

Rattlesnake Venoms

Their Actions
and
Treatment

edited by
Anthony T. Tu



RATTLESNAKE VENOMS

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edited by ANTHONY T. TU

*Department of Biochemistry
Colorado State University
Fort Collins, Colorado*

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RATTLESNAKE VENOMS



This book is dedicated to Dr. Karl H. Slotta, who pioneered modern research in the field of snake venoms by first using a fractionated component.

Foreword

In 1935, the government of the State of São Paulo, Brazil offered me the directorship of the newly established Chemical Institute in its world-famous snake and venom Instituto Butantan. Strangely enough, I was not asked to work on snake venoms, but rather to continue my research of sex hormones and also to enter a new field: the chemistry of coffee. At that time, Brazil was laboring under a surplus of coffee and was therefore looking for ways to use it industrially. However, my prime interest was to do research on snake venom, also in view of the abundant raw material available in Butantan, which received hundreds of snakes daily, shipped from all parts of Brazil. I started this research finally in early 1937 and came to the conclusion that rattlesnake venom might be a protein. In the fall of 1937 my brother-in-law, Heinz Fraenkel-Conrat, arrived in São Paulo for a short family visit, fresh from the Bergman laboratory in New York and thus an expert in proteins. Luckily, at that time I had received an outside grant toward a salary for an assistant for a year, so I suggested to Heinz that he stay in São Paulo and tackle the venom research with me. In 1938 we crystallized what we called "crotoxin" and determined its molecular structure. In a way, this discovery may have provided the impetus for world-wide research on animal venoms, the founding of the International Society on Toxinology in 1962 and its publication *Toxicon*, and all the great achievements up to the present time: research on snake venom enzymes, neurotoxins, cardiotoxins, phospholipase A, L-amino-acid oxidase, and hemolysis and blood coagulation and the search for the pharmacologic effects of all animal venoms.

The purpose of *Rattlesnake Venoms: Their Actions and Treatment* is to provide a survey of such important scientific research. Its publication definitely fills a void, and I am sure it will be widely read and thoroughly enjoyed.

Karl H. Slotta

Preface

Rattlesnakes are indigenous to the New World and are distributed throughout North, Central, and South America, possessing a unique morphological characteristic: a rattle at the end of the tail. The venoms of rattlesnakes, as compared with those of cobras, kraits, and sea snakes, are not well characterized. However, this situation is changing with the isolation of more venom components and the intensive investigation of their chemical and pharmacological properties. Since much of the information about rattlesnake venoms is widely scattered in different journals, this book attempts to assemble a great deal of this information as well as to review the various properties and actions of rattlesnake venoms systematically.

The degree of snakebite poisoning depends on many factors. Among them, toxicity and the amount of venom injected are most important. James L. Glenn and Richard C. Straight summarize these factors in Chapter 1. They also discuss and illustrate the major species and subspecies of rattlesnakes. Barbara J. Hawgood conducted rattlesnake venom research in Brazil and is presently a world-renowned physiologist on snake venom actions. In Chapter 2 she discusses the physiological and pharmacological effects of rattlesnake venoms. Charlotte L. Ownby is active in studying the pathological effects of rattlesnake venoms, particularly at the ultrastructural level, and discusses this in Chapter 3. Robert A. Hendon has been very active in research on crotoxin, and Allan L. Bieber is working on Mojave toxin. In Chapter 4 they cover presynaptic toxins from rattlesnake venoms. The chemistry of rattlesnake venom is discussed in Chapter 5 by Anthony T. Tu.

Snake treatment is an important yet variable and controversial medical practice. For the clinical aspects, two physicians experienced in the medical management of snakebite envenomation in the United States, Robert E. Arnold and Dr. Thomas Graham Glass, Jr., were invited to describe their experiences (Chapters 6 and 7). Although their views occasionally do not agree, it is important to hear opinions from both sides of this controversial issue.

