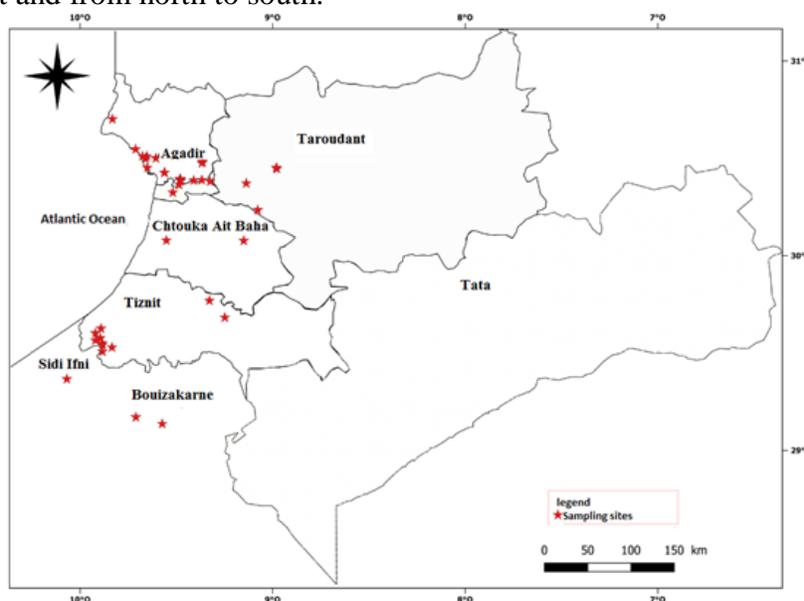


Figure 1: Map of collection sites for inventoried scorpion fauna

II. Scorpion collection and identification

Scorpions were collected in the field by lifting stones, rocks, tree bark and searching in litter boxes. Borrows that were suspected to be occupied by scorpions were shoveled to dislodge them. For anthropophilic species, we seek near homes, under the scree and old deposits. During collection, the main characteristics of each station were noted in particular, the topography, the type of substrate, the composition of vegetation, the proximity of water points and human settlements.

Scorpion fauna collection outings involved 33 sites in five provinces in the studied regions: Agadir Ida Outanane, ChtoukaAitBaha, InzeganeAitMelloul, Taroudant and Tiznit (Figure 1), for a period ranging from April to May 2018.

Specimens for taxonomic determination were kept in labeled containers containing 70% Alcohol. The venom was kept in individual boxes that were installed in the breeding room in laboratory at Faculty of Science Semalia Marrakech, Morocco until the time of collection.

Collection of data on scorpion stings

Data on scorpion stings includes four provinces and two prefectures of Souss-Massa region. In order to identify the epidemiological characteristics of scorpion envenomation in the study area, we carried out retrospective epidemiological studies:

Retrospective epidemiological study

This study was carried out on the basis of data from the register of monthly scorpion sting and envenomation records in the Souss-Massa region (DRS-SM) corresponding to the 2013-2017 period at the Regional Health Department of Souss-Massa. These data are distributed according to prefectures and provinces of the region, month, year, sex, age, admission classes, treatment and evolution of collected cases.

Geographical information system (GIS) database

Maps were made for envenomation and death incidence in each province of the studied area, using QGIS version 2.18.19.

Statistical analysis

All data were analyzed using SPSS software (version Statistics 21). The statistic test used in this study was Student's *t*-test. A probability below 5% was used as a threshold for statistical significance.

3. RESULTS

Inventory and presentation of the scorpion fauna

List of scorpion fauna

A total of 133 specimens were collected in different areas of the Souss-Massa region, during the various missions carried out. These specimens are divided into 5 species, 4 genera and 2 families (Table 1).

Table 1: List of scorpion species inventoried in the study area.

