VENOMOUS ANIMALS AND THEIR VENOMS

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Preface

The modern trend in the study of the wide field of venomous animals and their venoms is directed toward basic research that emphasizes zoological ecology, biochemistry, pharmacology, and immunobiology. The increasing importance of this development, stimulated also by the political and industrial expansion into the undeveloped areas of the tropics, is reflected by the great number of publications on venoms of animal origin. Every year about 10,000 papers are published on this subject, scattered in hundreds of journals in many languages, thus making it impossible for the individual scientist to keep abreast of new developments.

The present treatise is an attempt to offer, for the first time, a comprehensive presentation of the entire field of the venomous members of the animal kingdom, of the chemistry and biochemistry of the venoms, of their pharmacological actions and their antigenic properties. The medical aspects, both symptomatology and therapy, are included. The work is the result of close cooperation of fifty-three scientists from thirty-two countries on all continents. The authors are highly qualified specialists in their specific areas of research; their concerted efforts made this book one of unusual scope and depth.

This first volume of the three volume work is devoted to venomous mammals and begins the extensive section on snakes. Volume II will complete the discussion on snakes and include the saurians, batrachians, and fishes. The venomous invertebrates, such as insects, centipedes, spiders, and scorpions, venomous molluscs, and marine animals, will be considered in Volume III.

The interdisciplinary aspects of the subject necessitated assigning several chapters to a single group of animals and offering separate sections covering the zoological, chemical, and biomedical points of view.

It is hoped that these volumes will be valuable reference works and stimulating guides for future research to all investigators in the field; they will also serve the needs of physicians and veterinarians seeking information on the injuries caused by venomous animals. The volumes should also facilitate the teaching of this important topic and should prove a welcome source of instruction to students and to the large group of laymen interested in this fascinating field of natural science.

The editors wish to thank the authors for their cooperation and for generously contributing the results of their work and experience.

Our thanks are also due to the staff of Academic Press for helpful advice, patience, and understanding.

We cannot conclude this preface without expressing our gratitude to Professor Dionysio de Klobusitzky who conceived the idea of this book and outlined its initial organization.

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Introduction

The so-called venomous animals described in these volumes possess at least one or more venom glands and mechanism for excretion or extrusion of the venom, as well as apparatus with which to inflict wounds. The venom may be injected at will. These animals have been characterized by several authors as being "actively venomous." The "passively venomous" species have venom glands and venom-excreting ducts, but lack adequate apparatus for inflicting wounds.

In their struggle for life, all venomous animals seem to be rigorously extroverted. Their energies are directed against the other animal and vegetable organisms in their environment. All the venom glands of these animals are of the exocrine type. Their venoms, produced by special epithelial cells and stored in the lumina of glands, are always extruded to the outer world, generally by biting or stinging such as is the case with shrews, serpents, saurians, stinging insects, scolopendrids, spiders, scorpions, some fishes, molluscs, some echinoderms, and worms. Other animals envenomate the victim by direct bodily contact such as is true of caterpillars, certain echinoderms, sea anemones, jellyfishes, and hydroids. All venomous animals possess characteristics which distinguish them from other members of the animal kingdom. Often venomous animals are hunters, predators, solitaries, and also enemies of other members of the animal kingdom. There are exceptions, of course, such as the social Hymenoptera.

The wounding apparatus is located on the head, on the hind portion, or over the entire exposed surface of the animal. In shrews, serpents, and Gila monsters, the venom apparatus is inside the mouth. The venom glands are in fact salivary glands; the bite is inflicted by modified teeth equipped with venom canals. In scolopendrids and spiders, the venom system is situated outside the mouth, but is in close proximity to it, and is designed for protection and acquisition of food. A strange situation is present in the scorpion: the venomous mechanism is found in the last segment of the body, the "cauda venenum." In fact, the scorpion sting must be considered "peribuccal." The scorpion is able to move its tail sufficiently far in front of its head to kill its prey before eating it.

In the venomous Hymenoptera, such as ants, bees, wasps, and hornets, the wounding apparatus and the venom glands are also situated in the

last segments of the abdomen, far from the mouth. The stinging mechanism may function primarily as an ovipositor, having no connection with the mouth, and its venom-injecting function may only be secondary.

In some venomous fishes, molluscs, and bristleworms, the venomous organs may be distributed over certain exposed portions of the body or may cover more or less the entire body surface, as in caterpillars, some echinoderms, and coelenterates, with no relation to the mouth.

The location of the venom system and the transformation of certain organs into venom-conducting channels may lead us to theorize on the significance of venom in the animal kingdom. Why do venomous animals exist? What is the primary function of venom? Are venoms present principally for digestion of food, and is the wounding apparatus intended for self-defense and even attack in the never-ending struggle for survival? Is the stinging function designed mainly for oviposition, or for defense and attack, and is it combined with the mechanism for obtaining food and provision for offspring, as is true for all the solitary wasps? Thus, the role of venoms immediately appears very complex.

