Zeitschrift: Acta Tropica
Herausgeber: Schweizerisches Tropeninstitut (Basel)
Band: 29 (1972)
Heft: 4

Artikel: Poisonous and venomous animals in East Africa
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DOI: https://doi.org/10.5169/seals-311811

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Poisonous and Venomous Animals in East Africa

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"Ndege Huru"

Foreword

This paper has been written at the request of Mr. R. L. Belkher, M.D., former Head of Casualty/Trauma Firm, Muhimbili Hospital, Dar es Salaam.

It is based on over ten years teaching activity at the Rural Aid Centre, Ifakara in south-eastern Tanzania as well as in Switzerland. It is meant to be of help to the medical profession, to serve as a guide to the general public as well as to tourists from abroad, and – last but not least – to act as a stimulus for further research within the scope of the modern and much diversified field of Toxinology. For, as the reader will soon find out, the present summary is far from complete and much remains to be done, even to answer quite simple questions. Questions, however, which are equally relevant to the biologist, to the medical practitioner as well as to the field-worker upcountry.

This paper is affectionately dedicated to "Bwana Ngiri", Professor Rudolf Geigy, on the occasion of his 70th birthday, who has devoted so much of his life to the countries and peoples of East-Africa, and, to Mrs. Nina Geigy-Heese, his late wife, who took as active a part in her husband's work as she was permitted by her delicate health.

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Abbreviations

EA	East Africa, East African
P-Animals, V-Animals	please, refer to Table 1, p. 406
VD-animals, VP-Animals	please, refer to Table 2, p. 407

Glossary

The reader is invited to complete the present glossary himself, either with Swahili terms unknown to the author, or, with expressions of local significance. The author will gladly receive all contributions to a more accurate and comprehensive glossary.

	Kiswahili	Other tongues
Marine animals		
sponge	sifongo	
coelenterate		
bluebottle *(Physalia)*		
coral (red)	marijani, marijani ya fedhaluka	
jelly-fish	mnyama wa bahari wa yavuyavu	
sea-anemone	mnyama kama ua liotalo baharini	
sea nettle	kiwawi	
stinging coral *(Millepora)*		
mollusc		
cuttle-fish	pweza	
octopus	pweza mkubwa	
shellfish	wanyama wa bahari wenye gama au kombe	
slug	koa uchi	
snail	konokono, koa	
echinoderm		
brittle star		
sea-cucumber		
sea-lilie		
sea urchin	mwanamizi	
starfish	kiti cha pweza	
fish	samaki, nswi	
balloon fish *(Diodon)*		
barbel	kambare	samaki (Kipare)
barracouta, snek *(Thyrsites)*	mzira, sansuri	
barracuda *(Sphyraena)*		
bass *(Grammistes)*		
catfish *(Plotosus)*		
catfish *(Synodontis)*		gogo (Kindamba)
moray eel		
puffer *(Arothron)*	shogo	
ratfish		
ray	mwanga, mwangaza kianga, miale mshale wa nuru	
scorpionfish		
seahorse *(Hippocampus)*	dodozi	

	Kiswahili	Other tongues
shark	papa	
skate	taa	
stonefish		
sunfish		
surgeon fish *(Acanthurus)*	kangaja	
toadfish		
trunkfish		
zebrafish *(Pterois)*	chale	
Arthropods		
ant (brown)	siafu	
ant (red)	maji moto	
ant (small black)	sisimizi, nyenyere	
ant (soldier)	chungu	
bee *(Apis)*	nyuki	
bee (stingless)		
beetle	mdudu mwenye mabawa atambaaye wa jamii ya mende	
bumble-bee		
butterfly, moth	kipepeo, nondo	
caterpillar	mtoto wa kipepeo	
caterpillar (stinging)	kiwawi	
centipede	tandu	
insect	mdudu	
millipede	jongoo	
scorpion	nge, kisusuli	kipinini (Kimbunga)
spider	buibui	
tick (argasid)	papasi	
tick (ixodid)	kupe	
wasp	mdudu aumaye kama nyuki	
Vertebrates		
frog, toad	chura	
snake	nyoka, joka	
blindsnake *(Typhlops)*		
boomslang *(Dispholidus)*		
burrowing viper *(Atractaspis)*		
cobra *(Naja)*	namna ya nyoka anayeweza kuvimbisha shingo yake	? ndungulu (Kimbunga)
mamba *(Dendroaspis)*		? lukou (Kimbunga)
night adder *(Causus)*		kiwangalimi (Kimbunga)
puff adder *(Bitis)*	pili, kifutu, bafe, moma	boma (Kimbunga)
python	chatu	
sea-serpent *(Pelamis)*	joka kubwa la bahari	
spitting cobra *(N. nigricollis)*	fira, swila	ndemera (Kimbunga)

1. Introduction

1.1. Terminology

Toxins are substances which may harm or destroy life, even when applied in small quantities. By convention, small quantities mean some hundred mg as applied on one kg bodyweight. **Poisons** are toxins, considered to be metabolic by-products and produced in any part or organ of either plants or animals. Primarily, their toxic properties are accidental. Under natural conditions they act upon ingestion or, less frequently, upon contact. Under artificial and laboratory conditions they also act parenterally. **Venoms** are animal toxins, produced in special glands. As a rule, they are clearly correlated to one or more functions, biologically essential for the "toxic" animal. As a rule, they only act when applied by parenteral route or, less frequently, upon contact, but not upon ingestion, being destroyed by digestive enzymes.

It is evident, then, that one ought to distinguish between **Poisonous (P)** and **Venomous (V) Animals.** For clearness, the distinction has been summarized in Table 1.

For convenience, ectoparasites, such as mosquitoes, bugs or ticks, are not included among the venomous animals; yet, toxic ingredients of their saliva do act parenterally and clearly assume biologically important functions in the context of food obtainment. No absolute distinction between venomous animals and ectoparasites is possible, although it can be stated that, as a rule, venomous animals are able to make use of the venom apparatus for self-defense, while ectoparasites cannot. Neither are endoparasites, such as amoebae and helminths, included among poisonous animals. They have a certain poisoning capacity towards their hosts, but this is considered to be rather a side-effect of parasitism which, for practical reasons, will not be discussed here. Again it must be stressed, however, that there is no absolute distinction between poisonous animals and endoparasites.

In Table 2 characteristics of the various types of venomous animals are summarized. Letter D is being used as indicative of self-defense, which is the only function of the venom apparatus in the animals concerned. Letter P, for its group of animals, indicates that a prime function originally had to do either with food for the individual animal concerned (prey), or, with food for its offspring (progeniture).

1.2. Toxicity

Toxicity of a substance is relative. Essentially, it depends upon a) the species, subspecies and the origin of the enemy or prey

Table 1. Distinctive characters of Poisonous and Venomous Animals

Poisonous (P-)Animals	*Venomous (V-)Animals*
No venom apparatus present; toxin, "poison", produced in skin, muscles, blood and/or inner organs	Specific venom apparatus present; toxin, "venom", produced in special glands
Poison acts mainly upon ingestion ("poisoning")	Venom acts upon parenteral application ("envenomation") or, less frequently, upon contact with mucous membranes or even unbroken skin. When ingested, venom usually is destroyed
As a toxin, poison has no well defined biological function (metabolic by-products?)	Primary biological function is either self-defense, obtainment of prey, or, care for progeniture
Poison affords no protection to individual animal (group or species protection, however, is conceivable)	Venom affords protection to individual concerned, either primarily or secondarily
Medically important P-Animals in East-Africa are mainly found among marine fish (often brightly coloured or bizzarrely shaped)	Medically important V-Animals in East-Africa are mainly found among marine fish, among hymenopteran insects and snakes

organism – under laboratory conditions even upon its strain. This is to say that the same toxin may entail variable effects in different animals, including man;

b) the physiological and, possibly, the psychological state of the enemy or prey organism;

c) the application route. Not much is known in this respect with regard to poisons. Under laboratory conditions poisons are often applied parenterally and no comparisons have been made of their effects after peroral and parenteral application. Many venoms have been shown to act more efficiently when applied by intravenous (i.v.) than by intraperitonal (i.p.) and by i.p. than by subcutaneous (s.c.) route. Several exceptions are known, however, mainly among scorpions and spiders.

In addition, toxicity of either poison or venom is variable in individual animals. It varies with the physiological state of the animal concerned and, thus, in some instances, with factors such as reproduction cycle and seasons.

Table 2. The various types of Venomous Animals

	VD-Animals	*VP-Animals*
among e.g.	sponges millipedes insects echinoderms fish amphibians	coelenterates polychaetes snails scorpions spiders insects snakes
primary function of venom apparatus	self-defense	obtaining prey, or care for progeniture
secondary function	none	self-defense
venom apparatus	complete or incomplete, i.e. without means of parenteral application	always complete (glands, ducts, means of application such as dart, spines, fangs etc.)
derived from	integument or hind gut	mouthparts, forelegs etc. (prey); reproductory organs (progeniture)
chemistry of venom	often simple compounds of low molecular weight	often composed of biogenic amines, polypeptides and enzymes
main venom action	psychological, inflammation, blister formation *pain* paralysis necrosis	*shock* and/or *paralysis* tissue damage, necrosis
main venom function	determent of aggressor	prey: immobilization killing predigestion progeniture: immobilization preservation

Table 3. Repartition of Poisonous and Venomous Animals in the Animal Kingdom

	P	VD	VP
PROTOZOA (unicellular organisms)			
Sarcomastigophora (flagellates and rhizopods)	+	+	
Ciliophora (ciliates)		+	+
METAZOA (multicellular organisms)			
Spongia (sponges)		+	
Coelenterata (jelly-fish, anemones, corals etc.)	+		+
Annelida (segmented worms)	(+)	+	+
Arthropoda			
Arachnida			
Xiphosura (king-crabs or horseshoe-crabs)	+		
Scorpiones (scorpions)			++
Araneae (spiders)		(+)	++
Crustacea (crabs etc.)	+		
Diplopoda (millipedes)		+	
Chilopoda (centipedes)			+
HEXAPODA (insects)	+	+	+
Mollusca			
Gastropoda (snails)	(+)		+
Lamellibranchiata (mussels etc.)	+		
Cephalopoda (cuttle-fish, octopus etc.)	(+)		+
Echinodermata (star-fish, sea urchins, sea cucumbers etc.)		+	
Vertebrata (vertebrates)			
Cyclostomata (lampreys etc.)	+		
PISCES (fish)	+	+	
Amphibia (frogs, toads, newts, etc.)	(+)	+	
REPTILIA (reptiles)	(+)		+
Mammalia (mammals)	(+)	(+)	(+)

Explanations:
- P poisonous
- VD venomous/defense only
- VP venomous/prey, progeniture
- (+) few species only
- \+ several species
- ++ (nearly) all species of the group

Bold letters: group containing species of major medical importance

Capital letters: group containing species of major medical importance in East Africa

Note: animal groups which include no toxic representatives were omitted from this list.

Toxicity has been indicated in various ways, which makes comparisons extremely difficult. More recently most authors have adopted to express toxicity as LD_{50} (dose lethal to 50 % of the experimental animals chosen) and to refer to it in mg/kg body weight (or in μg/g). The LD_{50} has been shown to be mathematically the most accurate, although its determination still necessitates a serie of about 30 laboratory animals. After what has been said above, it is evident that indications about LD_{50} are of no use, unless full specifications are made about the venom used, the experimental animals, as well as the application route chosen.

1.3. Poisonous and Venomous Animals in the Animal Kingdom

It is probably correct to say that poisonous and venomous animals have evolved in most (non-parasitic) major groups of the Animal Kingdom. This is not to say the reader should fearfully try to avoid all sorts of animals, the existence of which he did not even notice so far. It is important to remember, however, that representatives of only comparatively few species of poisonous animals are ever eaten by man and that only few venomous animals are contacted by him. The common anthropocentric outlook leads to the rather one-sided impression that a disturbingly large number of animal species had produced some "chemical weapons", mainly for the purpose of troubling man. As Table 3 may show, the number of "toxic" animals is, in fact, rather large, but their vast majority are of no or only minor importance to man.

In conclusion, it may be said that, medically speaking, the situation with respect to poisonous and venomous animals is rather favourable in East Africa. For, there exist but a few species potentially harmful to man, namely various fish, bees and some snakes, i.e. marine animals, arthropods and land-dwelling vertebrates. For practical reasons, the next three chapters will follow this pragmatic classification rather than scientific systematics.

2. Marine Animals

The EA shores represent the western most boundary of the huge Indo-Pacific area, which from a biological viewpoint, is a unity. In contrast to terrestrial animals, marine animals are much the same from Hawaii to East Africa and from the Red Sea to Madagascar. However, poisonous and venomous animals species, known to be dangerous to man, either are, in fact, more numerous in, or are better known from Far Eastern and Australian than from EA waters.

Since HALSTEAD (1965–1970) wrote a most extensive and invaluable monograph on toxic marine animals, in the present chapter this author will often be quoted.

2.1. Unicellular organisms (Protozoa)

Quite a number of marine Protozoa are either poisonous or venomous. Yet, due to size, they play a role for man only where they represent the bulk of food to higher animals which, in turn, are eaten by man. Protozoa relevant to man, therefore, will be dealt with in the context of shellfish (cf. p. 413).

2.2. Sponges (Porifera, Spongia)

Species known to cause contact dermatitis occur in the West Indies, along California and Mexico, in some parts of the eastern shore of N-America as well as in European Seas. They seem to be of no importance in EA waters.

2.3. Coelenterates (Coelenterata, Radiata)

2.3.1. Taxonomy

There exist over 9,000 species, the vast majority of which are marine and belong to the Cnidaria, i.e. coelenterates which possess nematocysts or stinging thread-cells (as opposed to the small group of Acnidaria, supposedly without nematocysts). The Cnidaria are subdivided into three classes, the Hydrozoa (hydroids), Scyphozoa (jellyfish) and Anthozoa (corals and sea-anemones).