Family	Gender	Species
Buthidae C.L. Koch, 1837	<i>Buthus</i> Leach, 1815	<i>Buthus mardochei</i> Simon, 1878
		<i>Buthus elmoutaouakili</i> Lourenço & Qi, 2006
	<i>Androctonus</i> Ehrenberg, 1828	<i>Androctonus mauritanicus</i> Pocock, 1902
	<i>Hottentotta</i> Birula, 1908	<i>Hottentottagentili</i> Pallary, 1924
Scorpionidae Latreille, 1802	<i>Scorpio</i> Linnaeus, 1758	<i>Scorpiomogadorensis</i> Birula, 1910

Presentation and *Buthusmardochei*Simon distribution of inventoried scorpion species, 1878

Buthusmardochei Simon, 1878 corresponds to *Buthusoccitanusmardochei* before its elevation to the rank of the species after the revision of the genus (Lourenço, 2003). It is a species of brown to brown in color and of a size that can reach 5 to 6.5 cm long. The presence of a slight axial band and two laterals on the dorsal side of the abdomen characterizes this species (Vachon, 1952).

In the study area, this species has a wide distribution and occupies the northwestern part. We inventoried it in Alma, Taghazout, Amsekroud, Assersif, Tiwrar and DouarAnoufk in the region of Agadir, OuladTeima and El Koudiya near Taroudant (Figure 2).

So far, nothing is known about the toxic power of this species. However, a study [19] revealed that the LD₅₀ of its venom is equal to 1.5mg/kg.

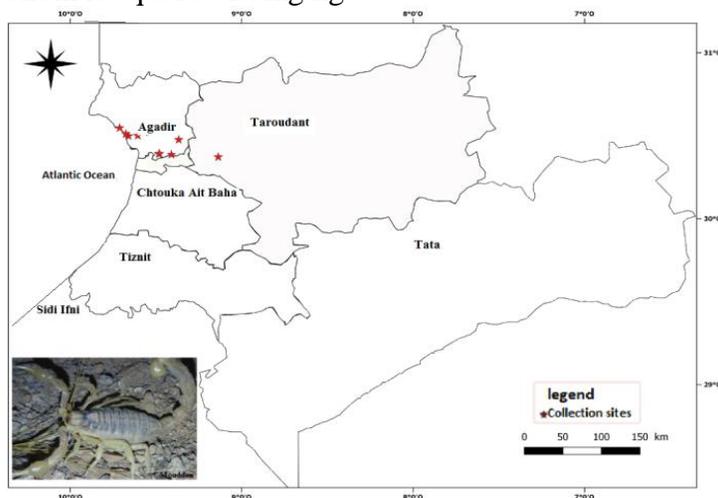


Figure 2: Distribution of *Buthusmardochei*Simon, 1878 in the study area

Buthus elmoutaouakili Lourenço & Qi, 2006

B. elmoutaouakili is a scorpion of yellowish color with a size that can reach 7 cm. On the dorsal part of the abdomen, a slight dark axial line and two dark bilateral are present. This scorpion has a moderately curved spur and a little shorter than venom bladder.

In the study area, we collected it in the southern parts of the ChtoukaAitBaha area (south-east of Agadir), south-east of SidiIfni and in the Tiznit province of Tagadirte, Afayan, Igalfen, Iggi-Iwrigh, Ibbassen and Taghzout (Figure 3).

So far, nothing is known about the venom toxicity of this species.

