

Unravelling the Diversity and Evolution of Venomous Scorpions: The re-classification of *Buthus occitanus* Complex and Insights to Scorpion Antivenom Development

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ABSTRACT

Taxonomical research plays an important role in the development of quality scorpion antivenoms through identification and classification of venomous scorpion species. The traditional view of scorpion evolution as a linear progression from primitive to advanced species has been challenged by new genetic data, which suggests a more complex pattern of diversification. The preliminary revision of the *Buthus occitanus* species by arachnologists concerns the reclassification of all species associated into a '*Buthus occitanus*' complex, rather than a single species. Investigations on morphological characters and molecular characterization has led to the definition of several species, previously considered only as subspecies or varieties, but also the description of new species. The species considered in these review studies originated mostly from the North and Western African regions and has concluded with the description of more than 40 *Buthus* species. Thus, the reclassification of the *Buthus occitanus* complex into new species and subspecies could extend to indicate potential for existence of variance in their venom toxin landscape. The significance of taxonomic research in antivenom production, highlights the understanding of *Buthus occitanus* species taxonomy, which can enhance the specificity and efficacy of antivenoms. By leveraging taxonomic data, broaden our understanding on scorpion biodiversity and evolution, as well as for the improving antivenom therapies that target specific venom components.

INTRODUCTION

Buthus species are recorded across a wide geographical range, extending from the Mediterranean region of south-western Europe (Spain and France) to African and Middle East regions. Recent efforts have focused on improving the accuracy of identifying *Buthus occitanus* species due to short comings in taxonomic work conducted by earlier researchers in the 19th century. The mitochondrial DNA lineages discovered, particularly those from Europe, were identified to be different, indicating an ancient split among *Buthus occitanus* group populations in France and Spain and MENA region. In 2017, a study revised the classification of *Buthus* species, leading to the recognition of more than 50 different species (1). Despite their significance in medicine, *Buthus occitanus* venom properties have not been extensively researched (2).

METHODOLOGY

The historical data was gathered and organized into a structured dataset, and important linkages and patterns that provided insight into the evolutionary history of the species were identified. All taxonomic descriptions were obtained from previously published works with assistance from other arachnologists. Every published location was evaluated in "The Scorpion Files" an updated database managed by Jan Ove Rein. The nomenclature of *Buthus* species and their national distribution were also verified.



RESULTS & DISCUSSION

Publicly available information has resolved the taxonomic uncertainty around the different *Buthus* species and groupings, resulting in the identification of 42 *Buthus* species in the MENA region (Table 1) (Figure 1). Numerous venom toxin demonstrated to recruited into the venom proteome throughout the evolutionary process in scorpion species. The result of adaptive evolution within the venom genome that followed gene duplication in the venom gland recruiting events, as a result of various factors including geography (3). The growing number of well-characterized venom proteins and the availability of relevant data have created the need for more efficient antivenom.

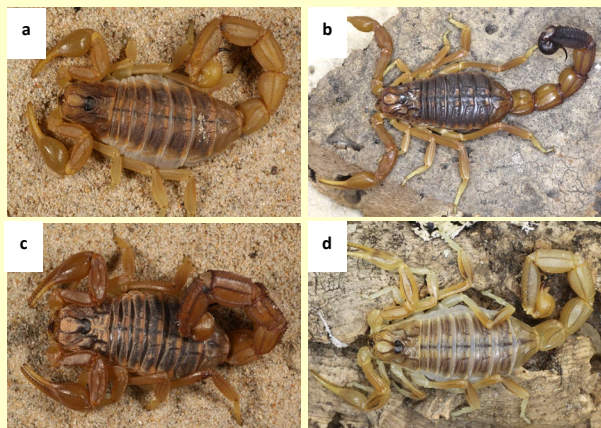


Figure 1. *Buthus* sp. from North Africa: (a) *Buthus lienhardi* (b) *Buthus draa* (c) *Buthus paris* (d) *Buthus atlantis*.

CONCLUSION

The rate at which new *Buthus* species are being identified and revised has escalated in the last 20 years. Currently, there are over 50 species in this genus, 42 of which are found in the MENA region. These discoveries have advanced our knowledge of evolution variables affecting the diversity of genetic and toxic species. These findings imply the significance of taking evolutionary data into account for correct species identification which will aid in the production of quality and effective antivenom. It is recommended to compare and consider the previously classified *Buthus occitanus* venoms from different regions to create precise antivenom for the given local species.

ACKNOWLEDGMENT

We would like to thank Dr. Mouad Kamal, Mr. Giorgio molisani & Mr. Mark Stockman for sharing photos for *Buthus* sp. from Morocco.

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Table.1. *Buthus* species in MENA region

Country	Species	Year published
Morocco	<i>Buthus maamora</i>	2023
	<i>Buthus maroccanus</i>	2021
	<i>Buthus mardochei</i>	2021
	<i>Buthus malhommi</i>	2021
	<i>Buthus mariefraancae</i>	2021
	<i>Buthus lienhardi</i>	2021
	<i>Buthus elmoutaouakili</i>	2021
	<i>Buthus draa</i>	2021
	<i>Buthus paris</i>	2021
	<i>Buthus atlantis parroti</i>	2017
	<i>Buthus bonito</i>	2021
	<i>Buthus nigrovesiculosus</i>	2017
	<i>Buthus oudjanii</i>	2017
	<i>Buthus confluens</i>	2012
<i>Buthus boumalenni</i>	2011	
<i>Buthus maamora</i>	2023	
Algeria	<i>Buthus ahaggar</i>	2021
	<i>Buthus goyffoni</i>	2021
	<i>Buthus saharicus</i>	2021
	<i>Buthus apiatus</i>	2020
	<i>Buthus boussaadi</i>	2018
	<i>Buthus aures</i>	2016
	<i>Buthus tunetanus</i>	2016
	<i>Buthus pusillus</i>	2013
	<i>Buthus tassili</i>	2002
Egypt	<i>Buthus adrianae</i>	2013
	<i>Buthus orientalis</i>	2012
	<i>Buthus egyptiensis</i>	2012
	<i>Buthus israelis</i>	2010
	<i>Buthus intumescens</i>	2000
Libya	<i>Buthus lourencoi</i>	2013
	<i>Buthus barcaeus</i>	2013
	<i>Buthus tunetanus</i>	2006
Tunis	<i>Buthus paris</i>	2021
	<i>Buthus chambiensis</i>	2006
	<i>Buthus dunlopi</i>	2006
Sudan	<i>Buthus duprei</i>	2016
	<i>Buthus karoraensis</i>	2016
Jordan	<i>Buthus nabataeus</i>	2021
	<i>Buthus amri</i>	2010
Yemen	<i>Buthus yemenensis</i>	2008
Mauritania	<i>Buthus occidentalis</i>	2009