I especially would like to thank Dr. Karl H. Slotta for the Foreword. As everyone in the venom research field knows, Dr. Slotta, together with Heinz Fraenkel-Conrat, started rattlesnake venom research using isolated components rather than crude venoms.

I hope this book will be a useful and interesting source of information for biochemists, toxicologists, herpetologists, physicians, and anyone else interested in rattlesnake venoms.

Anthony T. Tu

Contributors

Robert E. Arnold, M.D. Professor of Surgery, University of Louisville School of Medicine, Louisville, Kentucky

Allan L. Bieber, Ph.D. Professor, Department of Chemistry, Arizona State University, Tempe, Arizona

Thomas Graham Glass, Jr., M.D., F.A.C.S. Clinical Professor of Surgery, Department of General Surgery, The University of Texas Health Science Center, San Antonio, Texas

James L. Glenn Research Serpentologist, Venom Research Laboratory, Veterans Administration Medical Center; and Consultant Curator of Reptiles, Hogle Zoological Gardens, Salt Lake City, Utah

Barbara J. Hawgood, Ph.D. Lecturer, Department of Physiology, Queen Elizabeth College, University of London, London, England

Robert A. Hendon, Ph.D. Research Associate, Department of Biochemistry, Colorado State University, Fort Collins, Colorado

Charlotte L. Ownby, Ph.D. Associate Professor and Director, Electron Microscopy Laboratory, Department of Physiological Sciences, College of Veterinary Medicine, Oklahoma State University, Stillwater, Oklahoma

Richard C. Straight, Ph.D. Director, Venom Research Laboratory, Veterans Administration Medical Center, Salt Lake City, Utah

Anthony T. Tu, Ph.D. Professor, Department of Biochemistry, Colorado State University, Fort Collins, Colorado

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part I

Action of Venoms

1

The Rattlesnakes and Their Venom Yield and Lethal Toxicity

JAMES L. GLENN AND RICHARD C. STRAIGHT

Veteran's Administration Medical Center, Salt Lake City, Utah

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THE RATTLESNAKES

Introduction

Rattlesnakes, genera *Sistrurus* and *Crotalus*, are venomous snakes unique to the New World. Our knowledge of them has been increased by innumerable observers from the time of the earliest explorers to the present. The state of that knowledge has been reviewed in detail by Howard K. Gloyd (1940, reprinted in 1978) and Lawrence M. Klauber (1956, partially revised and reprinted in 1972). Both of these monographs, Gloyd's *The Rattlesnakes Genera Sistrurus and Crotalus* and Klauber's *Rattlesnakes: Their Habits, Life Histories and Influence on Mankind*, compliment each other. Combined they represent a most thorough, scholarly description of rattlesnake anatomy, taxonomy, phylogeny, distribution, and natural history. Although the pace of accumulation of new information and understanding of the rattlesnakes has slowed, there is still much that is not yet known and understood. Even in the area of taxonomy, where much of

our knowledge is well established and stable, there are still gaps, especially with regard to populations of South American and Mexican rattlesnakes.

Recent investigations into the Mexican rattlesnake fauna have enriched our knowledge of these poorly understood rattlesnakes. A recent publication *The Natural History of Mexican Rattlesnakes* (Armstrong and Murphy 1979), is an excellent source of behavioral and habitat information. It is to Klauber (1972) that we refer the reader for complete synonymies and taxonomic descriptive analysis of the 31 recognized species and the 70 recognized subspecies. Since that authoritative report, six newly described subspecies have withstood critical examination and are recognized as follows:

1. *Crotalus ruber lorenzoensis* (Radcliffe and Maslin, 1975).
2. *Crotalus willardi obscurus* (Harris, 1974). This subspecies was conventionally described by Harris and Simmons (1976); however, the name was occupied by Harris (1974). (See Smith et al., 1975.)
3. *Sistrurus ravus brunneus* (Harris and Simmons, 1978; as redescribed by Campbell and Armstrong, 1979).
4. *Sistrurus ravus exiguus* (Campbell and Armstrong, 1979).
5. *Crotalus triseriatus armstrongi* (Campbell, 1979).
6. *Crotalus lepidus maculosus* (Tanner, Dixon, and Harris, 1972).