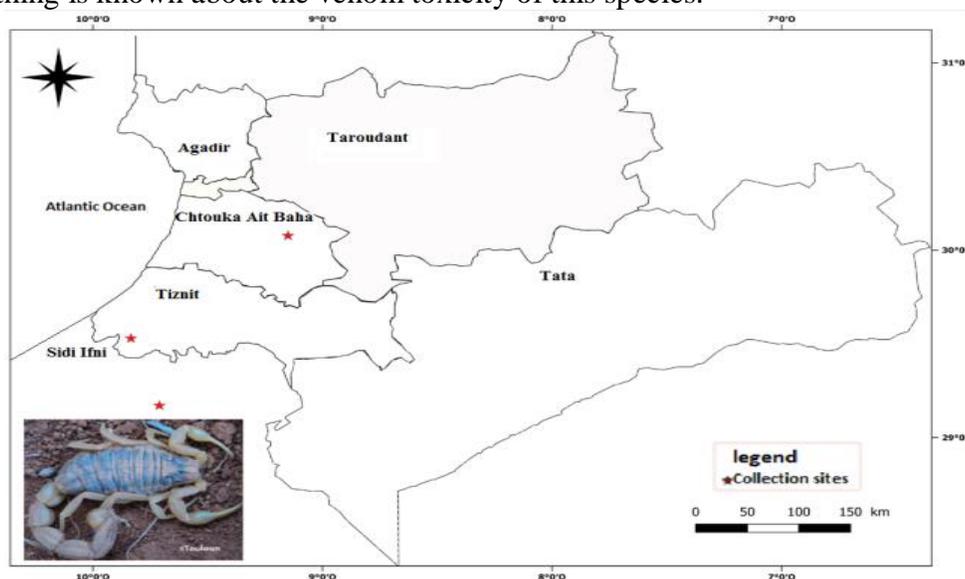


Figure3: Distribution of *Buthuselmoutaouakili*Lourenço& Qi, 2006 in the study area

Androctonus mauritanicus Pocock, 1902

*A. mauritanicus*Pocock, 1902 is a species endemic to Morocco with the largest distribution. This blackish scorpion can reach 9.5 cm long. It has a very thick tail and a venom vesicle shorter than the sting.This species has anthropophilichabits and mainly frequents human dwellings and their neighborhoods (Toulon, 2017).

In the study area, we collected this scorpion in Alma, Adrar, Drarga, Amskroud, near Agadir, ElKoudiya El Beida in the region of Taroudant and SidiLtnin near Sidi-Ifni, where it takes refuge often under large rocks near human habitation The only scorpion anti-venom produced in Morocco at that time was monovalent based on the venom of this species (Zerrouk, 1995).Toxicity tests carried out on the mice have shown that the venom of this species is more toxic than that of *A.australis*, deemed the most dangerous with a LD₅₀ of the order of 0.31 for the first and 0.32 for the second (Simard et Watt, 1990).

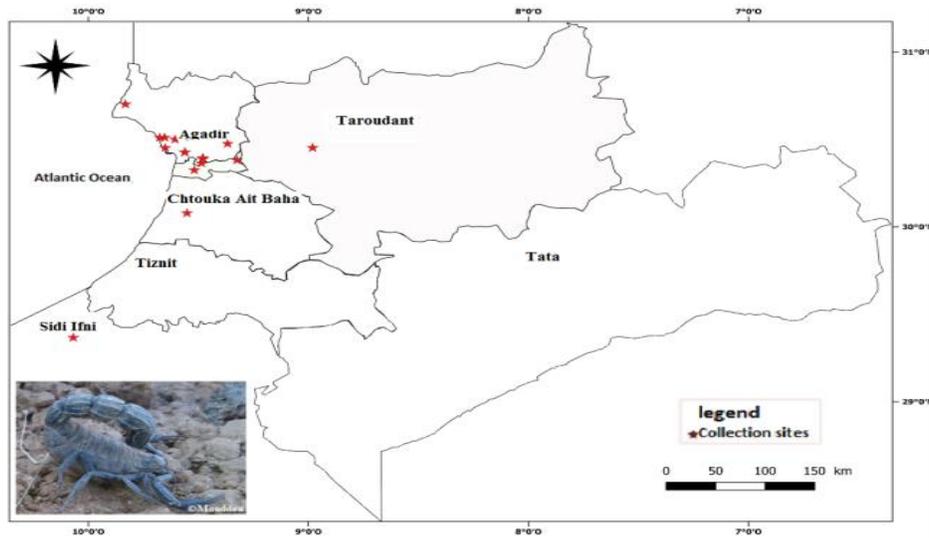


Figure 4: Distribution of *Androctonus mauritanicus* Pocock, 1902 in the study area **Hottentottagentili** Pallary, 1924

Hottentottagentili Pallary, 1924 is a black scorpion with a very hairy tail, thin forceps and a venom long vesicle in relation to the sting. The size of the adult can reach 8.5 cm.