Shrews, serpents, scolopendrids, spiders, scorpions, solitary wasps, and some coelenterates are exclusively *carnivorous,* but they never feed on an animal that is already dead. They are predators and active hunters, and they capture and kill their prey. The social wasps, bees, hornets, and caterpillars are exclusively *herbivorous;* other venomous animals may be *omnivorous,* i.e., they will feed on creatures that have died of other causes.

The venom and wounding apparatus must also be considered in relation to *sex,* particularly in venomous adult insects such as bees, wasps, and hornets. Only the adult female Hymenoptera are poisonous, not the adult males. In all other venomous animals both sexes may be equally poisonous, or the males, which are much smaller, may do less serious harm, as is true of most spider species.

Consideration of the localization of the venom apparatus, the mode with which these animals take their prey or their food, and the fact that often only one sex bears a venom-conducting apparatus may guide us to another very important question: For what purpose is the venom used?

Toads, venomous frogs, salamanders, and other "passively" venomous animals certainly may use their toxic products for self-defense. Often these animals may not rely entirely on their venomous power, but may prefer to use other protective methods such as mimicry, flight, and concealment. Caterpillars and other Lepidoptera larvae are also in this category. They procure food only from plants, and desire peace from other animals.

One habit of several solitary wasps is rather curious: They use their

stinging apparatus to paralyze spiders and other insects. Then they bring the prey to the nest, deposit an egg over the body of it, and close the orifice of the nest. The wasp larva, hatched a few weeks later, thus is provided with fresh food. These wasps possess a nerve- or muscle-paralyzing venom with long-lasting effect and they may attack in order to protect their offspring. The social Hymenoptera, such as the bee, wasp, and hornet, may use the venom apparatus primarily for defense against enemies, even against other groups of the same family. Also, they may attack and kill, e.g., the females of bees kill the males after fertilization of the new queen. A newly hatched queen bee kills all the other queens present in the hive. Thus the stinging apparatus and venom have both defensive and offensive functions. The venomous fishes, coelenterates, and echinoderms, as well as the bristleworms, use the wounding mechanism for self-defense.

It is curious that in all these animals—toads, salamanders, bees, wasps, hornets, caterpillars, some fishes, molluscs, sea cucumbers, urchins, starfishes, sea anemones, jellyfishes, and the like—the venom and the biting or stinging system have nothing to do with the acquisition of food. In the aggressive predators, such as the solitary wasp and the social bee, under certain circumstances, the venom system may be transformed to provide food for the young. Consequently, the venom apparatus will have nothing in common with the digestive or salivary organs.

In scolopendrids, spiders, scorpions, venomous snakes, Gila monsters, and venomous shrews, the venoms, venom apparatus, and the wounding system are designed primarily for food acquisition, and not so much for the predigestion of food. This is especially true of scorpions. Their venoms are paralyzing, not digestive agents. They use the sting only when the prey is large and vigorous in defending itself, as spiders. Small animals are captured directly with the pedipalps, and immediately killed and eaten; the sting is not needed. Scolopendrids and spiders use the wounding apparatus in two ways: to hold the prey and introduce it into the mouth, or, when resistance is offered, to inject and kill the prey with the venom. The salivary function of venom in scolopendrids, spiders, and especially in scorpions may be questionable.

The situation appears to differ with snakes, venomous saurians, and Insectivora. Since the venom glands and the venom-injecting apparatus are found in the mouth, with phylogenetic transformation of a few teeth, and the venom glands may be true salivary glands, with or without digestive ferments and enzymes, one might think that the main purposes of the venom mechanism are the capture of prey and the partial breakdown of body tissues. On the other hand, it is also true that venomous snakes may be force-fed with rats, birds, and other small animals, which they

do not envenomate but which they digest very well. Without the venom apparatus it may be very difficult or even impossible for them to obtain their food. Venom may also activate the digestive processes in some manner, but, probably, it is not necessary for this purpose. Scolopendrids, scorpions, spiders, snakes, venomous saurians, and shrews may be considered primarily of the offensive type, their venom-apparatus being used for the capturing of food; secondarily, of course, they use such apparatus for self-defense.

Exact knowledge of the biological habits of venomous animals would provide more accurate answers as to the real purpose of venoms. Too little is known about this broad subject.

Another very important issue to be clarified concerns the intensity of action of the venoms of all species. For example, a venom of one species of snake may be several times more active in rats, mice, and birds than in other animals. Human beings are extremely sensitive to certain animal venoms. One-tenth of one milligram of *Loxosceles* venom may seriously endanger human life. It is conservatively estimated that 40,000 to 50,000 people throughout the world may be killed every year by accidental contact with venomous animals. Every scientific effort must be directed toward the prevention of this tragedy.

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