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Dangerous scorpion fauna of Mali

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Abstract: Although the main Malian scorpion species of medical interest, *Androctonus amoreuxi*, is responsible for severe envenomings and perhaps some deaths, it has hitherto been considered not dangerous for humans. This population is located in the Saharian North-Eastern regions of Mali where it is accompanied by *Leiurus quinquestriatus*, a well known dangerous species of the Sahara. In the Gao district, divided by the Niger River, less desolate than the Tessalit and Kidal regions, one specimen of the dangerous species *Androctonus australis* was found. To summarize, Mali harbors at least three dangerous scorpion species: *Leiurus quinquestriatus*, *Androctonus amoreuxi* and *A. australis*, the latter recently having been identified in Mali for the first time. The absence of *Androctonus aeneas* is surprising in this context because it is found in neighboring countries (Algeria, Niger) and should be detected by new surveys. The possibility of preparing a single scorpion antivenom intended for Saharian and sub-Saharian populations is discussed.

Key words: scorpions, Mali, dangerous species, *Androctonus* sp., antivenom.

INTRODUCTION

Scorpionism in Saharan and sub-Saharan countries remains a little-known reality despite the existence of copious knowledge on the scorpion fauna of the region (1). Recent studies of dangerous scorpions in Saharan and sub-Saharan regions are uncommon (2, 3). These studies usually go through two interlinked stages, the second of which is sometimes overlooked:

- an epidemiological study: sting incidence, frequency of severe envenomings, lethality;
- a specific study of the dangerous scorpion fauna that aims to ascertain the species involved and their preferred biotopes, their distribution, their abundance, but also to evaluate the possibility of preparing a specific antivenom.

The dangerous scorpions are often known by the human populations suffering from frequent accidents and can be identified rapidly by being collected. Such scorpion collections are often solicited by local health agencies (3, 4).

However, the distribution status of the dangerous scorpion species in Saharan and sub-Saharan Africa remains largely incomplete regardless of the countries (2). Such research may raise delicate questions. Is the discovery of a dangerous scorpion species in a place where it had never been documented, or in an area where it had not been reported for a long time, in fact the result of an inadvertent transport by humans into a new favorable habitat (the most common case) or a step-by-step territorial expansion? Is it on the contrary the consequence of a continuous distribution which became discontinuous over time under the pressure of environmental,

climatic or anthropic factors? These and other questions obviously did not fail to arise in a country as vast and varied as Mali.

The frequent endemism of scorpions is a well-known fact. Only one species is now considered ubiquitous, *Isometrus maculatus* (Buthidae family, non-dangerous), whose existence throughout the tropical belt of the world is likely related to maritime transport including the delivery of foodstuffs (fruit). Between a strict endemism, even in large territories such as *Androctonus mauritanicus* of Morocco, and ubiquity, it is possible to find a number of species with a wide or even intercontinental distribution. For example, *Androctonus amoreuxi* is present from West Africa to Iran or beyond; *Leiurus quinquestriatus* and species of the genus *Leiurus*, all considered dangerous, are found from West Africa to Iraq (5). In countries with a large area such as Mali, it is important to take in account the main habitat types encountered, the diversity of which will determine, at least in part, the scorpion fauna. So far, no endemic species of Mali has been described.

Throughout the desert area of Mali, north of the Niger River, the incidence of scorpion stings is particularly high, on the same order of magnitude as in the Maghreb, *i.e.* from 250 to 500 stings per 100,000 inhabitants a year. Stings occur within human settlements, often at home during the night, more frequently than during the day at work. The case fatality rate is ten times higher in children, especially younger ones, than in adults in whom the incidence is double that of the former (4).

SCORPION FAUNA OF MALI

Mali, covering about 1,250,000 square kilometers, can be divided into two main zones (Figure 1). The northern and central portions of the country are part of the Sahara Desert. The northeastern regions of Kidal and Tessalit are often characterized by a high incidence of scorpionism (4). Collected by one member of our research group (A. Dabo), a batch of 22 scorpions responsible for a severe form of scorpionism or