In the study area, this species occupies the province of Tiznit where we captured it (in Tagadirte, Afayan, Tigordine, AitJerrar and LhdNboutfrna), in Taroudant (El Koudiya El Beida), ChtoukaAitBaha (Belfaa) also DouarAnoufk, Taghazout and Alma in the province of Agadir (Figure 5). This scorpion has been found under rocks, in areas with dense vegetation and generally rough substrates. It is also an anthropophilic species (Toulon, 2004).

H. gentili Pallary, 1924 is a dangerous species (El Hidan *et al.*, 2016), it is responsible for several cases of envenomation, mainly south of the High Atlas where this species is more frequent and abundant (Toulon *et al.*, 2004). In the study area, local people fear it mainly because of its very hairy tail.

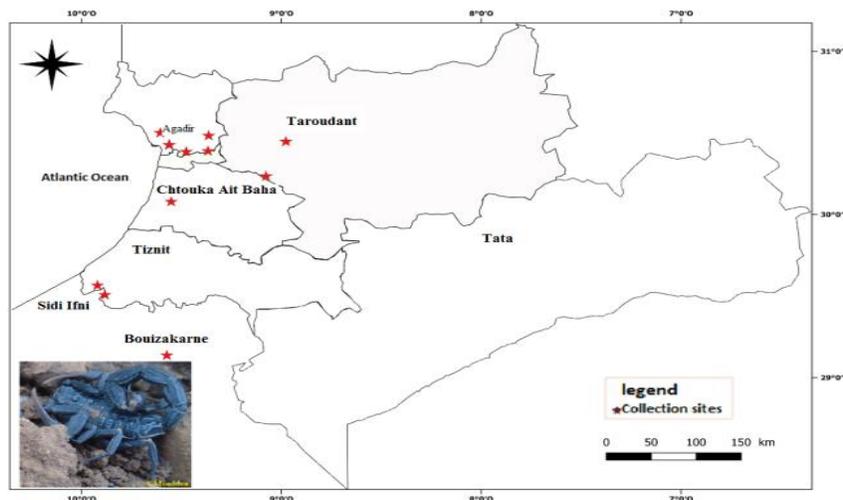


Figure 5: Distribution of *Hottentottagentili* Pallary, 1924 in the study area

Scorpio mogadorensis Birula, 1910

Scorpio mogadorensis Birula, 1910 is a species endemic to Morocco, described for the first time in the region of Essaouira. It is a uniform black brown scorpion. The gallbladder and ambulatory paws are less dark than the body. It has strong, flattened forceps and a shorter tail than the body. The size of the adult can reach 7cm. It is a soil scorpion whose burrows are often located near clumps of vegetation especially jujube and spurge sea urchin. Following the missions carried out, this species was collected in Afayan and Iggilwrih near Tiznit, around Sidi-Ifni, and in the region of Agadir in Drarga and Tamri (Figure 6).