2.3.2. Biology and Morphology

Basically, two forms occur during life-cycle: the sedentary, asexual polyps or hydroids and the free swimming, sexual medusa. Polyps are sac-like organisms, with a single orifice or mouth at the upper end, surrounded by stinging tentacles. Medusa are umbrella- or bell-like, with an elongated tubular mouth which hangs down from the centre of its under surface. The tentacles insert at, or near, the rim of the bell. All Coelenterates are predatory. Their prey consists of other marine animals, e.g. molluscs, crustaceans or fish.

In the Hydrozoa and Anthozoa the hydroid form is dominant, in the Scyphozoa it is the medusoid form. Some Hydrozoa give rise to complex colonies, e.g. the sedentary *Millepora,* or the free-floating *Physalia.* Anthozoa, too, may produce vast colonies, well known as 'true corals", among which the reef-building, calcareous Madreporaria (see Fig. 1) are most spectacular.

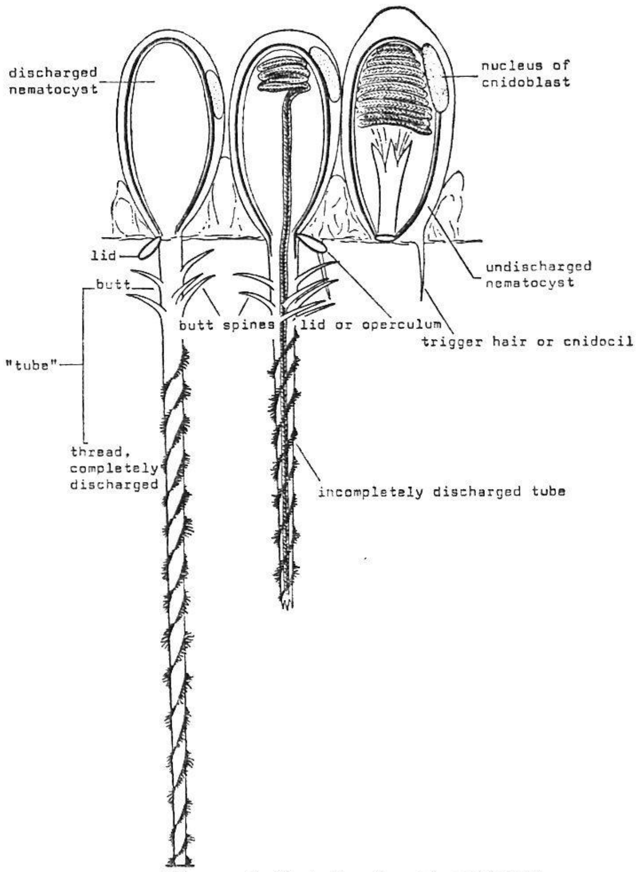


Diagram to illustrate action of nematocyst.

Diagram to illustrate action of nematocyst (reprinted with the kind permission from R. V. SOUTHCOTT, "Coelenterates of medical importance", in "Venomous and Poisonous Animals and Noxious Plants of the Pacific Region", ed. by H. L. KEEGAN and W. V. MACFARLANE, 1963, Pergamon Press, Inc. (out of print).

2.3.3. Venom apparatus

It consists of a multitude of nematocysts (cnidocysts, nettling cells, stinging cells) distributed in groups, mainly at the surface of the tentacles. Each single nematocyst represents a minute, but complete venom apparatus (see diagram). It is contained in a cnidoblast cell or in what remains of it between the supporting epithelial cells. The nematocyst producing cnidoblasts develop in sites other than the tentacles.

When mature they migrate to their final destination by amoeboid movements. 17 types of nematocysts have been described, the occurrence and distribution of which is said to be specific for the taxonomic groups of Coelenterates. Among these the types known as "microbasic mastigophores" and "stenoteles" or "penetrants" are most likely to be involved in human envenomations.

The discharge of nematocysts seems to be triggered off, either chemically or mechanically, by contact of the cnidocil, or in both ways, the stimuli following each other. The exact nature of eversion of the thread is not understood, but it is assumed that venom, first contained in the capsule, is injected into the victim through the thread or tube which, in the nematocyst types concerned, is open at its tip.

2.3.4. *Venom*

Much work is actually being undertaken to elucidate its composition. Pain is ascribed, in part, to serotonin demonstrated to exist in various Coelenterate venoms. Paralysis is claimed to be caused, in part, by tetramine (tetramethylammonium hydroxide), a quaternary amine, and in part to substances of proteinaceous nature. Proteins of high molecular weight (70,000–150,000) are strongly suspected to be responsible for the severe symptoms due to dangerous Coelenterates. Proteolytic enzymes and phospholipases A and B have been found in the venom of *Physalia physalis,* the Atlantic Bluebottle.

2.3.5. *Functions*

Primary function of the venom apparatus appears to be obtainment of prey. It is evident that self-defense plays an important additional role. (A few species of anemones are known to be poisonous and to cause acute gastritis, upon ingestion, followed in some cases by death).

2.3.6. *Medical significance*

Species particularly dangerous to man belong to the genera *Millepora* ("Stinging coral, fire coral, false coral") and *Physalia* ("Portuguese man-o-war, Bluebottle") among the Hydrozoa, and to the genera *Chironex* and *Chiropsalmus* ("sea-wasps, box-jellies") as well as *Chrysaora* ("sea nettle") among the Scyphozoa, the last three all occurring off N-Australia and in Far Eastern seas.

It is apparently limited in EA. A "Red Coral" is claimed to cause lesions which necessitate medical care. Near Dar es Salaam the author has experienced the rather painful sting of what he thinks must have been the single fishing tentacle of *Physalia utriculus,* the Indo-Pacific Bluebottle.

Systematic studies on lesions or, possibly, fatalities due to Coelenterates in EA are few, however. It is difficult, therefore, to assess the medical importance of Coelenterates in EA. Also, one has to bear in mind that people, if stung while being in the sea, may loose consciousness and get drowned and that the cause of death may never be established. All these facts may assume more importance in the years to come, in connection with expansion of tourism as well as with swimming becoming a popular sport among local people.

2.3.7. Prevention

Avoid direct contact with any Coelenterates. (The tentacle of *Physalia utriculus* may trail up to 30 m from the body of the animal.) Also, avoid contact with animals washed ashore, or, with tentacles severed from the animals' bodies; the nematocysts may still discharge their contents for a considerable period of time.

For First Aid Treatment cf. p. 438.

2.4. Molluscs (Mollusca)

The chief classes are: Amphineura with a shell made of several transversal plates; Lamellibranchiata with a shell of two lateral plates; Gastropoda with a single spiral shell; Cephalopoda with a shell either spiral, reduced or absent. Poisonous or venomous species are found among all classes, but are negligible among the first.

2.4.1. Lamellibranchiata (Pelecypoda; bivalves, shell-fish)

In some parts of the world shell-fish poisoning is comparatively frequent at certain times. Four types of poisoning may be discerned: gastrointestinal or choleratic, erythematous, "venerupin-" and paralytic.

Gastrointestinal shell-fish poisoning is due to rapid bacterial deterioration after collection of the animals. Its progress is largely dependent on temperature. Therefore, the rule has been adopted to eat shell-fish when fresh only, and, in temperate climate, preferably in the cool season of the year.

Erythematous shell-fish poisoning is likely to be of allergic nature.

Venerupin poisoning – which owes its name to the Japanese cockle *Tapes (Venerupis) semidecussata* – occurs in Japan, where it is due to ingestion of various shell-fish. The poison is believed to be derived from a protozoan, the dinoflagellate *Prorocentrum*. The clinical features are gastric, and later on, hepatic troubles, which may lead to death.

Paralytic shell-fish poisoning is known to occur in temperate regions, on the Pacific coast of N-America, in NW-Europe and to a lesser degree in some other places, including S-Africa. It is due to the ingestion of mussels, oysters, clams and other shell-fish which have fed on large numbers of another dinoflagellate, *Gonyaulax*. These are abundant during the warm period of the year only. Their poison is known as Saxitoxin. Consumption of shell-fish involved may lead to death as a result of respiratory paralysis, within 12 hours.

2.4.2. Gastropoda (snails, slugs)

Besides some few species known to be poisonous there are three venomous families forming together the sub-group of the Toxoglossa.

For practical reasons only one family, the Conidae, is of some medical importance.

Conidae (s. Figs. 5 and 6) are predacious. Some species live on molluscs, some exclusively on worms, others on fish. The venom apparatus is of the VP type. It consists of a venom bulb, a venom duct (acting simultaneously as venom gland), radular sheath and radular teeth. These are flat chitinous sheets, rolled into arrow-like tubes. They are introduced, one at a time, into a victim by the muscular, extensible proboscis, and then act as harpoon to pull the victim into the snail's buccal cavity.

As to worm-feeders, to which the majority of *Conus* species apparently belong, recent investigations indicate that their venom is rather species-specific and is efficient only towards the particular prey-animals of each cone species. It is said to inhibit the Polychaetes' response to stimulation and to render them incapable of normal progression. There seems, therefore, to be a neurotoxic action which leads to incomplete, though effective, immobilization of the prey. In addition, the venoms of several (although not all) species concerned show proteolytic activity. Thus, if man is stung, it seems possible that he experiences local necrosis. It is, however, said to be unlikely that vermivorous cones make use of their venom apparatus in self-defense.

It is known that the venoms of *C. marmoreus* and *C. textile,* both molluscivorous, paralyse gastropods, but produce no toxic effects in mice and rats. On the other hand, the venoms of piscivorous *C. geographus, C. catus* and *C. tulipa* cause respiratory failure and death in mice. It is thought that only piscivorous cones present a threat to man. The venom seems to be of proteinaceous nature. Death cases have been reported from various places, mainly in the Indo-Pacific area, including the Seychelles. Species most often incriminated are *C. geographus* (see Fig. 6) and – possibly wrongly – *C. textile* (see Fig. 5), but others such as *C. magus, C. aulicus, C. striatus* and *C. obscurus* may be dangerous, too.

People most likely to get stung are shell collectors. Live animals should be handled with extreme care, as the proboscis may be extended from the anterior, tapered end of the shell to a considerable length. For First Aid Treatment see p. 438.

2.4.3. Cephalopoda (cuttle-fish, squid, octopus)

Cephalopods are all marine; they prey on crustaceans, shellfish and occasionally fish.

Poisonous Cephalopods are known to occur in Japan. Venomous Cephalopods include species of the genera *Sepia* and *Loligo* among the Decapoda (cuttle-fish) and *Eledone* and *Octopus* among the Octopoda (octopus). They produce venom in their posterior salivary glands and apply it into puncture wounds inflicted by their chitinous jaws. It is evident that this venom apparatus serves for the obtainment and, possibly, digestion of prey. It can be used for defense too. Neither venomous nor poisonous Cephalopods, however, are considered to be a public health problem. A few human fatalities, though, are known to have occurred around Australia and were attributed to the Blue-ringed Octopus, *O. maculosus* and allied species. Their venom is rather particular in that it, apparently, contains a neurotoxin of molecular weight less than 540, with no antigenic properties.

2.5. Echinoderms (Echinodermata)

The phylum Echinodermata is entirely marine and composed of five classes: Crinoidea (sea-lilies), Asteroidea (star-fish), Ophiuroidea (brittle stars, serpent stars), Echinoidea (sea urchins) and Holothurioidea (sea-cucumbers). No toxic species are known among the Crinoidea. Scanty information only is available on Ophiuroidea, among which there seem to exist some few species bearing venomous spines.

2.5.1. Asteroidea (star-fish)

Various species, which belong to several families, seem to have glandular cells in their epidermis, producing a slimy, venomous substance. It may cause contact dermatitis; the species concerned are also believed to be toxic to eat, although it may rather be the contact with lips and mucous membranes of the mouth which produces harmful consequences. If this assumption is correct, the star-fish concerned would belong to the VD animals, possessing an incomplete defense apparatus.

Some species seem to have a complete venom apparatus. Of these the best known is likely to be *Acanthaster planci,* the "venomous star-fish" or "crown of thorns sea star", of bad reputation in modern times for destroying large coral reefs. It is found from Polynesia to the Red Sea. Its epidermis covers elongate, pungent spines. If these penetrate human skin, envenomation will follow with extreme pain, redness, swelling, vomiting, numbness and possibly paralysis. The venom is compared to venom of Holothurioidea; it is believed to be of saponin nature.

2.5.2. Echinoidea (sea urchins)

Many Echinoids are characterized by their spiny appearance. The spines are of calcareous substance and covered by a thin layer of epithelium. With numerous species the spines cause no more than mechanical lesions. In the families Echinothuridae and Diadematidae (see Fig. 3), however, the spines are slender, sharp, hollow and they readily break off in wounds. Whether they contain venom is still controversial. In some Echinothurid species, the tip of certain spines is encased within a venom sac. Thus, further to traumatic action by the spines, the patient experiences consequences of envenomation, i.e. intense pain, redness, swelling and sometimes more serious symptoms. – It seems evident that one has to deal with a VD-apparatus, essentially the same as in the Asteroids discussed above.

In other sea urchins, of the genera *Toxopneustes* and *Tripneustes* (see Fig. 4) pedicellariae of the venomous, globiferous type seem to dominate over the spines in a protective function. Pedicellariae, five types of which have been described, are small seizing organs, distributed over most of the surface of sea urchins. They consist of two to four fangs or jaws, mounted on a stalk. In animal experiments pedicellarial venom was shown to exert a strong paralytic activity. Man may suffer severe pain, respiratory distress, giddiness and paralytic symptoms of lips, tongue and facial muscles.

2.5.3. Holothurioidea (sea cucumbers)

These are worm- and sausage-shaped Echinoderms. They feed on bottom materials. A number of species possess Cuvierian tubules, i.e. white, pink or red tubules attached to the common stem of the respiratory trees which, in turn, are fixed on the cloaca. If a sea cucumber is badly treated, it may emit some tubules through the anus. Immediately upon contact with sea water these take the aspect of viscous white threads (see Fig. 2), which are said to be capable of entangling an enemy. Experiments showed that toxic substances emanate from these threads and that fish kept in an aquarium with a Holothurian may die rather quickly after expulsion of parts of Cuvierian organs. How these venoms remain effective in the open sea, where dilution of the active substances must be considerable, is open to exploration. Recent investigations confirmed the chemical nature of "holothurin" to be steroidal saponin or derivatives of "holostanol". These substances are known to interfere with neuro-muscular transmission; upon contact with human skin burning pain and violent inflammatory reaction may ensue. Blindness may result from contact with eyes. Ingestion may be fatal, although some Holothurians are regularly eaten by people in the Far East.