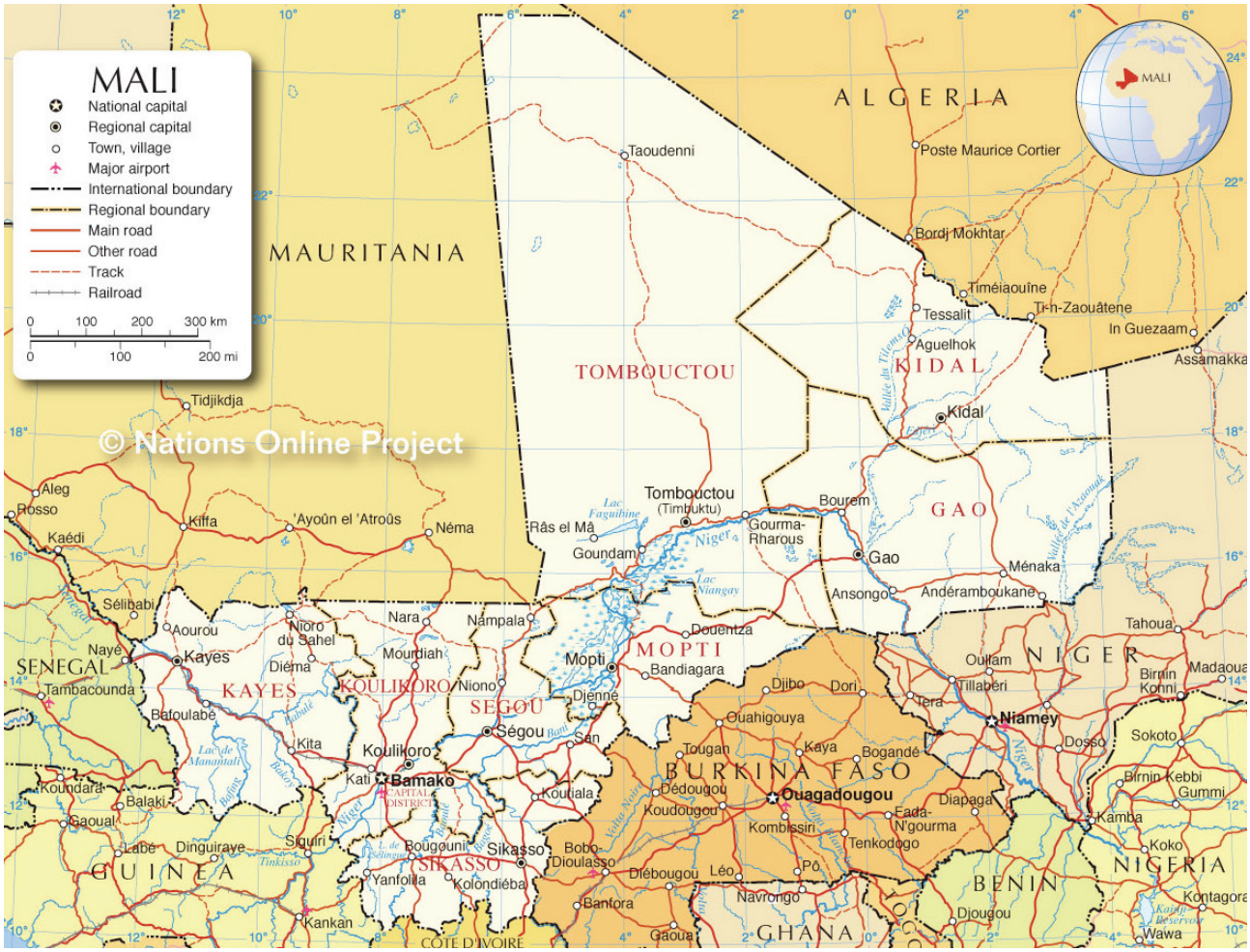

Figure 1. Map of Mali.

Table 1. List of scorpions examined

Genus	Species	Family	Number	%
Species collected in northeast Mali (districts of Kidal and Tessalit)				
Buthiscus	*bicalcaratus*	Buthidae	1	4.5
Leiurus	*quinquestriatus*	Buthidae	8	36.4
Androctonus	*amoreuxi*	Buthidae	13	59.1
Species from the southeast of the country (district of Gao)				
Androctonus	*australis*	Buthidae	1	

even death was examined. Each specimen was identified. This batch consisted of three species (Table 1) belonging to the family Buthidae, which is by far the most important due to its plurality (about 40% of all scorpion species) and medical significance for it contains virtually all the dangerous scorpion species verified in Africa. Within this family, it is possible to distinguish two subfamilies on the basis of morphological and immunochemical criteria, the Buthinae and the Parabuthinae subfamilies (6).