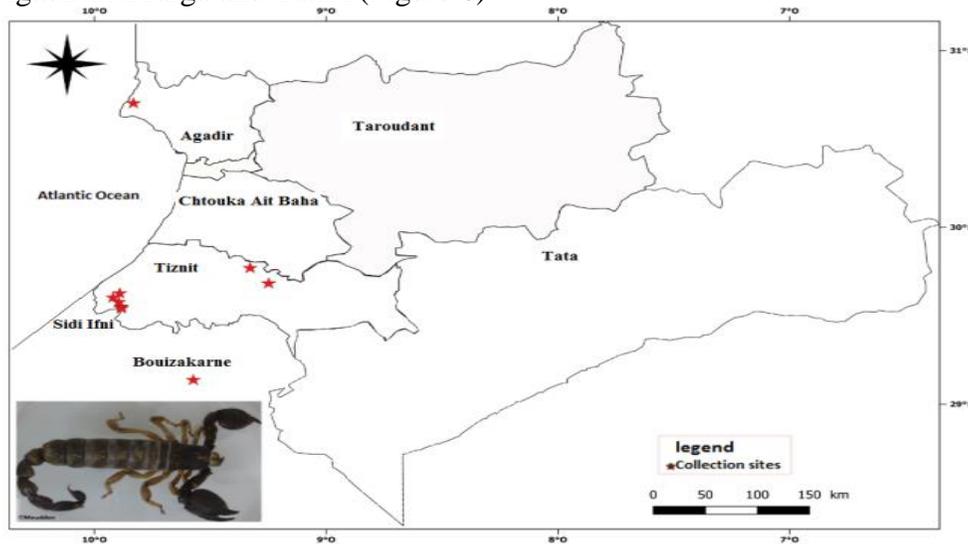


Figure 6: Distribution of *Scorpio mogadorensis* Birula, 1910 in the study area

According to the local population, the pain caused by the bite of this species is similar to that produced by the bite of a wasp or a bee, yet some local people fear it because of the shape of its claws.

Retrospective epidemiological study between 2013 and 2017

Annual evolution of the number of cases of scorpion envenomation

The number of scorpion stings reported by the regional health department between 2013 and 2017 is 24550 cases in the 6 provinces. This number, which was 4015 in 2013, reached 6556 in 2017 (Figure 7). During the period covered by this study, a total of 19 cases died. The highest number of deaths was recorded in 2013 and 2016 with 6 cases (Figure 8). A study in the region of Souss-Massa (El Hidan *et al.*, 2016) showed a gradual increase in the number of stings in the period from 2005 to 2010 with a total of 29437 cases and a spike in 2010. These results can be explained by the frequency of awareness-raising interventions organized by the health authorities in the study area.

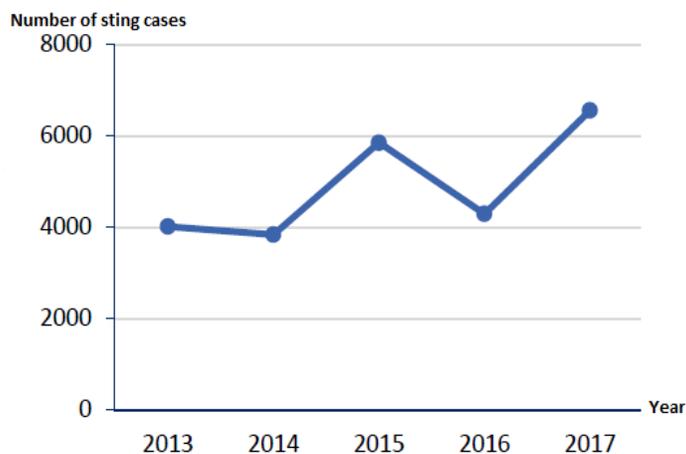


Figure7: Annual evolution of recorded scorpion sting cases

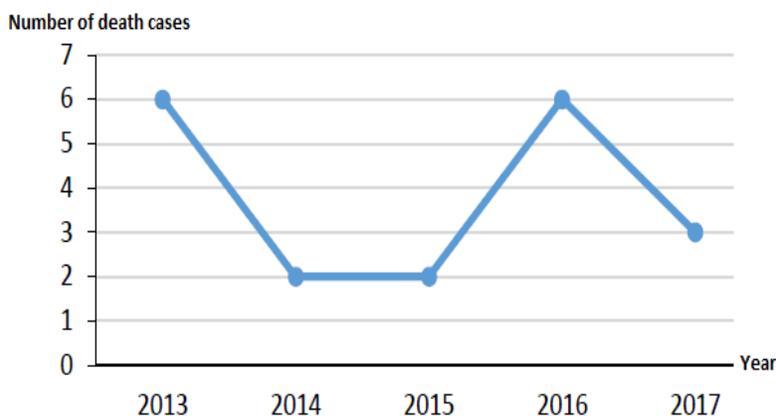


Figure8: Yearly number of deaths caused by scorpion sting

Distribution of incidence of scorpion envenomation.