2.5.4. Prevention

Most star-fish may be handled without special precautions. Care should be taken to avoid venomous species, which may best be pointed out by local fishermen. Spiny specimens should not be handled except when wearing protecting gloves.

Numerous sea urchins may be handled without danger. Care should be taken, however, not to allow Toxopneustidae to apply pedicellarian bites. Sea urchins with brittle spines of extreme length should be left alone.

When Holothurians have secreted tubules of the Cuvierian organs they should not be contacted with bare skin. Children must be warned not to rub eyes while playing around with Echinoderms and to wash hands before proceeding to other operations.

For First Aid Treatment see p. 438.

2.6. *Poisonous fish*

Many more species of fish than are usually supposed may, at least temporarily, contain toxic substances which may cause serious disturbances when ingested. This is a vast open field for research, all the more as, on a global scale, man largely depends on fish for food. Also, the biological function of poison is still subject to speculations (cf. Table 1).

Halstead (1965–1970) subdivided poisonous fish as follows:

Ichthyosarcotoxic:	Poisons are contained in tissues, mainly in musculature, viscera and skin. The poisons are supposed to be of small molecular weight; they are destroyed neither by heat nor by gastric juices.
Ichthyootoxic:	Poison is produced in the gonads, in context with reproductory activity.
Ichthyohaemotoxic:	Poison is contained in the blood serum. It is usually destroyed by heat and gastric juices.

2.6.1. *Ichthyosarcotoxic fish*

They include some Chondrichthyes (Elasmobranchii) or cartilaginous fish such as sharks, rays, skates and chimaeras, as well as Osteichthyes or bony fish.

The sharks concerned belong mainly to large tropical species. The poison is concentrated in the liver. Poisonous rays and skates seem to be more frequent in the Atlantic. Chimaeras or ratfish, which are poor swimmers, prefer cooler seas to tropical waters. As to the Osteichthyes, six groups of ichthyosarcotoxic fish may be discerned, of which two only will be discussed here.

2.6.1.1. Ciguatoxic fish

It is the largest group of poisonous fish, the ingestion of which cause gastro-intestinal troubles called "Ciguatera". The group ranges from herrings to trunk fishes, including such well known species as sardines, moray eels (see Fig. 13), seahorses, surgeon fish, barracuda and puffers (see Fig. 15). The group, thus, includes herbivorous and carnivorous fish. They have in common that they all inhabit warm seas, that their vast majority are reef dwellers and that they live either as bottom feeders or, being predatory, of these. Those observations have led to the "algal food chain theory" according to which mainly blue-green algae, such as *Lyngbya majuscula* of the group of Cyanophyta, would be at the origin of ciguatoxism. This theory makes it possible to explain why all these fish are known, in certain areas, as well as in certain years, to be non-poisonous.

The organs most toxic are the liver, intestine, gonads and musculature. 3 to 5 hours after the fish or parts of it are eaten there is a sudden onset of abdominal pain, followed by nausea, vomiting and a watery diarrhea. The symptoms disappear usually within 8–10 hours and the patient recovers within 24 hours, unless complications set in. Neurotoxic effects, then, may become prevalent. Mortality amounts to about 12 %.

2.6.1.2. Tetrodotoxic fish

These belong to the group of Tetraodontiformes and comprise sharp-nosed puffers (genus *Canthigaster),* porcupine fish or balloonfish (*Diodon, Chilomycterus*), sunfish (*Mola, Ranzania*) and puffers (*Amblyorhynchotes, Arothron, Lagocephalus, Triodon*). The best known fish of this group is the Fugu puffer (Tetraodontidae), which is served in Japanese restaurants under a special licence. The cause of toxicity and the origin of the poison are still unknown. Much of what has been said about ciguatoxic fish may equally well apply to tetrodotoxic fish. However, the chemical nature of tetradotoxin is known: it is a derivative of aminoperhydroquinazoline (which – surprisingly – is identical with tarichatoxin found in Californian newts).

The organs most toxic are the skin, liver, ovaries and intestines. The musculature is safer, but may be toxic, too. There is a definite correlation between gonadal activity and toxicity since the fish are most toxic immediately prior to and during reproduction season. Also, females are found to be more toxic than males. Symptoms usually are first felt between 10 and 45 minutes after ingestion. It may, however, take up to three hours for the first symptoms to appear. They consist of general malaise and paresthesias of lips and tongue. Later on, hypersalivation, swetting, headache, hypothermia, decreased blood pressure and extreme weakness may follow. Gastrointestinal disorders may come up too, but may also be entirely lacking. Respiratory distress soon becomes the dominant feature. Ascending paralysis may finally lead to death, while the patient retains his mental faculties almost up to the end. Mortality rate is 60 %. After 24 hours prognosis is good.

2.6.2. *Ichthyootoxic fish*

In this group poison is usually confined to the reproductory organs and may lead to fish roe poisoning. The fish concerned belong to a wide variety of species, of which many are fresh water inhabitants, mostly in temperate zones. Two species only are recorded from EA: the barbel (*Barbus altianalis*) from inland lakes and the marine catfish *Plotosus lineatus* (cf. also p. 420/422).

2.6.3. *Ichthyohaemotoxic fish*

As far as is known, fish serum poisoning is due to ingestion of various eels – morays, congers and anguillids – reported to live in the Atlantic, the Mediterranean or in European rivers. With respect to EA moray-eels, reference is made to Ciguatera (cf. p. 417).

2.6.4. *Prevention of fish poisoning*

Avoid eating all reef-dwelling fish, especially all scaleless fish, all bizarrely shaped or conspicuously coloured fish and all large predacious fish, including particularly the moray-eels.

Never eat either the viscera (liver, gonads, intestine) or the skin.

Avoid eating fish eggs or roe of little known species.

For First Aid Treatment see p. 438.

2.7. *Venomous fish*

Where venom apparatus exist in fish, they all consist of dermal glandular cells. However, their distribution and concentration on the animals' surface varies with the species; also, in numerous species, the glandular cells or glands are combined with specialised spines, acting as means of parenteral application, while in others no special spines are present and the glands simply secrete their products onto the skin's surface. Thus, among fish one finds complete as well as incomplete venom apparatus. With respect to the latter one, which is sometimes referred to as ichthyocrinotoxic, its close resemblance to the venom apparatus in amphibians seems striking (cf. p. 430). It seems likely that these venom apparatus, no matter whether complete or incomplete, function for self-defense. With regard to incomplete apparatus, moreover, the view has been expressed that the secretion products played an eminent, yet ill defined role in the marine ecosystems by regulating growth of other, possibly competitive or symbiotic, organisms.

2.7.1. *Fish with incomplete venom apparatus*

The venom apparatus is made up of numerous "club cells" of epidermal origin with excretory orifices to the surface, but without or only loose connection with fins or spines. Few fish species are known yet to be "ichthyocrinotoxic": hagfish and lampreys (Agnatha) which occur in temperate zones, one moray-eel species, *Muraena helena,* in the Eastern Atlantic and Mediterranean; a few perch-like fish of the family Serranidae, among which *Grammistes sexlineatus,* the golden striped bass of the Indo-Pacific; some Batrachoididae or toadfish, which might be found in EA waters; and a substantial number of Tetraodontiformes, among which genera as *Alutera* (scrawled filefish), *Canthigaster* (sharp-nosed puffer), *Diodon* (porcupine fish), *Lactoria, Ostracion* (trunkfish) and *Arothron* (see Fig. 15), most of them common in EA.

In the trunkfish *Ostracion meleagris* (syn. *O. lentiginosus*) glandular club cells are located in the soft skin parts on the lips, the base of the fins and the caudal peduncle. The fish is said to release foamy mucous secretions at the base of the fins and the caudal peduncle when disturbed. With reference to the lips, labial glands in part surround the teeth, so as to form dental pockets, the function of which does not seem to have been clarified yet. In the puffer *Arothron hispidus* glandular masses surround the numerous dermal cartilaginous spines. In Batrachoid fish, glands are located in the pectoral axillae and on the pectoral fins.

The chemistry of the venoms concerned is unknown. It cannot be excluded that they are identical with tetrodotoxin (cf. p. 418). As has been outlined above, the skin of Tetraodontiformes is known to be poisonous and should never been eaten.

2.7.2. Fish with complete venom apparatus

They all occur in warm seas. They are too numerous to be dealt with in detail here. Fish occurring in the Indo-Pacific and possibly significant in EA are:

Sharks:	*Squalus acanthias* (spiny dog fish)
Rays:	genera *Dasyatis, Gymnura, Aetobatus* and others (sting-rays)
Catfish:	various marine species, e.g. *Plotosus lineatus,* some fresh water species e.g.? *Synodontis zambesensis*
Scorpionfish:	genera *Brachirus* (lionfish), *Pterois* (zebrafish, lionfish, see Fig. 14), *Scorpaena* (scorpionfish), *Scorpaenopsis* (false stone fish), *Sebastapistes* (scorpionfish, see Fig. 16), *Synanceja* (stonefish) and others
Toadfish	
Squirrelfish:	genus *Holocentrus*
Jacks:	*Scomberoides sanctipetri* (leatherback fish)
Stargazers:	*Uranoscopus duvali*
Rabbitfish:	genus *Siganus*
Surgeonfish:	genera *Acanthurus, Ctenochaetus*

2.7.2.1. Stingrays (Rajiformes)

Biology: These cartilaginous fish feed on various marine animals. They are bottom dwellers and often bury themselves into sand or mud with only their tail, eyes and spirales exposed. Thus, they are easily overlooked and stepped on inadvertently.

Venom apparatus: Stingrays have one (or several) spines on the dorsum of their tail. When not in use the spine, which points backwards, is kept alongside the tail in a longitudinal depression or cuneiform area. The spine is covered by an integumentary sheath and shows two longitudinal grooves on its lower side. It is there that the venomous glandular cells are concentrated.

Stingrays may inflict bad wounds, usually when marched on, by erecting the spine and thrusting the tail sidewards or up. When the spine penetrates a victim's skin, its integumentary sheath is damaged and, thus, venom is released into the wound.

Venom: It is likely that the venom contains proteins besides serotonin and some enzymes.

Medical significance: 750 cases of stingray injury are estimated to occur yearly in the USA. No figures are available for other places in the world. The main result of a sting is extreme pain. Death cases have been reported.

Prevention: Shuffling one's feet along the bottom is recommended in areas where stingrays occur. Also, a stick may be used to probe the bottom while wading in shallow water.

2.7.2.2. Catfish (Siluroidei)

Biology: There are marine and freshwater species. Most of them are carnivorous bottom feeders.

Venom apparatus: It consists of a single dorsal and a pair of pectoral stings, as well as venom glands. The stings are hollow and composed of a number of coalesced ossified rays. They show longitudinal rows of retrorse hooks on anterior and posterior ridges and can be locked in an upright or extended position by a special mechanism. They are covered by an integumentary sheath which contains sheet-like masses of venom producing cells. In addition to these, in some species, axillary glands are found at the base of each pectoral fin. An excretory canal opens onto the dorsal side of each pectoral spine.

Venom: Its chemistry is unknown. It is said to have neurotoxic and haemotoxic properties in Plotosid species.

Medical significance: Negligible as a public health problem. However, stings may be violently painful and wounds may take several weeks to heal. Human fatalities are said to occur due to *Plotosus* stings.

Local fishermen claim that *Synodontis zambesensis,* a fish readily eaten and very common in the Kilombero River in SE Tanzania, is venomous too. In experiments with two human volunteers the author was unable to demonstrate any ill effects due to treatment of the scarified skin with a crude homogenate of integumentary sheath. Also, there was no evidence of axillary glands.

2.7.2.3. Scorpionfish (Scorpaenidae)

Biology: They all are poor swimmers. Most of them live in shallow waters, in coral reefs. They may lay motionless, either in coral crevices, under rocks, among debris or buried in sand. *Pterois* may, at times, be seen hovering around. *Scorpaena* and *Synanceja* blend extremely well with the surroundings; *Synanceja* may even be covered by algae. They all are carnivorous and feed on invertebrates or other fish.

Pterois and *Scorpaena* may "counter-attack" in self-defense.

Venom apparatus: It may be considered to be the most highly developed among fish, possibly at the exception of Batrachoid fish (where the hollow spines serve for venom injection). It includes 12–13 dorsal, 3 anal and 2 pelvic spines, enveloped in their integumentary sheaths, harbouring the pair of fusiform glands in the two antero-lateral grooves. Largest are the glands of *Synanceja,* which also show a venom duct each.

Venom: It is believed to be of protein nature.

Medical significance: Scorpionfish are not considered to present a public health problem. Victims, however, experience excruciating radiating pain and may suffer from primary shock, nausea, diarrhea, generalized weakness and paralysis of the limb affected. In severe cases there may be respiratory distress, convulsions and death.

Prevention: Extreme care should be observed when handling any such fish. Neither *Pterois* nor *Scorpaena* should be approached to closely as they may suddenly erect their fins and behave "aggressively". If possible, one should drag one's feet when wading through an area inhabited by stonefish; these will not move, but rather erect their dorsal spines at the approach of a potential enemy such as man. The spines may easily penetrate rubber soles or divers' fins.

For First Aid Treatment see p. 438.

3. Land-dwelling Arthropods

3.1. Scorpions (Scorpiones)

Taxonomy: 6 families, two of which (Buthidae, Scorpionidae) are represented by at least 23 species in EA.

Biology: Scorpions lead a hidden life, are thigmotactic, depend upon microclimatic conditions, are nocturnal predators, whereby prey is caught with pincers and chewed with cheliceres.

General morphology: See Fig. 9.

Venom apparatus: Complete, consisting of post-abdominal appendage (telson) with dart, containing one pair of glands, with separate excretory ducts, leading to two separate orifices in a supraterminal position (see Fig. 10).