The six subspecies nominated by Hoge (1965) of South America's races of *Crotalus durissus* [(*terrificus*)] [see *Crotalus durissus* (neotropical rattlesnake)] are in need of redescriptive, comparative analysis in accordance with the rules of the *International Commission on Zoological Nomenclature* (see Klauber, 1972: pp. 35–36) and are therefore not included in Table 1. The same problem of taxonomic status applies to *Crotalus durissus trigonicus*, *Crotalus ruber monseratensis* and *Crotalus triseriatus quadrangularis* (Harris and Simmons, 1978), and *Crotalus lepidus castaneus* (Zertuche and Trevino, 1978). We also suggest that further analysis is required concerning Harris and Simmons' (1978) elevation of *Crotalus triseriatus aquilus* to species status (see McCranie and Wilson, 1979). We have presented briefly in this chapter some common characteristics of rattlesnakes, the recognized species, and their distribution and have reviewed the yield and lethal toxicity of their venoms.

Species and Distribution

The rattlesnakes are members of the family of venomous snakes known as the Crotalidae (or, as preferred by some taxonomists, Crotalinae—a subfamily of

Table 1 Recognized Rattlesnake Species and Subspecies, Original Describer, Year, and Common Name

Genus— <i>Crotalus</i> , Linnaeus, 1758	
<i>C. adamanteus</i>	Beauvois, 1799, Eastern diamondback rattlesnake
<i>C. atrox</i>	Baird and Girard, 1853, Western diamondback rattlesnake
<i>C. basiliscus basiliscus</i>	Cope, 1864, Mexican west coast rattlesnake
<i>C. basiliscus oaxacus</i>	Gloyd, 1948, Oaxacan rattlesnake
<i>C. catalinensis</i>	Cliff, 1954, Santa Catalina Island rattlesnake
<i>C. cerastes cerastes</i>	Hallowell, 1854, Mojave Desert sidewinder
<i>C. cerastes cercobombus</i>	Savage and Cliff, 1953, Sonoran Desert sidewinder
<i>C. cerastes laterorepens</i>	Klauber, 1944, Colorado Desert sidewinder
<i>C. durissus durissus</i>	Linnaeus, 1758, Central American rattlesnake
<i>C. durissus culminatus</i>	Klauber, 1952, Northwestern neotropical rattlesnake
<i>C. durissus terrificus</i>	Laurenti, 1768, South American rattlesnake
<i>C. durissus totonacus</i>	Gloyd and Kauffield, 1940, Totonacan rattlesnake
<i>C. durissus tzabcan</i>	Klauber, 1952, Yucatan neotropical rattlesnake
<i>C. enyo enyo</i>	Cope, 1861, lower California rattlesnake
<i>C. enyo cerralvensis</i>	Cliff, 1954, Cerralvo Island rattlesnake
<i>C. enyo furvus</i>	Lowe and Norris, 1954, Rosario rattlesnake
<i>C. exsul</i>	Garman, 1883, Cedros Island diamond rattlesnake
<i>C. horridus horridus</i>	Linnaeus, 1758, timber rattlesnake
<i>C. horridus atricaudatus</i>	Latreille, 1802, canebrake rattlesnake
<i>C. intermedius intermedius</i>	Troschel, 1865, Totalcan small-headed rattlesnake
<i>C. intermedius gloydi</i>	Taylor, 1941, Oaxacan small-headed rattlesnake
<i>C. intermedius omiltemanus</i>	Gunther, 1895, Omilteman small-headed rattlesnake
<i>C. lannomi</i>	Tanner, 1966, Autlan rattlesnake
<i>C. lepidus lepidus</i>	Kennicott, 1861, Mottled rock rattlesnake
<i>C. lepidus klauberi</i>	Gloyd, 1936, banded rock rattlesnake
<i>C. lepidus maculosus</i>	Tanner, Dixon, and Harris, 1972, Durango rock rattlesnake
<i>C. lepidus morulus</i>	Klauber, 1952, Tamaulipan rock rattlesnake
<i>C. mitchellii mitchellii</i>	Cope, 1861, San Lucan speckled rattlesnake
<i>C. mitchellii angelensis</i>	Klauber, 1963, Angel de la Guarda Island speckled rattlesnake
<i>C. mitchellii muertensis</i>	Klauber, 1949, El Muerto Island speckled rattlesnake