Incidence of scorpionic stiches and lethality

We have shown from established maps that the incidence and lethality associated with scorpion envenomation vary by province (Figure 9 and10). The highest incidence of stings was reported in Tiznit (37.84 cases/100.000 inhabitants/year), while the InezganeAitMelloul province recorded the lowest incidence (0.1 cases/100.000 inhabitants/year).

The highest lethality was recorded in Agadir Ida Outanane province (182 deaths/100,000 inhabitants/year), while the InezganeAitMelloul and Tata provinces recorded the lowest lethality (0 death case/100.000 inhabitants/year). This difference in incidence and lethality following scorpion envenomation between the provinces of the study area may be related to the difference in the distribution of scorpion fauna in this region. Establishing more accurate maps showing the distribution of species of medical interest may shed light on this problem.

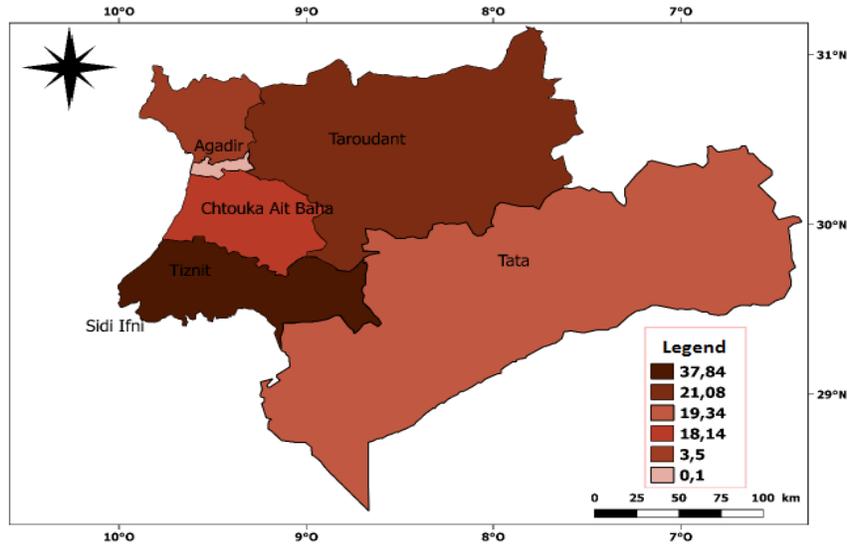


Figure 9: Distribution map of incidence related to scorpion envenomation by province