Venom: The chemical composition of neurotoxins of a few species dangerous to man has been elucidated. These are chains composed of 63–64 amino-acids, including 4 sulphur double-bonds. Besides these substances, 5 hydroxytryptamine and a few enzymes seem to be present in the venom of various species. Venom composition of species non-dangerous to man is almost unknown.

Functions: Presumably primarily the overwhelming of prey despite the exceptional location of the venom apparatus. Most EA-species sting reluctantly, for obtainment of prey as well as for self-defense.

Medical significance: Negligible in tropical Africa (the effect of a sting is often compared to one by a single bee). Very important for children up to ten years in Central- *(Centruroides)* and South- *(Tityus)* America as well as in North-Africa and the Near-East *(Androctonus, Buthus, Leiurus).* Of some importance in S-Africa *(Parabuthus).*

Prevention: After night beat out shoes before putting them on. Do not walk bare-footed inside dark houses.

3.2. Spiders (Araneae)

Taxonomy: The taxonomy of the group is still subject to discussion. For practical purposes it may be sufficient to state that in EA representatives of two sections are found, of the *Orthognatha* (Mygalomorpha, "birdspiders", "tarantulas") (see Fig. 11) and of the *Labidognatha* (Araneomorpha, "true spiders") (see Fig. 12).

Biology: All spiders lead a predatory life. They display, in the various taxonomic groups, a wide behaviouristic spectrum with respect to the mode of capturing their prey. But, with rare exceptions, they all kill it with their venom apparatus. In addition, venom seems to play an important role for its extracorporal predigestion.

General morphology: See Figs. 11 and 12.

Venom apparatus: Complete, consisting of (i) a pair of glands, located in the paturon (basal segment) of the cheliceres (Orthognata), or in the cephalothorax (Labidognatha), respectively; (ii) excretory ducts leading from the glands to the orifice in "supraterminal" location on each unguis (claw) of the cheliceres; (iii) means of application in the form of the two cheliceres' claws.

Venom: The composition of spiders' venom is far from known. Many venoms seem to contain biogenic amines, polypeptides and various enzymes. Speaking in general terms, there exist two categories of venoms: preponderantly neurotoxic, leading to paralysis, and, preponderantly (haemo-) cytotoxic, leading to shock and necrosis.

Main function: To capture, kill and predigest prey.

Secondary function: Self-defense. With regard to man it is questionable, for the vast majority of spider species, whether they normally use quantities potentially dangerous. Observations seem to indicate that they rather apply no or little venom, sufficient only to deter the enemy.

Medical significance: Negligible in tropical Africa (although some spider species are known to produce venoms highly neurotoxic in laboratory animals). Important in N-America, Europe and Southwestern Africa *(Latrodectus)*, in S-America *(Ctenus* syn. *Phoneutria, Loxosceles, Lycosa)* and Australia *(Atrax)*[1].

Prevention: As for scorpions. In addition, inspect seat (in car, privy, etc.) whenever you want to sit down.

3.3. Ticks (Argasidae and Ixodidae)

Soft ticks (Argasidae) as well as hard ticks (Ixodidae) are to be considered as ectoparasites rather than venomous animals. Yet, the following Ixodid species are known to be the causative agents of "tick

[1] Solifugidae, known as "hunting spiders" in some areas, do not belong to the Araneae and have no venomous apparatus. They may bite man, but not envenomate him.

paralysis" in domestic animals and, occasionally, man – a phenomenon which, to the biologist, is merely a side-effect of haematophagy:

Dermacentor andersoni	North-America
D. variabilis	North-America
Amblyomma spec.	North-America
Ixodes holocyclus	Australia
I. rubicundus	South-Africa

Tick paralysis is thought to be due to neurotoxins secreted in the ticks' saliva. In man, especially infants, the ascending paralysis is due to an engorging tick attached to the back of the neck, at the base of the head. One or two days after removal of the tick concerned, complete recovery usually follows.

3.4. Millipedes (Diplopoda)

Taxonomy: 7 orders, out of which mainly one (Opisthospermophora) is represented in EA (see Fig. 7).

Biology: Feed mainly on decaying plant material and vegetable mould. Quite dependent on ambient air humidity. Display positive geotaxis if air humidity gets to low. Therefore, to be seen mainly during and after rainy season.

General morphology: See Fig. 7. Of elongate cylindrical shape, multi-segmented, each segment with two pairs of legs. Cross-section round.

Venom apparatus: Incomplete, consisting of one pair of glands and excretory ducts in most body segments. These show one orifice on each side (foramina repugnatoria), without any means of application.

Venom: Organic compounds of low molecular weight, e.g. chinones. They cause yellow coloration, changing to red, of light human skin and cause a burning sensation upon contact with mucous membranes (e.g. on tongue).

Function: Determent of enemies.

Medical significance: None.

3.5. Centipedes (Chilopoda)

Taxonomy: 5 orders, one of which (Scolopendromorpha) is commonly known in tropical Africa.

Biology: Lead a nocturnal, predatory life.

General morphology: See Fig. 8. Body elongate, multisegmented, each segment with one pair of legs. Cross-section dorso-ventrally compressed.

Venom apparatus: Complete, consisting of a pair of maxillipedes, the transformed first pair of legs. Each maxillipede, in its basal part, contains a venom gland, with an excretory duct. It leads to the venom orifice located "supraterminally" on the distal, unguis-like, part of the maxillipede.

Venom: Known to contain, in certain species, histamin and various enzymes.

Main function: Analogous to spiders.

Secondary function: Self-defense. As a rule, these animals bite only when handled very roughly, e.g. when stepped on, or when insistently disturbed.

Medical significance: Negligible, though bites are said to be rather painful and to cause local haemorrhagies. (Laboratory mice may die in consequence of a bite and show haemorrhagies of the lungs.)

Prevention: As for scorpions and spiders.

3.6. Insects (Hexapoda)

The number of insect species is estimated at around one million. They are classified into some 35 orders, of which three comprise a number of species, relevant to man with respect to their toxic qualities: Hymenoptera (wasps), Coleoptera (beetles) and Lepidoptera (butterflies). As these exhibit very different venom apparatus they are to be presented separately.

3.6.1. Hymenoptera

Taxonomy and biology: Suborder Symphyta (sawflies, etc.). Oviposition in plants, including wooden parts, with the help of an ovipositor. No venom apparatus.

Suborder Heterophaga (Terebrantes). Oviposition on or in either live plants or animals (e.g. caterpillars, spiders) with an ovipositor, combined with venom glands.

Suborder Aculeata (wasps, ants, bees, etc.). Oviposition independent of ovipositor, which acts only as a dart.

Hymenoptera are holometabolous insects, i.e. they pass through a complete metamorphosis, in which the larva is very different from the adult and in which there is always a pupal stage.

Venom apparatus: Complete, with the exception of two subfamilies of ants, where the dart is rudimentary (Dolichoderinae) or missing altogether (Formicinae) as well as of one subfamily of bees (Meliponinae, stingless bees, present in EA). Found in the female sex exclusively, in sexually functional females as well as in sexually non-functional "soldiers" and "workers"; located in the abdomen, in the context of, or, derived from the female reproductory organs. Composed of tubular glands, accessory glands, a venom reservoir and a complex sting apparatus. In the Aculeata, when not in use, the sting is concealed in the dart chamber. In the honeybees the sting bears hooks.

Venom: Best known for European honeybees (*Apis mellifera mellifera*), apparently quite similar in bulldog-ants (*Myrmecia pyriformis*) and of comparable composition in various wasps and hornets (Vespidae). In honeybees the most important substance is "Melittin", a basic polypeptide composed of 26 amino acids. It causes direct haemolysis, liberates pharmacologically active substances in the human organism and affects parts of the musculature, including the heart. Beside that, bee venom contains histamine, a causative agent of pain, enzymes, mainly hyaluronidase, acting as a "spreading factor" for the active venom components, and phospholipase A, which strongly affects the permeability of various cell membranes and, thus, leads to indirect "lysolecithin haemolysis" and promotes shock conditions. Vespidae venoms contain additional biogenic amines, such as serotonin (wasps) and serotonin as well as acetylcholine (hornets).

Functions: Evolution of the Hymenoptera group brought along changes in the functions of the venom apparatus. While the Symphyta show no venom apparatus at all, the Heterophaga clearly use theirs to provide their offspring with food. It is noteworthy that in various instances the venom does not kill but rather preserves the victim alive, though in a state of paralysis, until it is eventually eaten up by the "heterophagous" larvae before pupation.

Among the Aculeata, in some families the insects use their venom to obtain food for themselves as well as for the offspring. Care for progeniture and obtainment of prey may, thus, not be distinguished. Parallel to the loss of the predatory mode of life, in the two subfamilies of ants mentioned above, is a tendency to reduce the dart and, simultaneously, a change to a purely defensive function of the venom apparatus. Similarly, the venom apparatus assumes defensive functions only in bees, whereby in the subfamily of the Meliponinae, again, no sting is left. On the other hand, in the honeybees, the sting is even more developed in that it has hooks. If the enemy is a vertebrate, the dart frequently remains stuck in its skin. The consequence may be fatal to the bees concerned, a phenomenon which is compatible only with life in large social groups, where the loss of even numerous individuals is less important than the survival of the whole colony.

Medical significance: As a rule, single hymenopteran stings are harmless, though possibly painful. But, if the patient is either stung in a particularly susceptible place, e.g. inside the throat, or else, if the patient happens to be hypersensitized, even a single sting may be highly dangerous. The main reason, however, why hymenopterans regularly cause a limited number of deaths is because bees often "attack" in large numbers. Envenomation, then, may lead to a fatal failure of the kidneys.

Prevention: Whenever possible, keep off swarms and hives. – Avoid provoking bees or wasps, especially with smoke, petrol, insecticides, sweat odour, etc. If a nest or hive has been built in a human habitation and must be removed, have it done at night (when bees cannot orient themselves) and, if possible, by a (naturally) immunized person.

If "attacked" – the African bee *Apis mellifera adansoni* is said to be more "aggressive" than its European counterpart *A.m. mellifera* and, also, to cause more vicious stings – run as fast as you can into the nearest shelter, e.g. a house, car, pond, ditch or any shaded place. Is there no shelter available, lie down and remain motionless until the insects quiet down and leave the place.

For First Aid see p. 439.

3.6.2. Coleoptera

Taxonomy: About a quarter of a million species. The following examples necessarily remain incomplete.

General morphology: The fore-wings are thickened to elytra or covers which protect the membranous hind-wings.

Biology: Holometabolous insects. The mode of feeding of larvae and adults varies from one group to another.

Venom apparatus: There exist various venom apparatus. Also, besides venomous species poisonous beetles seem to exist. One has to admit, though, that it is not easy in all cases to clearly distinguish between venomous and poisonous beetles.

P-beetles: *Diamphidia simplex* (poison arrow beetle), the larvae and pupae of which are used by Bushmen in the Kalahari to prepare poison arrows. Toxicity depends on the food plants of the larvae.

P- and/or VD-beetles: *Meloidae* (oil beetles and blister beetles), the haemolymph of which contains cantharidin. This substance may act perorally, or, upon contact with skin, when beetles either are crushed or when they release haemolymph through joints.

VD-beetles: *Staphylinidae* (rove beetles), the haemolymph of which contains pederin. It, too, acts upon contact with skin.
Dytiscidae (water beetles) with prothoracic and pygidial or anal glands.
Brachyninae (bombardier beetles) among the *Carabidae* (ground beetles), with a highly elaborate pygidial apparatus; *Silphidae* (carrion beetles), *Elateridae* (click-beetles), *Tenebrionidae* (darkling ground beetles) and others, with more simple pygidial glands.

VP-beetles: *Dytiscidae* (water beetles), which lead a predatory aquatic life and the larvae of which have venomous mouth-parts.

Toxic substances: – unknown to the writer for *Diamphidia* (contained in sap of *Commiphora*-shrubs),
- cantharidin, pederin in haemolymph,
- derivatives of chinones in pygidial apparatus (*Brachyninae*),
- unsaturated fatty acids (*Carabidae*) or derivatives of benzoic acid (*Dytiscidae*) in anal glands,
- cortexone in prothoracic glands (*Dytiscidae*),
- unknown to the writer for VP-apparatus in *Dytiscus*-larvae.

Medical significance: When they occur in large numbers, Blister beetles and Rove beetles may become a nuisance; patients may suffer from painful inflammation and blisters and require medical care.

3.6.3. Lepidoptera

Among the estimated 140,000 species of butterflies and moths, there are P-species (e.g. *Danais chrysippus* in South-western Africa), thus protected against predatory birds, as well as VD-species, whose caterpillars bear urticating hair (*Thaumetopoiidae, Lymantriidae, Lasiocampidae*) or venom spines (*Saturniidae, Megalopygidae, Limacodidae*). The medical significance of such caterpillars in EA is unknown to the writer. It is advisable to avoid contact with unidentified hairy caterpillars or with their cocoons.

4. Land-dwelling Vertebrates

4.1. Amphibians (Amphibia)

Taxonomy:

3 orders, of which Anura (Batrachia) only, i.e. frogs and toads, are frequently found in EA.

Venom apparatus:

Incomplete, consists of venom glands in the skin, often concentrated in specific spots, e.g. paratoids behind and above the eyes.

Venoms:

Besides some highly toxic substances recently identified in South-American Dendrobatidae, more generally, the following substances are so far known to occur in Anurans:
- Steroids, in part with Digitalis-like action on heart.
- Derivatives of 5-hydroxytryptamine (serotonin).
- Possibly amino acids, polypeptides and enzymes.

Function:

Self-defense, of limited efficiency.

Medical significance:

Practically none, due to the fact that the animals have no means to apply their venoms parenterally. The substances concerned have no effect on unbroken skin; they are painful, however, on contact with mucous membranes, and some are extremely dangerous when applied parenterally (poison arrows of South-American Indians).

Prevention:

Children should be told not to play around with either frogs or toads. Hands should be washed after handling these animals.