In contrast, the southern and southeastern parts of Mali are divided by the Niger River from the Bamako to the Gao regions. This region is much less inhabited than the previous ones. In the Gao district, vegetation is present and sometimes abundant, with forested areas. It is in this region transected by the Niger River that an adult specimen of the dangerous species *Androctonus australis* was captured, one of the most dangerous species in the African continent along with *Leiurus quinquestriatus*.

Harvested species have prompted the following remarks:

Species in the Northeastern Region (Kidal, Tessalit)

Buthiscus bicalcaratus

This species (Figure 2) is quite common in the northern Sahara. To the best of our knowledge, this is the first time it has been reported in Mali.

Figure 2. *Buthiscus bicalcaratus*, a harmless scorpion, principally described in southern Tunisia or southern Algeria. It is a Saharan species which is probably common in northeastern Mali

Despite appearing among a set of dangerous scorpions species collected, this one is harmless to humans, but its stings can be painful. It is absent from the long list of scorpions responsible for severe poisoning or death compiled by Junqua and Vachon (7), which includes even doubtful cases. On the other hand, the adult size of this species does not exceed 6 cm, barely larger than the minimum size of a buthid species whose sting can be dangerous: it is assumed that a buthid species recognized as dangerous to humans presents no risk if its length is not greater than 5 cm. *B. bicalcaratus* is not considered dangerous in southern Tunisia or southern Algeria where it is fairly common. So, this species of a monospecific genus has to be excluded from the dangerous scorpion fauna of Mali. It is easy to identify and differentiate from *Buthacus leptochelys*, with which it might be confused, thanks to its particular arrangement of the trichobothria (sensory setae) of the external side of the pedipalps (1).

Leiurus quinquestriatus

This typically Saharan species that also inhabits the Middle East is also one of the world's most dangerous scorpion species (Figure 3), along with *Androctonus australis* in Africa, and *Tityus serrulatus* in Brazil. In Africa, it occurs from Mauritania in the west to Sudan and Egypt to the east, but goes far beyond the Middle East from Israel and Saudi Arabia to Iraq, and perhaps even further east. Long considered a monospecific genus, *Leiurus* now includes several species, all of which are dangerous and reported in the Middle East (5). In Africa, and particularly in Sahara, *L. quinquestriatus* is very common in some desert areas where *Androctonus amoreuxi* is also found. These two scorpion species appear to be typical in the driest areas of the Sahara. *L. quinquestriatus* is particularly abundant in northern Niger and southern Egypt. It is also the most copious species among the batch of 22 scorpions collected in northeast Mali, and is likely to be abundant also in the border area of Algeria (4).

Androctonus amoreuxi

The lot of eight collected scorpions was highly homogeneous (Figure 4). There were principally adult specimens whose the length did not exceed 9 cm, significantly shorter than adults from other parts of Sahara. However, Vachon (1) reported that some regions of Algeria contain scorpion populations whose adults are relatively short. *A. amoreuxi*, probably the most deserticolous species of Saharian scorpions, is characterized by a maximum resistance among scorpions to high body temperature (47°C) as well as a high radioresistance to gamma rays (8). More generally, its tolerance to extreme environmental conditions makes it an easy species to breed.

Despite its size, it is usually considered harmless to humans. So, its relatively abundant presence in a batch of scorpions considered dangerous by the human populations of the districts of Tessalit and Kidal raises an important question: would the districts of Tessalit and Kidal not possess an *A. amoreuxi* population, perhaps a particular subspecies, with venom that is potent and toxic to humans? With a presence of eight *A. amoreuxi* specimens in a batch of 22 scorpions, the danger presented by this species needs to be reexamined. It is particularly important to experimentally evaluate the toxicity of its venom, given the

Figure 3. *Leiurus quinquestriatus*, a scorpion species very dangerous for humans, frequently described in Saharan desertic zones, sometimes with *Androctonus amoreuxi*.