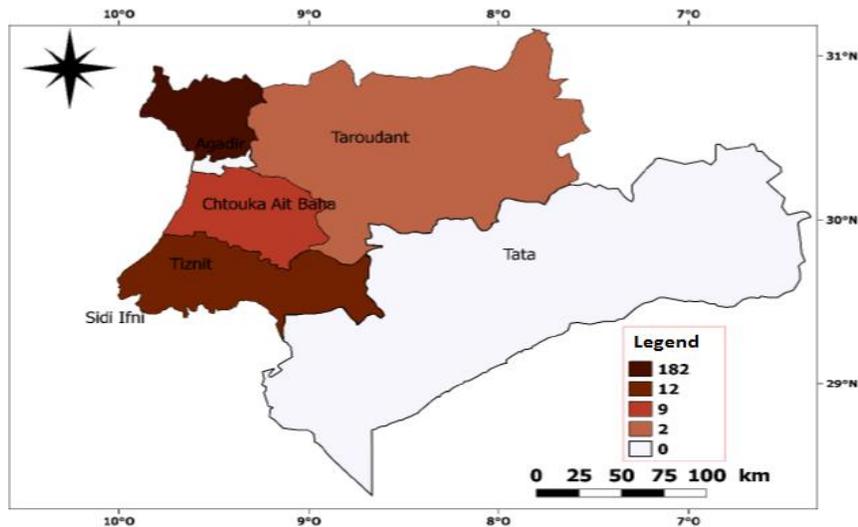


Figure 10: Distribution map of lethality related to scorpion envenomation by province (100000 inhabitants/year)

Analysis of cases stung by sex, age, admission classes, evolution and type of treatment

With regard to cases of scorpion stings, according to data provided by the health services of the Souss-Massa region, men represent 47.15%, while women represent 52.86%. Between the two sexes, a significant difference ($P < 0.05$) was observed.

The high-risk class of under-15 represents 24.87% of the cases recorded during the study period. A significant difference was observed following the T test ($P < 0.05$), between the class <15 and that >15 years.

According to the Table 2, the distribution of dives according to admission classes shows that 94.07% of cases belong to class I (only local signs). Indeed, this class includes patients stung by a non-dangerous scorpion and those whose sting is white or dry without venom injection [24]. 5.48% belongs to class II with general signs of scorpion envenomation. 0.45% belongs to class III characterized by the appearance of signs of vital failure. The difference was significant ($P < 0.05$) between class I, II and between classes I, II and III.

Table 2: Distribution of cases stung by sex, age (100000 inhabitants/year) and admission class in the study area

	Characteristics	Sum	%
Sex	Men	11699	47,65
	Women	12851	52,35
Age groups	<15	6211	24,87
	>15	18758	75,13
Admission classes	I	23084	94,07
	II	1345	5,48
	III	109	0,45

61% of the cases recorded during this period were hospitalized while 39% left the health facilities after a simple observation examination. 10,03% of the victims did not undergo any treatment, while 89,97% were treated (85,90% for the symptomatic treatment of the local signs (T1) and 4,07% for the symptomatic treatment of the general signs (T2)).

As has been shown previously, a scorpion sting does not always mean venom injection.

In this study, 99.92% of the cases have recovered, while 0.08% of the cases have evolved unfavorably and correspond to the cases of death.

After the first 24 hours, the vital prognosis is no longer involved. In some cases, death occurs within 6 to 15 hours after sting, by pulmonary or cardiovascular complications. Whatever the treatment adopted, a first assessment will assess the severity of the clinical presentation according to the risk factors related to the young age of the patient, the species responsible for the sting (a black scorpion larger than 5 cm), the season (summer) and the time elapsed between the bite and the possibility of medical intervention (Rhalem *et al.*, 1998).

4. CONCLUSION

Scorpion envenomation is a serious public health problem in Morocco. Its richness in scorpion fauna shows a variability of its geographical distribution. The region of Souss-Massa is one of the most affected Moroccan regions by scorpion envenomation particularly in summer, which

causes serious problems to local populations and especially children, with some mortality. Its severity depends on many factors such as the victim's age, the offending species and seasons...

This work constitutes a contribution to the study of the scorpion fauna of the Souss-Massa region, treating its different ecological and epidemiological aspects. In our study, five scorpion species were inventoried and a distribution map of each of these species has been compiled. The distribution maps of Souss-Massa's fauna, using Geographic Information System, are considerably important. More complete maps of the study area will have biomedical implications.

Yet, they will be used in the development of a comprehensive strategy to struggle scorpion envenomation in this region. For that reason, we aim to widen the area prospected and intend to carry out a field survey to obtain more complete data on the scorpion envenomation problem in the Souss-Massa region.

5. Acknowledgements

The Authors would like to thank Mouhammed Ousudi, Yassine Goumri and Mr EL Hiba for wildfield help.

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