4.2. Reptiles (Reptilia): Ophidia (Serpentes, snakes)

Reptiles include the following orders: Rhynchocephalia (the Tuatara of New Zealand), Testudines (Chelonia, tortoises), Squamata (lizards, chameleons and snakes) and Crocodilia (crocodiles). It is emphasized here that, besides certain snakes, only one reptilian genus is venomous, namely *Heloderma* (Beaded Lizard), two species of which occur in the Southern USA and in Mexico. Despite a widespread belief to the contrary, no other reptiles, including the chameleons, are venomous.

4.2.1. Taxonomy

There are 7 families without any venomous representatives, three of which are found in Africa south of the Sahara (Typhlopidae, Blind

Snakes; Leptotyphlopidae, Flower pot snakes; Boidae/Pythoninae, pythons).

5 additional families group the venomous snakes, the vast majority of species being quite harmless. Of these the Crotalidae (rattle-snakes) are missing in Africa.

4.2.2. Biology and defensive behaviour

All snakes are carnivorous. Those with no or weak venom kill their prey by coiling up around the victim. Those with fast acting venoms bite once and release the victim until it dies. In all cases the snakes swallow their whole prey, what is rendered possible by movable quadrate bones and an elastic ligament uniting the two halves of the lower jaw.

Whether a snake bites in self-defense depends largely upon its "critical distance", i.e. the distance above which an animal flees in order to escape and below which an animal "counterattacks". It is, unfortunately, easily possible to pass over the critical distance without being aware of it, a situation which may lead to seemingly unprovoked attacks by the snake concerned. In addition, critical distances may vary, depending on several factors, e.g. on reproduction cycles.

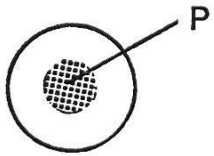
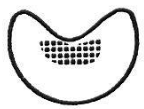
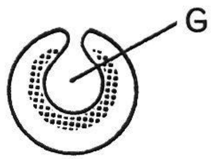
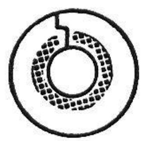
Before inflicting a bite in self-defense several snakes emit some warning signals. Boomslangs may inflate the throat, cobras spread it to a hood and puff adders may produce a hissing noise, the "puff". Instead of biting, the "Spitting Cobra" squirts little venom at its enemy, usually aiming at the eyes. It may bite in self-defense too, if caught and if the squirting has no effect. Also, most snakes seem to use comparatively little venom when biting in self-defense. (It is evident that, for obtainment of prey, no warnings are issued, no squirting of venom takes place, and venom is applied in quantities sufficient to kill the prey.)

4.2.3. Venom apparatus

Complete, consisting of a pair of venom glands in the upper jaws, below and somewhat behind the eyes, of excretory ducts, of one pair of functional fangs, the shape of which varies from one group to another (see Table 4) and of several pairs of spare fangs in various stages of development.

The Colubrinae are frequently called non-venomous. This is not correct, however, for all Colubrinae. Some, among them *Natrix tessellata,* definitely possess venom glands, although no grooved fangs. On each side the short efferent duct leads to a venom reservoir, the dental pocket, in which is located the solid last tooth. Together, venom reservoir and fangs form an application organ.

Table 4. Venomous snakes and characterization of their venom apparatus

Snake family	Type of venom apparatus	Venom fangs		Main venom action in man (natural conditions)	Examples of species
		Cross-section	Description		
Colubridae Colubrinae	aglyphous "non-fanged"		immovable, solid, placed in dental pockets	harmless	*Boaedon fuliginosus* (Common house-snake)
Boiginae	opisthoglyphous "back-fanged"		last teeth in upper jaws, immovable with rostral longitudinal groove	usually harmless,	*Psammophis sibilans* (Hissing sand-snake, sun-snake)
				exceptions haemorrhagic	*Dispholidus typus* (Boomslang)
Elapidae	proteroglyphous "front-fanged"		in front position immovable, rostal groove almost closed	neurotoxic	*Naja nigricollis* (Spitting Cobra) *Dendroaspis angusticeps* (Common Mamba)
Hydrophiidae				neurotoxic and myotoxic	*Pelamis platurus* (Yellow-bellied sea snake)
Viperidae	solenoglyphous "hollow-fanged"		in front position, erectile, channelled (hollow)	haemo-cytotoxic	*Bitis lachesis* (Puff Adder)

Note: The Crotalidae have been omitted for their absence from Africa. Explanation of diagrams: P = pulpa, G = venom groove.

Despite of their grooved fangs, most Boiginae are harmless to man (see Fig. 17); for it is exceptional that they insert their posterior fangs into the human skin when biting. In addition, their venom is said to be inefficient in man, though not much is known in this respect. There are exceptions, however, among tree snakes, which feed on fast animals such as birds or lizards. Most mentioned are *Boiga dendrophila,* the Mangrove-snake of SE-Asia and *Dispholidus typus,* the Boomslang of tropical and southern Africa. *Thelotornis kirtlandii,* the vine-snake, also present in EA, is sometimes referred to, although no serious accidents due to this snake seem to have been reported in the literature. There are several reasons for these snakes being potentially dangerous to man. The anterior half of their head seems somewhat shorter than in other Colubrids, and the posterior fangs are located comparatively far forwardly, almost beneath the eyes. Both factors make it easier for the snake to insert the venom fangs with the very first bite. Furthermore, in *Dispholidus typus,* the fangs show a blade-like ridge along one side of the groove, which may help penetration of the victim's skin. Lastly, from experience, the venoms of *B. dendrophila* and *D. typus* are known to act powerfully, even in man. (People most likely to be afflicted are those who handle snakes either professionally or for pastime).

Elapidae and Hydrophiidae have the same type of venom apparatus. Most developed is the one of the genus *Dendroaspis,* which again are arboreal snakes. In *Dendroaspis* the maxillary bones bear the one pair of venom fangs only (besides their spares) and are shorter than in other Elapids; thus, they are slightly movable, and, with the bones, the fangs can slightly be erected when it comes to a bite.

From a morphological viewpoint, the highest degree of perfection of the venom apparatus has been attained in the Viperidae. Here, too, the maxillary bones bear no more than the venom fangs (and spare-fangs), are square-shaped and highly movable. The fangs, thus, being erectile, can be much longer than in other snakes. The greatest size, in relation to body length, is found in the earth-burrowing vipers of the genus *Atractaspis.* These lead a subterraneous life, hunting for rodents in their burrows. The body is worm-shaped, with a narrow head. Because of the comparatively small size of the head the fangs can hardly be erected at all. However, they can singly be spread out, sidewards, of the mouth and hit a prey while the snake is by-passing it in the burrow, or hit the hand of a snake-collector when he keeps the animal in the usual fashion, behind the head. Special care is, therefore, necessary for the handling of burrowing vipers!

4.2.4. Venoms

Considerable work is actually being performed for further elucidation of the chemical properties of snake venoms. At the present stage of our knowledge, main components may briefly be summarized as follows:

Colubridae (?) and Viperidae: Mainly enzymes, acting as synergists, in part also polypeptides, e.g.

Enzymes

- Endopeptidases, possibly responsible for the release of bradykinin and, thus, responsible for pain, oedema, haemorrhagies, decreased blood pressure, contractions of unstriped muscles, etc.
- Exopeptidases, L-leucine aminopeptidase *(Natrix tessellata).*
- Proteinases, e.g. Protease A *(Bitis lachesis),* responsible for digestion of certain proteins,
  e.g. with Arginin-ester-hydrolyse activity, responsible for formation of intravascular thrombi, haemolysis, haemoglobinaemia, haemoglobinuria, afibrinogenaemia and loss of coagulation *(Dispholidus typus).*
- Phospholipase A, responsible, in combination with other factors, for various effects, among which haemolysis (see below).

Viperotoxin, a polypeptide, molecular weight 12,212, composed of 108 amino acids *(Vipera palaestinae).*

Elapidae and Hydrophiidae: Mainly polypeptides ("neurotoxins" and "cardiotoxins") and the enzyme phospholipase A:

Neurotoxins: polypeptides, composed of 61–71 amino acid residues, of molecular weight 6,300–7,400, with 4 disulfide bonds, with reversible, postsynaptical antidepolarizing effect on neuro-muscular junction (*Naja nigricollis, N. naja atra, Dendroaspis, Laticauda semifasciata, L. laticauda* and others).

Cardiotoxins (Direct Lytic Factor or DLF, Cobramine, Cytotoxin, Toxin γ): strongly basic polypeptides, composed of 57–62 amino acid residues, of molecular weight 6,000–7,000, with 4 disulfide bonds, causing irreversible depolarization of cell membranes of various kinds of cells, including heart muscle cells, and potentiating some effects of phospholipase A.

Phospholipase A: synergistic with DLF, causing indirect haemolysis, vascular haemorrhagic effects and affecting blood pressure as well as frequency and volume of respiration.

4.2.5. Functions

- to immobilize, kill and predigest prey,
- to deter enemies.

Where venoms are mainly composed of enzymes, immobilization is due to shock; where the main components are neurotoxins, immobilization is caused by paralysis.

For determent of enemies infliction of pain is sufficient. As was mentioned earlier, in self-defense, snakes apply often small quantities of venom only. But, if highly excited, they may, of course, inject large quantities. The very fact that variable venom quantities are used against enemies explains the numerous contradictory reports about consequences of envenomations.

4.2.6. Medical significance

The following are some of the potentially dangerous snakes present in EA:

Colubridae	*Dispholidus typus*	Boomslang	throughout EA
Elapidae	*Boulengerina annulata*	Water Cobra	Lake Tanganyika
	**Dendroaspis angusticeps* (see Fig. 19)	Common (Green) Mamba	Coasts of Kenya, Tanzania incl. Zanzibar
	**D. jamesoni*	Jameson's Mamba	Burundi, W-Kenya, Ruanda, Uganda
	**D. polylepis*	Black Mamba	Kenya, Tanzania
	Naja haje	Egyptian Cobra	Kenya, N-Tanzania Uganda
	N. melanoleuca	Black (Black-lipped) Cobra	throughout EA
	**N. nigricollis* (see Fig. 18)	Spitting (Black-necked) Cobra	throughout EA
Hydrophiidae	*Pelamis platurus*	Yellow-bellied Sea-snake	Kenya-coast (rare)
Viperidae	*Atheris nitschei*	(Mt. Rungwe) Bush Viper	Burundi, Ruanda, W-Tanzania, Ugand
	A. ceratophorus		Usambara Mountai
	A. squamiger	Green Bush Viper	W-Kenya, Uganda (?)
	Atractaspis bibronii	Burrowing Viper	throughout EA
	Bitis gabonica	Gaboon Viper	Tanzania, Uganda
	**B. lachesis* (syn. *arietans*, see Fig. 20)	Puff Adder	throughout EA
	B. nasicornis		Burundi, W-Kenya, Ruanda, Uganda
	Causus rhombeatus	Rhombic Night Adder	throughout EA
	Echis carinatus	Saw-scaled Viper	N-Kenya, Uganda
	Elapsoidea sundevallii	EA-Garter-Snake	throughout EA
	Vipera hindii		Aberdare Range
	V. supeciliaris		SW-Tanzania (Mwaya)

Most accidents which make medical assistance really necessary are likely to be due to one of the species marked with *. The other species are either rare, live with no contact with man, avoid him (*D. typus*), or dispose of venom inefficient in man (*C. rhombeatus* and related species).

As to Sea-snakes, *P. platurus*, the most widely distributed species, known to have caused human fatalities, has been reported from Madagascar, the Seychelles, Somalia and S-Africa and, so far, exceptionally only from Kenya.

N. nigricollis, fortunately, has adopted the squirting method. If it bit, many more serious accidents might occur. Eyes, when hurt by its venom, must be treated (s. p. 439).

The *Dendroaspis* species named above are the most dangerous of the snakes mentioned. Action of their venom may be extremely rapid and lead to respiratory failure within less than half an hour (exceptionally within a few minutes).

B. lachesis is a sluggish snake and may easily be overlooked. It is very fast in striking, though. In man its venom acts more slowly, but may lead to considerable necrosis if the bite is not treated adequately. *B. gabonica* does not seem to be frequent, although it may be distributed more widely than usually supposed. (One specimen was seen by the author in 1970, after it had been killed in a bush-clearing operation N of Ifakara, Ulanga District, Tanzania.) Its venom is said to be composed of potent neurotoxins as well as of haemo-cytotoxins. This seems equally to apply to *B. nasicornis.*

According to an estimate published by WHO in 1963 between 400 and 1,000 people die yearly from snake bites in the whole of the African continent. This figure may be too low, but, at any rate, compares favourably with the 30,000 fatal cases known to occur each year in India and Burma. Also, from clinical experience, today the view is generally accepted that 75 % of bites due to potentially dangerous snakes entail no serious envenomation. This is not to say that snake bites should not be taken seriously, but rather that prognosis is generally far better than patients fear, and that physicians ought to carefully appreciate each case before submitting patients to a treatment possibly more dangerous than the bites to be cured.

For First Aid Treatment see p. 439.

4.2.7. Prevention

- Around your house, remove shrubs and keep grass short.
- Step down firmly when walking outdoors. Most snakes will then flee.
- When stepping over stones or fallen trees, step first on top of the obstacle and make sure there is no snake on the other side.
- When lifting stones of wooden logs, lift them towards you, so as to open a gap leading away from you. A snake may be resting underneath and would bite if it found itself suddenly faced with your feet.
- Beware of "empty" boxes or cases in storehouses!
- If you meet a snake – which is seldom the case – at near distance, stand still und wait for the snake to move off. If it does not, step back slowly.
- If you meet a "dead" snake, do not touch it, before you have made sure it is dead. If so, avoid contact with its fangs.

5. First Aid Treatment

5.1. Introductory remarks

It is beyond the scope of the present paper to discuss actual medical treatment. Members of the medical profession are referred to the special literature. By First Aid Treatment are meant "mesures taken by the victim or associates prior to receiving medical treatment" (H. H. Reid, personal communication).