Table 1 (Continued)

<i>C. mitchellii pyrrhus</i> Cope, 1866, Southwestern speckled rattlesnake
<i>C. mitchellii stephensi</i> Klauber, 1930, panamint rattlesnake
<i>C. molossus molossus</i> Baird and Girard, 1853, Northern blacktail rattlesnake
<i>C. molossus estebanensis</i> Klauber, 1949, San Esteban Island rattlesnake
<i>C. molossus nigrescens</i> Gloyd, 1936, Mexican blacktail rattlesnake
<i>C. polystictus</i> Cope, 1865, Mexican lance-headed rattlesnake
<i>C. pricei pricei</i> Van Denburgh, 1895, Western twin-spotted rattlesnake
<i>C. pricei miquihuanus</i> Gloyd, 1940, Eastern twin-spotted rattlesnake
<i>C. pusillus</i> Klauber, 1952, Tancitaran dusky rattlesnake
<i>C. ruber ruber</i> Cope, 1892, red diamond rattlesnake
<i>C. ruber lorenzoensis</i> Radcliffe and Maslin, 1975, San Lorenzo Island diamond rattlesnake
<i>C. ruber lucasensis</i> Van Denburgh, 1920, San Lucan diamond rattlesnake
<i>C. scutulatus scutulatus</i> Kennicott, 1861, Mojave rattlesnake
<i>C. scutulatus salvini</i> Gunther, 1895, Huamantlan rattlesnake
<i>C. stejnegeri</i> Dunn, 1919, long-tailed rattlesnake
<i>C. tigris</i> Kennicott, 1859, tiger rattlesnake
<i>C. tortugensis</i> Van Denburgh and Slevin, 1921, Tortuga Island diamond rattlesnake
<i>C. transversus</i> Taylor, 1944, cross-banded mountain rattlesnake
<i>C. triseriatus triseriatus</i> Wagler, 1830, central plateau dusky rattlesnake
<i>C. triseriatus aquilus</i> Klauber, 1952, Queretaran dusky rattlesnake
<i>C. triseriatus armstrongi</i> Campbell, 1979, Armstrong's dusky rattlesnake
<i>C. unicolor</i> Van Lidth de Jeude, 1887, Aruba Island rattlesnake
<i>C. vegrandis</i> Klauber, 1941, Uracoan rattlesnake
<i>C. viridis viridis</i> Rafinesque, 1818, prairie rattlesnake
<i>C. viridis abyssus</i> Klauber, 1930, Grand Canyon rattlesnake
<i>C. viridis caliginis</i> Klauber, 1949, Coronado Island rattlesnake
<i>C. viridis cerberus</i> Coues, 1875, Arizona black rattlesnake
<i>C. viridis concolor</i> Woodbury, 1929, midget faded rattlesnake
<i>C. viridis helleri</i> Meek, 1905, southern Pacific rattlesnake
<i>C. viridis lutosus</i> Klauber, 1930, Great Basin rattlesnake
<i>C. viridis nuntius</i> Klauber, 1935, Hopi rattlesnake
<i>C. viridis oreganus</i> Holbrook, 1840, northern Pacific rattlesnake
