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Mini-review

Southern African scorpion toxins: An overview

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Abstract

In southern Africa there are 130 species of scorpions and only a few species' venom have been investigated to date. This review gives an overview of the research done on the venom of southern African scorpions and the toxins and peptides identified up to date. It also aims to highlight the enormous potential that lies in this field of research. Southern African scorpion toxins include four long-chain Na^+-channel toxins, four short-chain α-K^+-channel toxins (α-KTx), three Ca^{2+}-channel toxins and also an insect-selective peptide active on K^+ and Cl^- channels. Three antimicrobial peptides have also been isolated and characterized. All of these peptides are diverse not only in function and target but also in the species they are isolated from.

Keywords: Southern Africa; Scorpion; Venom; Toxin; Ion channels; Cysteine-free peptides

Contents

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1. Introduction

Scorpion envenomation is a relatively common event in subtropical and tropical countries (Ismail, 1995) and can cause lethal envenomation in humans, especially in children. Symptoms displayed by victims of scorpion envenomation are usually complex in nature and can be attributed mainly to hyperactivity of the autonomic nervous system (Gwee et al., 2002). The neurotoxic peptides in the venom are responsible for the symptoms that present during envenomation by interacting with ion channels. Ion channels are gated pores of which gating may be intrinsic or regulated by ligand binding or changes in the voltage gradient across the membrane. They are found in all animal, plant and bacterial cell membranes and function in diverse processes such as nerve and muscle excitation, hormonal secretion, learning and memory, cell proliferation, sensory transduction, the control of salt and water balance and regulation of blood pressure (Ashcroft, 2000). Because of their specificity and high affinity, scorpion toxins have been used as pharmacological tools to characterize various receptor proteins involved in normal ion channel functioning, as well as abnormal channel functioning in disease states (Lecomte et al., 1998; Lehmann-Horn and Jurkat-Rott, 1999). This review will focus on toxins isolated specifically from southern African scorpions and their functions in excitable cells. It will also compare some of the research done on scorpions from other parts of the world to southern African scorpions to highlight open areas of interest.

2. Scorpions

Scorpions are venomous arthropods of the class Arachnida, order Scorpiones. Scorpions are adapted to survive in a wide variety of habitats including tropical forests, rain forests, grasslands, savanna, temperate forests, caves and even snow-covered mountains (Leeming, 2003). Medically important scorpion species belonging to the family Buthidae are represented by the genera *Androctonus*, *Buthus*, *Mesobuthus*, *Buthotus*, *Parabuthus* and *Leirus* located in North Africa, Asia, the Middle East and India. *Centruroides* spp. are located in United States, Mexico and Central America, while *Tityus* spp. are found in South America. *Parabuthus* and *Uroplectes* are located in Africa (Simard and Watt, 1990; Debont et al., 1998; Loret and Hammock, 2001). In southern Africa there are more than 130 species which fall into four families, namely Buthidae (C.L. Koch, 1837), Scorpionidae (Latreille, 1802), Bothriuridae (Simon, 1880) and Ischnuridae (Simon, 1879) (Prendini, 2001). *Parabuthus* (Pocock, 1890) currently comprises 28 species, 20 of which are distributed all over the southwestern parts of Southern Africa (Prendini, 2001; Dyason et al., 2002). Three species—*Parabuhtus granulatus* (Ehrenberg, 1831), *Parabuthus transvaalicus* (Purcell, 1899) and *Parabuthus mossambicensis* (Peters, 1861)—are responsible for a number of fatalities annually (Müller, 1993; Bergman, 1997; Leeming, 2003).

3. Composition of scorpion venom

Scorpion venom is used for both prey capture and defense. The venom can be described as being a complex, aqueous mixture containing mucus, inorganic salts, low-molecular-weight organic molecules and many small basic proteins, namely neurotoxic peptides. Serotonin and enzyme inhibitors are also present in the venom (Simard and Watt, 1990; Müller, 1993). Unlike most snake and spider venom, scorpion venom generally lacks enzymes or possesses very low levels of enzyme activity (Gwee et al., 2002).

4. Peptide toxins in scorpion venom

Advanced methods of fractionation, chromatography and peptide sequencing have made it possible to characterize the components of scorpion venom (Miljanich, 1997). The venom can be characterized by identification of peptide toxins, analysis of the structure of the toxins (primary, secondary and tertiary structure determination), analysis of the function of each of the toxins, analysis of the relationships between these components (synergism) and the target sites or kinetics (Favreau et al., 2006). The specialized peptides found in the venom affect molecular targets like membranes, receptors and ion channels. In doing so they exert a wide variety of physiological actions, including membrane destabilization, blocking of the central and peripheral nervous systems or alteration of smooth or skeletal muscle activity (Ménez et al., 1992). Research has shown that some of the most pharmacologically interesting components of many types of venoms, including scorpion venom, are these neurotoxic peptides (Miljanich, 1997). Multiple toxins may be present in the venom of a single