Fatal accidents with either poisonous or venomous animals are rare. Also, neither poisons nor venoms were evolved with special respect to man. In no instance is man ever considered as prey by a VP animal. Yet, man undoubtedly represents one of the most potent enemies of any other living creature. Acts of self-defense, therefore, are meaningful. Much depends on the amount of toxin involved. As to poison, for the quantity ingested, it depends on man how much of the animal concerned he ingests. Similarly, where VD animals are involved, it largely depends on him, how large venom quantities are used. The closer his contact with the animal, the more venom is likely to be applied. Unlike with P- and VD-animals, with VP-animals the venom quantity invested, to a large extent, depends on the animal. As a rule, it is thought that in self-defense VP-animals apply only comparatively little venom. Such behaviour would make sense as it allowed the animal to keep its venom rather for obtainment of food. Also, for simple determent, no maximum effects of venom, i.e. to kill the enemy, is necessary. The defensive behaviour of numerous snakes and arthropods seems to support this view. It also helps to explain the many contradictory reports on the toxicity of certain species of venomous animals.

The sequels of intoxication to be counteracted immediately, i.e. prior to actual medical treatment are fear of death, irrational behaviour and, often, pain. In rare instances severe symptoms such as respiratory distress and shock may necessitate quick action. In addition, all measures should be taken to avoid aggravation of the situation, e.g. secondary bacterial infections should be prevented by normal desinfection procedures. Steps to be taken are:

- Fright, anxiety: Remain calm yourself and reassure the patient. Have him lie down.
- Pain: Alleviate pain with whatever means are at your disposition, with the exception of opium and its derivatives.
- Respiratory distress: Facilitate respiration by conveniently laying down patient in a well aerated place. Open collar and tie if present.
- Shock: Allow patient to drink, either water, tea or coffee, but no alcoholic beverage. (Never force liquid down the throat of a patient who has lost consciousness!)

  Keep patient moderately warm.

- Further treatment: Bring the patient to the nearest doctor. Inform the doctor about date, time, conditions of the accident and previous treatment. Bring him whatever is left of the causative animal for further identification.

5.2. Poisonings

- Cause patient to vomit upon the first signs of poisoning.
- Bring him to the nearest doctor.
- Where needed, combat shock and apply artificial respiration (mouth to mouth or mouth to nose).

5.3. Envenomations

5.3.1. Marine accidents

General rules
- Get patient out of the water!
- If he was drowning, prevent suffocation.
- Try to ascertain the causative agent.
- Act according to the particular rules.

Particular rules

Jellyfish, Bluebottle
- Remove adhering tentacles from patient with sand, brush, towel or other available material. (Be careful not to be stung yourself!)
- Apply alcohol, sun lotion, oil or other available stuff onto affected skin areas, in order to impede remaining nematocysts.
- If available apply oral antihistamine or topical antihistaminic cream.
- Bring patient to the nearest doctor.

Coral cuts
- Wounds are to be cleansed from debris and painted with desinfection solution at once.

Cone snails
- Act as for snakes, with neurotoxic venom.

Sea urchins
- For removal of non-venomous spines apply adhesive plaster. Exchange it every 24 hours. After a few days no spines will be left in the skin.
- *Diadema* – spines must be removed surgically. Consult your doctor.
- Adhering pedicellariae must be removed promptly as they continue to introduce venom into the wound, even after separation from the animal.

Venomous fish
- Immediately rinse the wound with sea water.
- Remove what you can from debris of integumentary sheath.
- Soak the affected limb in water, as hot as the patient can bear, for approximately half an hour.

- Call for a doctor or prepare for transport to hospital in the meantime.
  (Stonefish Antivenene is produced by the Commonwealth Serum Laboratories, Melbourne, Australia.)

5.3.2. Arthropod envenomations

Various arthropods
- Remember that in EA bees only present real danger to man.
- Apply antihistaminic ointment or oral antihistamines.
- In doubtful cases consult your doctor.

Bees
- Remove remaining stings with fine forceps. As the venom sac often remains attached to the sting, the use of larger forceps or even fingers leads to compression of the venom sac and, thus, to further venom injection.
- Treat as for other arthropods.
- In severe cases bring patient to the nearest doctor.

5.3.3. Snake bites

More than 30 min. since accident occurred:
- If symptoms of any kind are observed, transport patient to nearest doctor or hospital; to this effect put affected limb into splints as for a bone fracture.
- Otherwise paint site of the wound(s) with desinfectant tincture.

Less than 30 minutes since accident occurred:
- Try to get hold of the snake which has bitten.
- If its venom is NEUROTOXIC apply a tourniquet or ligature above the bite. It should interrupt the venous and lymphatic, but not the arterial flow; the skin must take on a bluish appearance but never become white. The ligature must be loosened every 15 minutes for one minute. Is the venom HAEMOCYTOTOXIC do not apply a ligature.
- Wipe off venom which remained on the patient's skin.
- Immobilize affected limb as in the case of a bone fracture.
- Transport patient to the nearest doctor or hospital.

5.3.4. Snake "spits" (by Spitting Cobra, Naja nigricollis)

- Rinse hit eye(s) immediately with water (or, if no water is available, with any watery liquid, incl. e.g. breastmilk) to dilute venom as much as possible.
- Lead patient to nearest doctor.

5.3.5. Some "don'ts"

Do not
- incise in order to suck out venom.
- cauterize woundsite.
- rub potassium permanganate crystals into the wound.
- apply ice ("cryotherapy").
- inject antivenin unless you underwent specific training and know about the risks involved in serum application.
- rely on local medicine. All laboratory experiments carried out so far showed the "drugs" concerned to be ineffective. However, this is not to say that their psychic effect is negligible. In desperate situations everything must be applied which may reasonably be assumed to improve conditions.

Acknowledgments

I am grateful to Mr. B. Perret who read through the manuscript and made valuable suggestions. I thank Mr. J. Gysin and Dr. P. Probst who took several pictures now shown in this paper. I am indebted to Dr. F. Markwalder for a serie of photographic slides of marine animals in their natural habitats. I also thank Comet-Photo, Zurich, for permission to use one of their photographs, and Pergamon Press Inc., London, for permission to reproduce a diagram out of one of their publications. Finally, I wish to express my gratitude to all those who in some way or another helped me in the realization of the present review.

Literature

Literature on the subject of toxinology is as abundant as widespread. A very limited selection of titles, either of general interest, or of particular use in East Africa, is offered here. It should though render access easy to students interested in the subject of toxinology.

Whoever wants to follow current progress in the field, should consult TOXICON, the official journal of the International Society on Toxinology (published by Pergamon Press; Oxford, London, New York, Paris). Beside that, the reader is referred to the following publications:

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Legend to photographic plates

General remarks

- All figures depict live specimens, at the exception of fig. 9 and 10 (scorpion and sting).
- All marine animals are from the coast off Dar es Salaam, at the exception of fig. 15 (puffer fish) taken off Tanga.
- All arthropods are from Ifakara, SE Tanzania.
- All snakes are from Ifakara, SE Tanzania, at the exception of the mamba, fig. 19, which was commercially available in Switzerland.
- All pictures were taken by the author and his staff, at the exception of fig. 7 and 15 (by courtesy of Comet-Photo AG Zürich, and Dr. F. Markwalder, Zürich, respectively).

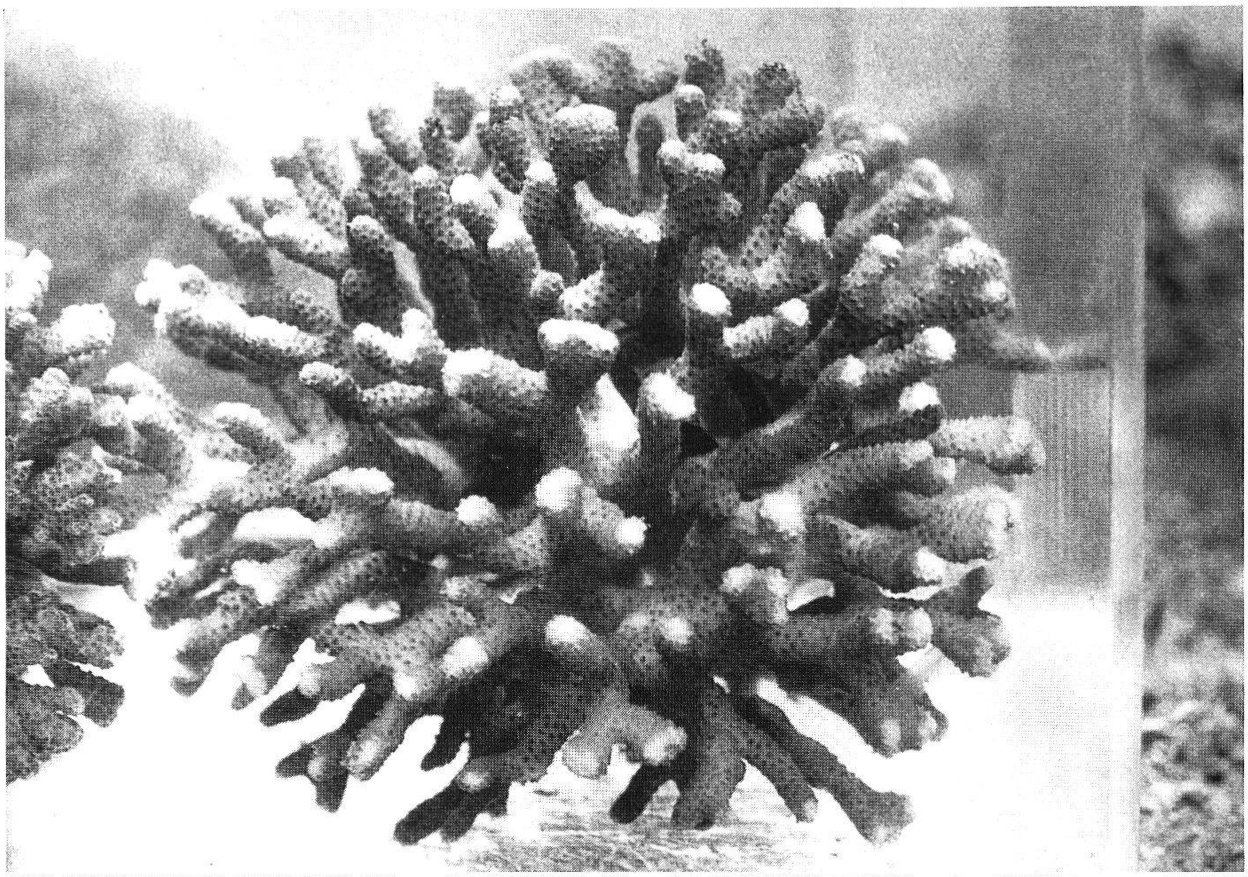
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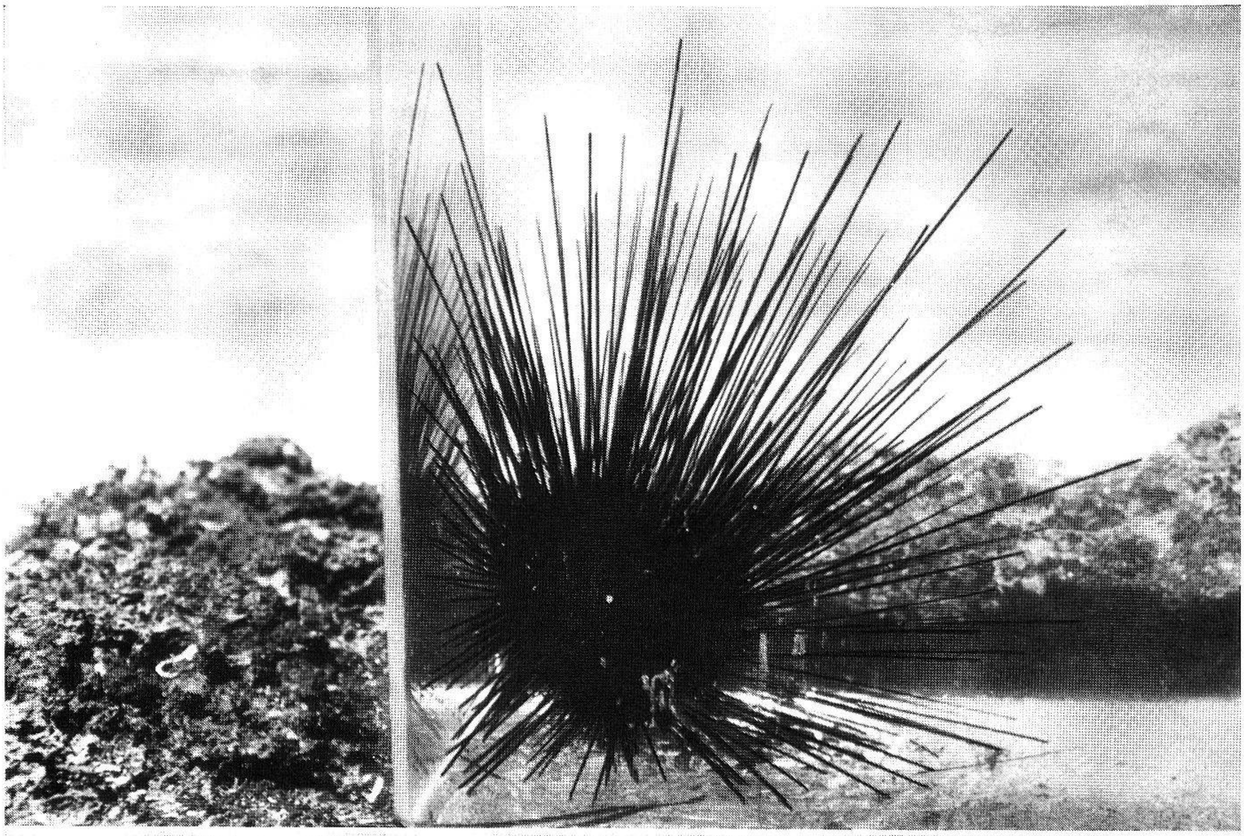
Fig. 1. Madreporarian coral (undetermined). Diameter approx. 12 cm. Note integument covering calcareous skeleton. Polyps are hidden in the numerous integumentary depressions.