Figure 4. *Androctonus amoreuxi*, classically described as a non-dangerous scorpion species. In the desert regions of northeastern Mali, it appears to be dangerous.

unusually small adult size. To summarize, this population of *A. amoreuxi* requires further research studies due to the possible local presence of a highly venomous species or a subspecies that is dangerous to humans. This possibility has been previously discussed elsewhere (2). Local variations in the toxicity of venoms are well known, especially in species with a wide distribution such as *A. amoreuxi* (9).

Species of the Southeastern Region (Gao)

In another epidemiological study on scorpionism, one member of our research group (S. K. Coulibaly) has identified in the Gao district a dangerous scorpion unknown in northern Mali, *Androctonus australis*. The Gao district is divided by the Niger River and presents much less desert than the Tessalit and Kidal districts. Notably, it is the first time that the presence of *A. australis* in Mali has been reported. *A. australis* (Figure 5) is best known as a Saharan species, from Algeria in the west to Egypt in the east. It is also located in Saudi Arabia on the eastern shore of the Red Sea (around Jeddah) (5). But really its range in Africa is wider: southern Morocco to Mauritania (10). In northern Senegal, its presence was described many decades ago, then never reported again until a recent documentation (2).

The presence of *A. australis* in South-Eastern Mali, along with previous observations, clearly indicates that its distribution is much broader than that usually estimated. Indeed, *A. australis* is a Saharan species less deserticolous and less arenicolous than *L. quinquestriatus* or *A. amoreuxi*. It prefers rocky rather than sandy habitats, and especially biotopes with minimal vegetation. It appears that *A. australis* requires higher humidity than truly deserticolous scorpion species, such as *A. amoreuxi* and *L. quinquestriatus*. An oasis often presents small creeks or irrigation channels: *A. australis* is always found living inside the palm grove, never or rarely *A. amoreuxi*, and never *L. quinquestriatus*. Outside, in the sand, *A. amoreuxi* or *L. quinquestriatus* is found, but never or rarely *A. australis*. The totality of observations suggests that the two species *A. australis* and *A. amoreuxi* compete such that the presence of one excludes the other. Moreover, the occurrence of *A. australis* in the Gao district suggests its presence near the Niger River in other neighboring countries including Niger.

Figure 5. *Androctonus australis*, a very dangerous scorpion species, described for the first time in Mali (Gao district). This species requires a minimal hygrometry, and its presence is very likely along the river Niger towards other countries (Niger).

DISCUSSION

Although a potential harmfulness to humans of *B. bicalcaratus* can be rejected, the dangers posed by two species, *L. quinquestriatus* and *A. australis*, are well documented (2, 3, 10). Two other species, *A. amoreuxi* and *A. aeneas*, out of which only the former was collected in the present study, deserve special attention. First of all, the fact that eight *A. amoreuxi* specimens were collected from a sample of 22 scorpions considered dangerous or lethal in the regions of Tessalit and Kidal has led us to review the status of this species generally considered not dangerous for humans. The relatively short adult length (8-9 cm, less than 10 cm) in a homogeneous sample suggests that the population of *A. amoreuxi* from Tessalit and Kidal districts possesses venom which makes them particularly dangerous to humans. Further research is needed to determine whether this Malian scorpion population would not represent a subspecies that produces a particularly powerful venom. And *A. amoreuxi*, contrary to *B. bicalcaratus*, already appears on the list of perilous ancient scorpion species established by Junqua and Vachon (7), Table 2.

The case of *A. australis* is equally interesting. The Gao district is one of the southernmost stations of this species in Saharan Africa. Some questions are raised by this observation, because only one adult specimen was collected whereas its abundance remains unknown. The presence of this scorpion in an area not far from the Niger River may demonstrate its affinity for moist habitats. Given its well-established ability to spread step-by-step to new territories, new surveys are needed in areas on each side of the Niger River and in neighboring countries (11). But perhaps this presence does reflect a gradual desertification of the country as the aridity isohyetes have progressed southward 200 km over the 50 past years. A complementary study on the current density of this dangerous species is essential.

The absence of the black scorpion *Androctonus aeneas* is noteworthy since this dangerous species is found in Tunisia, in Algeria, including southern Algeria, and also in Niger (3). We will not go into

Table 2. African Buthidae with a risk]according to Junqua and Vachon (7)]

Genus	Species	Remarks
Androctonus	*amoreuxi*	Large-sized species Usually considered harmless
	hoggarensis	Altitude species (1000 m)
Buthacus	*arenicola*	Saharan species
Buthus	*atlantis*	Endemic species of Morocco
Hottentota	*hottentota*	Sub-Saharan species (Morocco, Algeria) [now considered dangerous]
Parabuthus	*liosoma*	Eastern Africa, Saudi Arabia
	villosus	South Africa [genus now considered dangerous]

the debate on the synonymy of *A. aeneas* and *A. bicolor* except to note that the species previously termed *A. aeneas* in Africa is morphologically homogeneous regardless of its capture site (Tunisia, Algeria, southern Algeria, Niger). It is always a monochrome species in very low density, easily recognizable by its "leptodactyl" claws. This medium-size species, 8 cm or slightly longer, is regularly responsible for human death. Furthermore, it can coexist with *L. quinquestriatus* and live in arid biotopes (Niger). Research in Mali in the areas bordering Algeria and Niger would enable observation of this dangerous species.

TOWARDS A SINGLE ANTIVENOM FOR SAHARAN AFRICA?

Under what conditions might an antivenom be prepared in a form of a unique model for populations of Saharan and sub-Saharan Africa?

There is not a broad consensus for serotherapy in scorpion envenoming, unlike ophidian envenomings. Despite general agreement on the importance of early serotherapy regardless of envenoming origin, especially in cases when the delay following a scorpion bite exceeds two hours thereby diminishing antivenom effectiveness, the usefulness of antiscorpionic serotherapy is still under debate. Without going into a detailed discussion of the arguments of supporters and opponents of antiscorpion serotherapy, an epidemiological observation may be proposed: the systematic use of antivenom could reduce the scorpionism case fatality rate in countries where it exceeds 1% down to 0.2% or even less, independently of other measures (collection of scorpions, precocity of medical care, accessibility of antivenom). In countries that did not or could not use antivenom, often for reasons of accessibility (cost, storage), lethality did not fall below the 1% threshold.

It is empirically known that clinically effective antivenoms are those possessing a high neutralizing titer. Indeed, it is less the total amount of antivenom administered in a 24 hours period or more than the initial concentration of neutralizing antibodies that seems crucial in the therapeutic effect. It should be useful or even necessary to standardize differently the expression of neutralizing potency of the antivenin, too often expressed as the number of LD50 neutralizable in a vial of variable volume. A real neutralizing titer has to be expressed specifically as milligrams of venom neutralized by 1 mL of antivenom, or by 1 mg of proteins (or by 10 or 100 mg of proteins) contained in the antivenom.

The preparation of a standardized polyvalent scorpionic antivenom for the Saharan and sub-Saharan countries can be considered only after a comprehensive long-term study involving several stages:

- Given the risk and the wide distribution, perhaps underestimated, of the two main dangerous species *A. australis* and *L. quinquestriatus*, the basis of the antivenom should take in account at least the venom of both species in its preparation,
- The second step would be to check the paraspecific neutralizing effect of this bivalent antivenom on the venoms of other species

considered dangerous such as *A. *aeneas*, *A. *amoreuxi*, *A. *crassicauda*, **A. mauritanicus*, *Buthus* sp., *Hottentota* sp., possibly compared to the neutralizing specific effect of each single antivenom in isolation.

- The last step would be to determine the venoms kept for preparation after the previous tests in order to produce a standardized antivenom for all of equatorial North Africa, preferably in lyophilized form.

This process may also provide an opportunity to prepare and test the potential of antivenoms prepared by immunization of camelids, even though some results are not completely encouraging unless all camelid IgG, IgG with heavy and light chains and IgG with heavy chains are kept (12). Recombinant antibodies are also very interesting (13).

Among the African species of dangerous and potentially dangerous scorpions (Table 2), the predominance of the genus *Androctonus* is remarkable. Some of them have been little studied or even ignored (*A. hoggarensis*). It would be useful to consider *a priori* dangerous all the species of the genus *Androctonus*, such as all the species of the genus *Tityus* in Brazil.

* Notes on systematics concerning some species quoted in the text (5):

- The written form "*Androctonus mauritanicus*" has now replaced "*Androctonus mauretanicus*".
- *Androctonus aeneas* is now considered synonymous for *A. bicolor*, which is questionable and deserving of a specific note. Pending the resolution of this ambiguity, it is possible to accept the written form proposed by Stockmann and Ythier (5): *A. bicolor aeneas*.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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