Fig. 2. Sea cucumber (undetermined) in its natural habitat. Body length approx. 15 cm. Note excretion of Cuvierian organs from anal pole, in the form of white, viscous threads.



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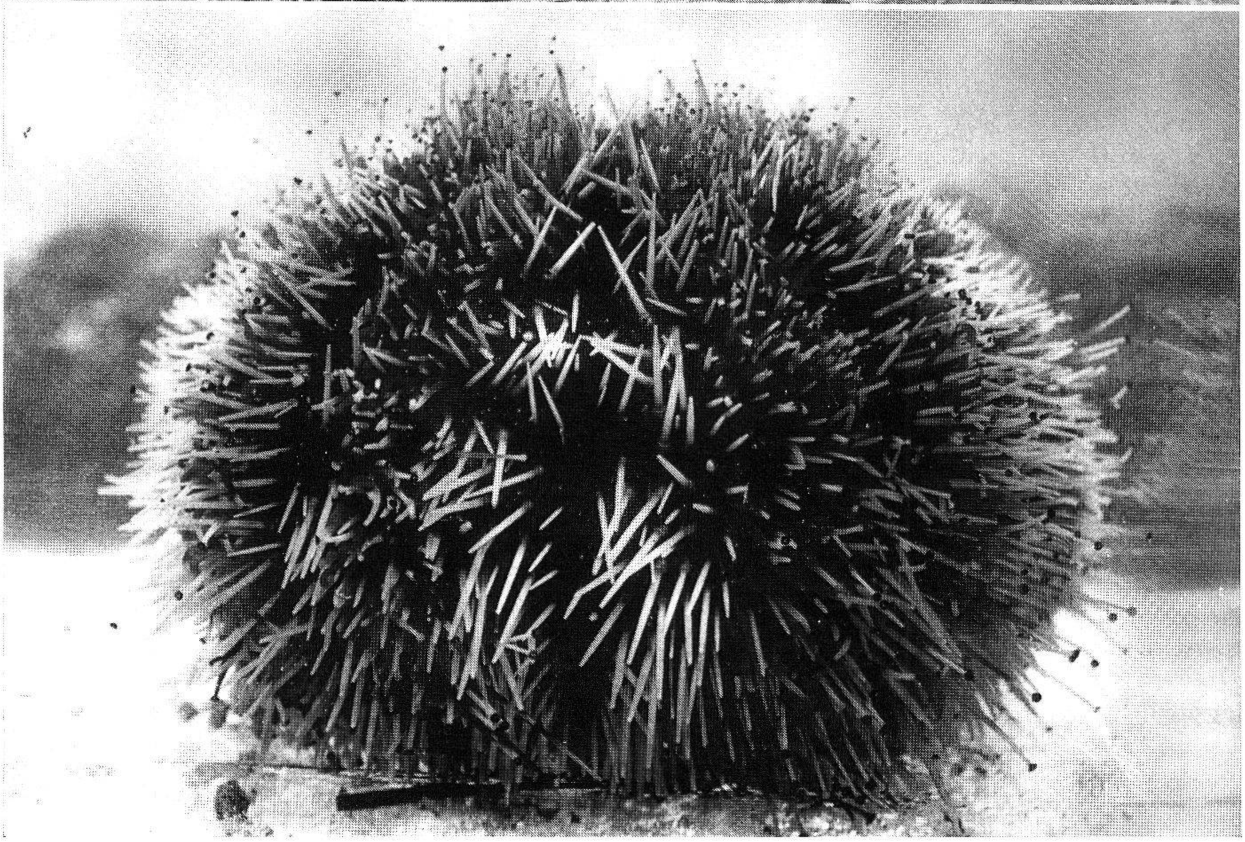

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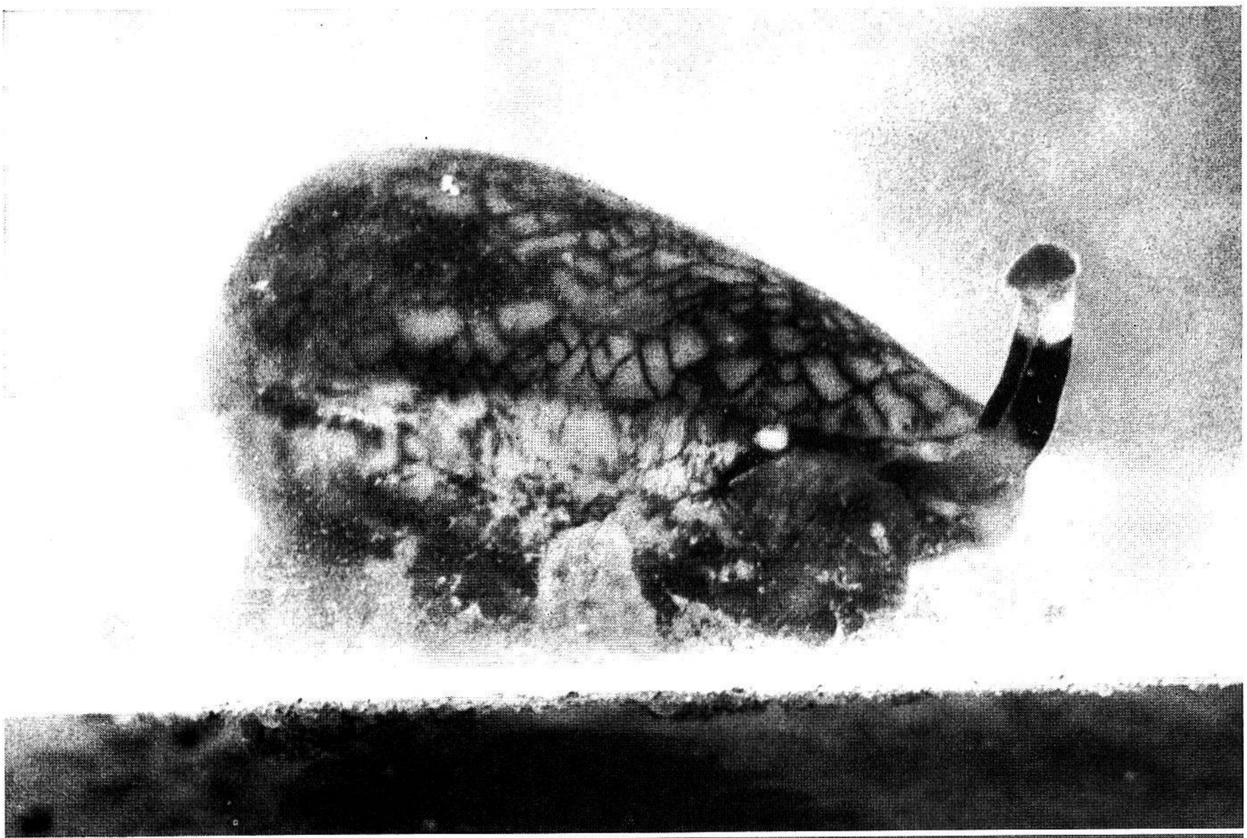
Fig. 3. Diadema setosum. Length of longest spines up to 30 cm.

Fig. 4. Tripneustes (?) gratilla. Diameter approx. 9 cm. Note comparatively short spines, and, rising above them ambulacral tube-feet. Pedicellariae are distributed all over the interambulacra, between the spines but too small in this species to be seen clearly in the photograph.



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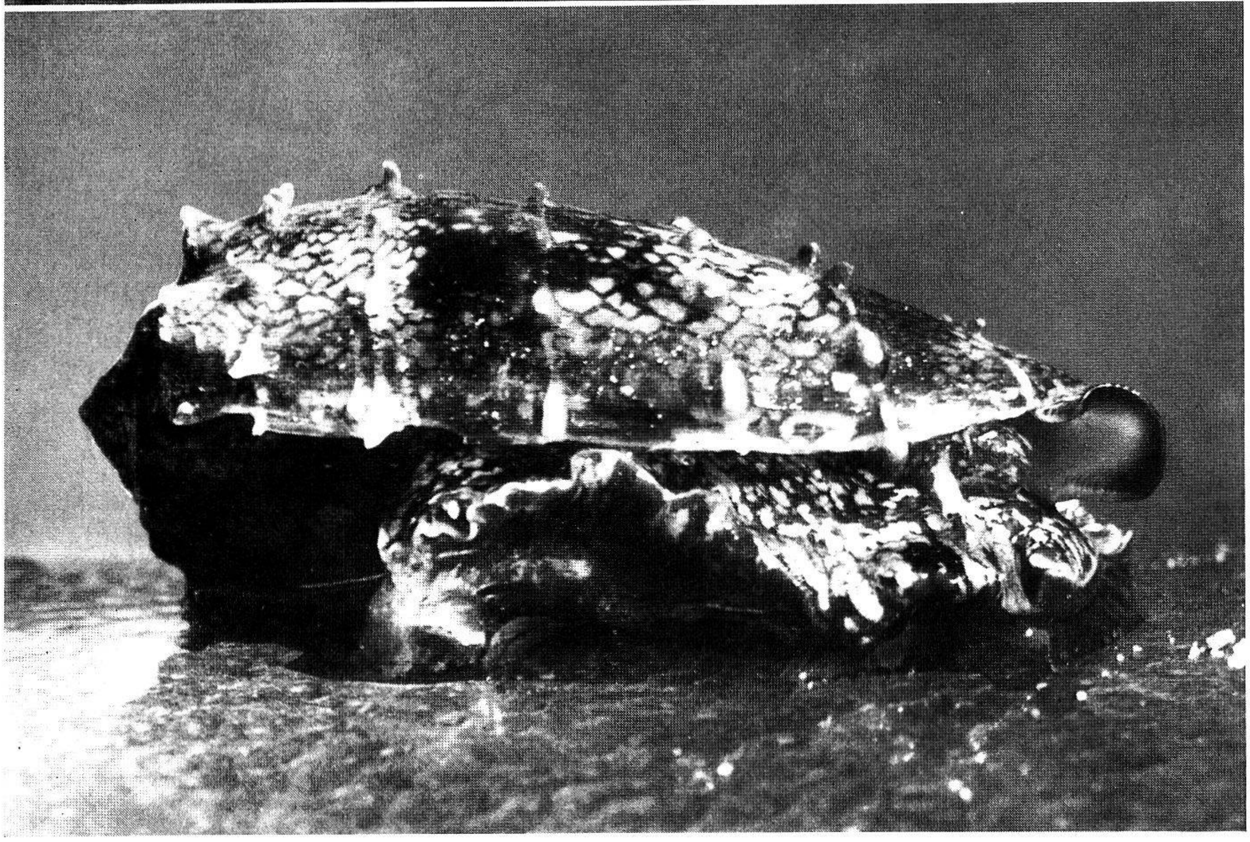

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Fig. 5. Conus textile. Shell length approx. 6 cm. Note extended black/white/red siphon. The proboscis can be extended from underneath siphon.

Fig. 6. Conus geographus, outside water. Shell length approx. 8 cm. Note black/white siphon and rows of small bristles on periostracum.

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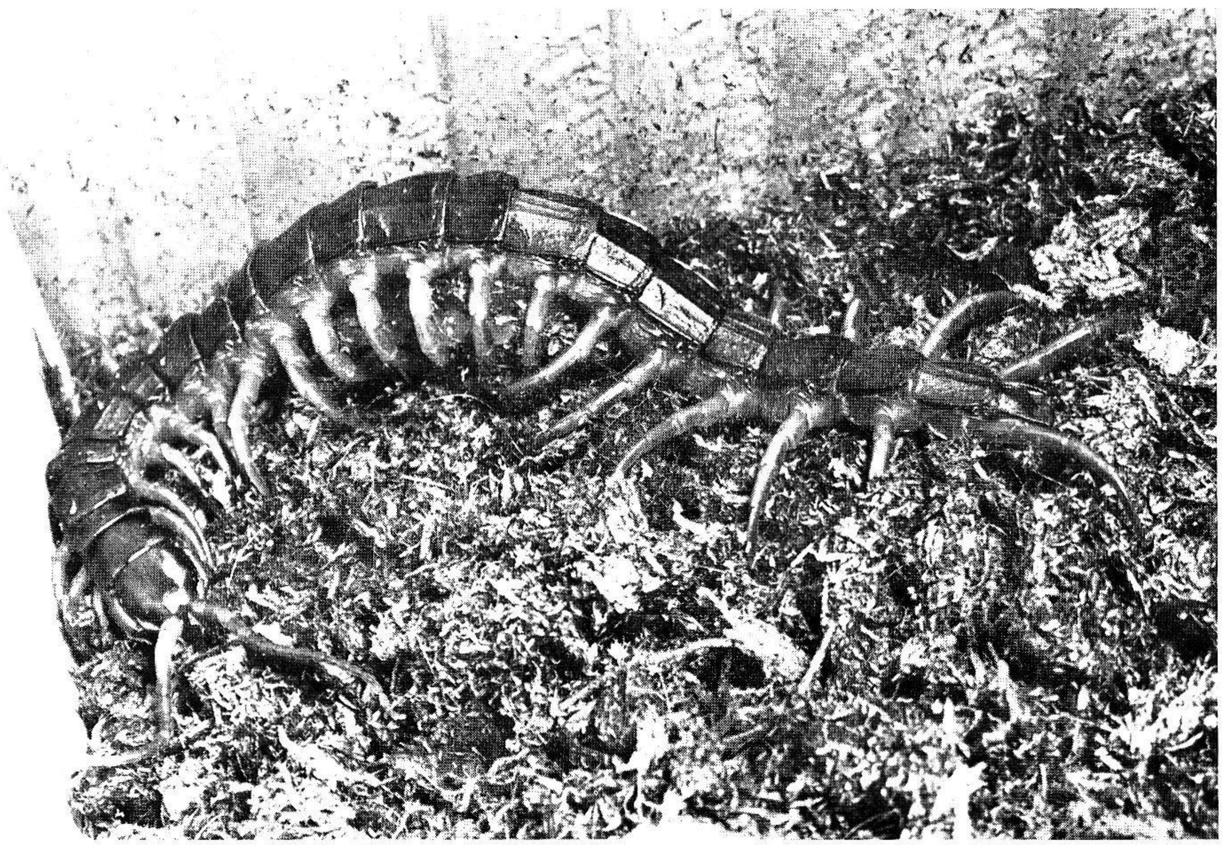

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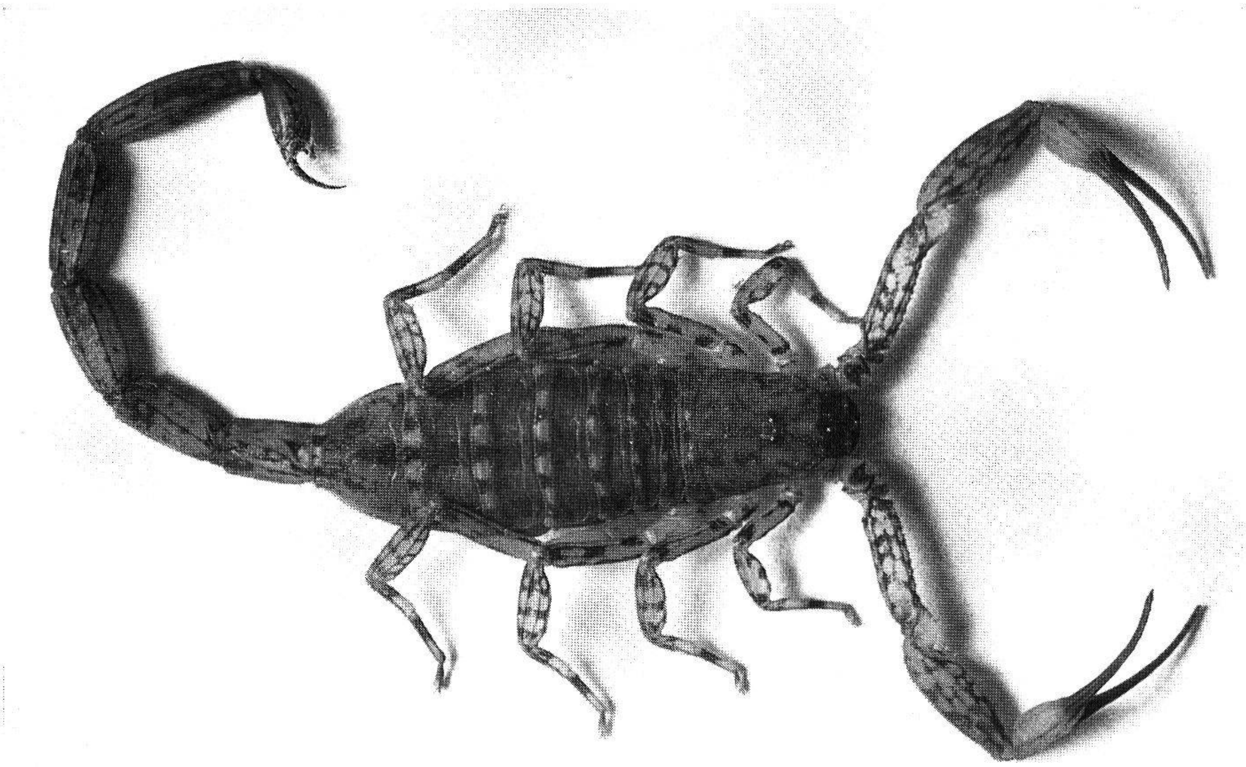
Fig. 7. Millipedes, *Spirostreptus* spec. Adult body length approx. 15 cm, diameter approx. 1.5 cm. (By courtesy of Comet-Photo AG, Zürich.)

Fig. 8. Female centipede, *Ethmostigmus* spec. Body length approx. 12 cm. Note egg packs carried along by five pairs of legs of middle segments.



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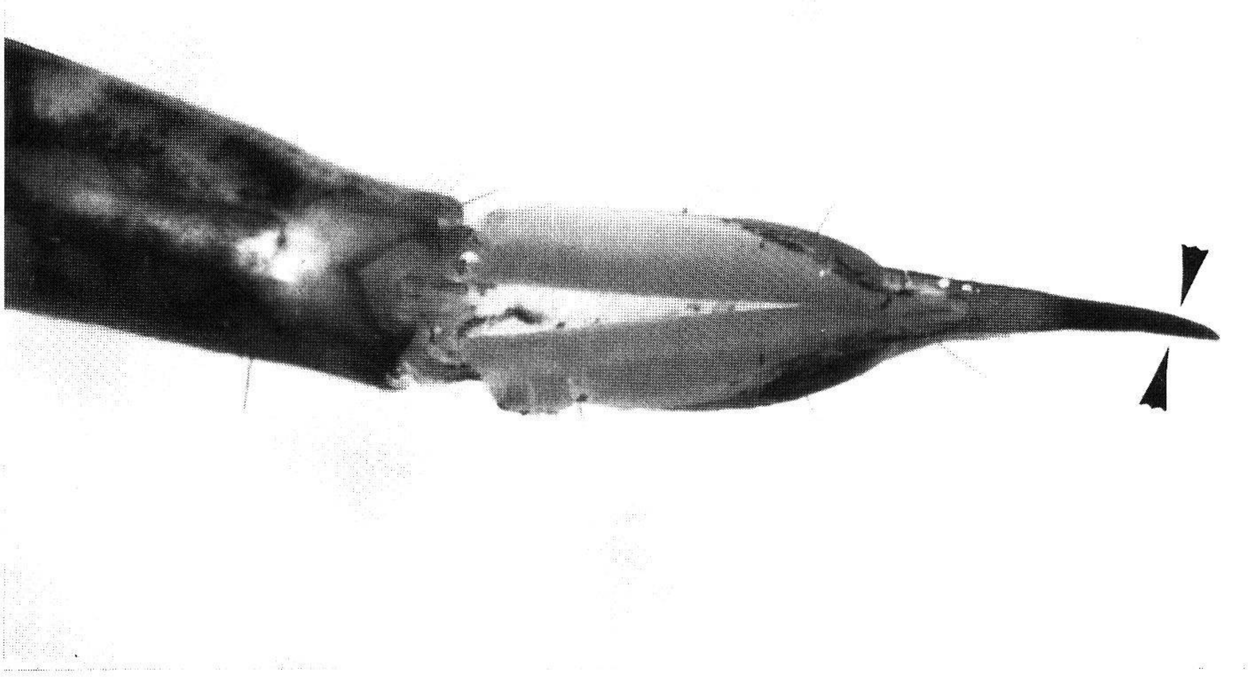

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Fig. 9. Isometrus maculatus, female. Body length (incl. postabdomen or "tail") approx. 4 cm.

Fig. 10. Sting of *I. maculatus,* as seen from above after removal of dorsal integument. The pair of glands is visible, each surrounded by musculature. Arrows point to the location of the separate venom orifices.

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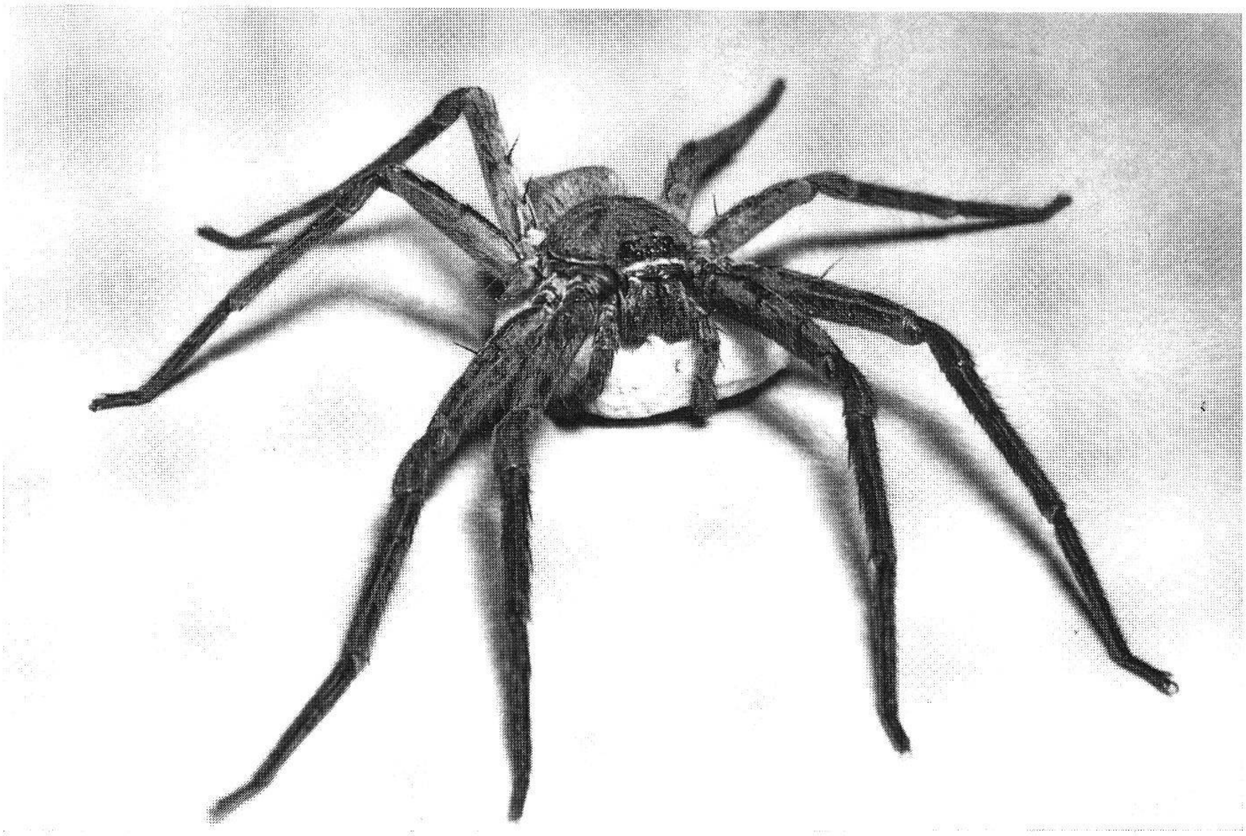

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Fig. 11. Orthognath spider of the genus *Pterinochilus*. The scale is in cm.

Fig. 12. Labidognath spider, *Heteropoda venatoria*. Length of cephalothorax approx. 1 cm. Note egg cocoon being carried along with the two pedipalps.

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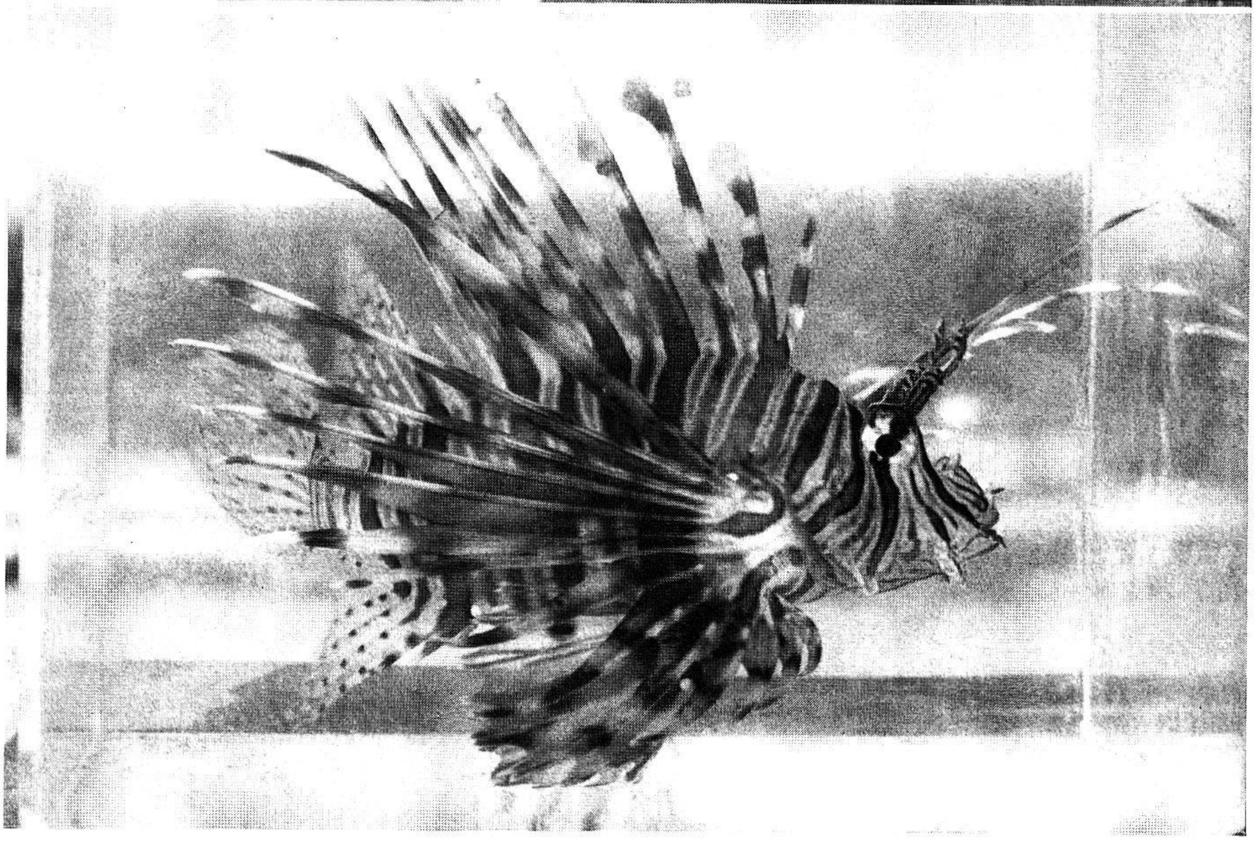

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Fig. 13. Moray eal, *Echidna nebulosa.* Body length up to 75 cm.

Fig. 14. Lion- or Zebrafish, *Pterois volitans.* Approx. size 15 cm. Note that on some venomous dorsal spines integumentary sheath was damaged as the fish was captured.

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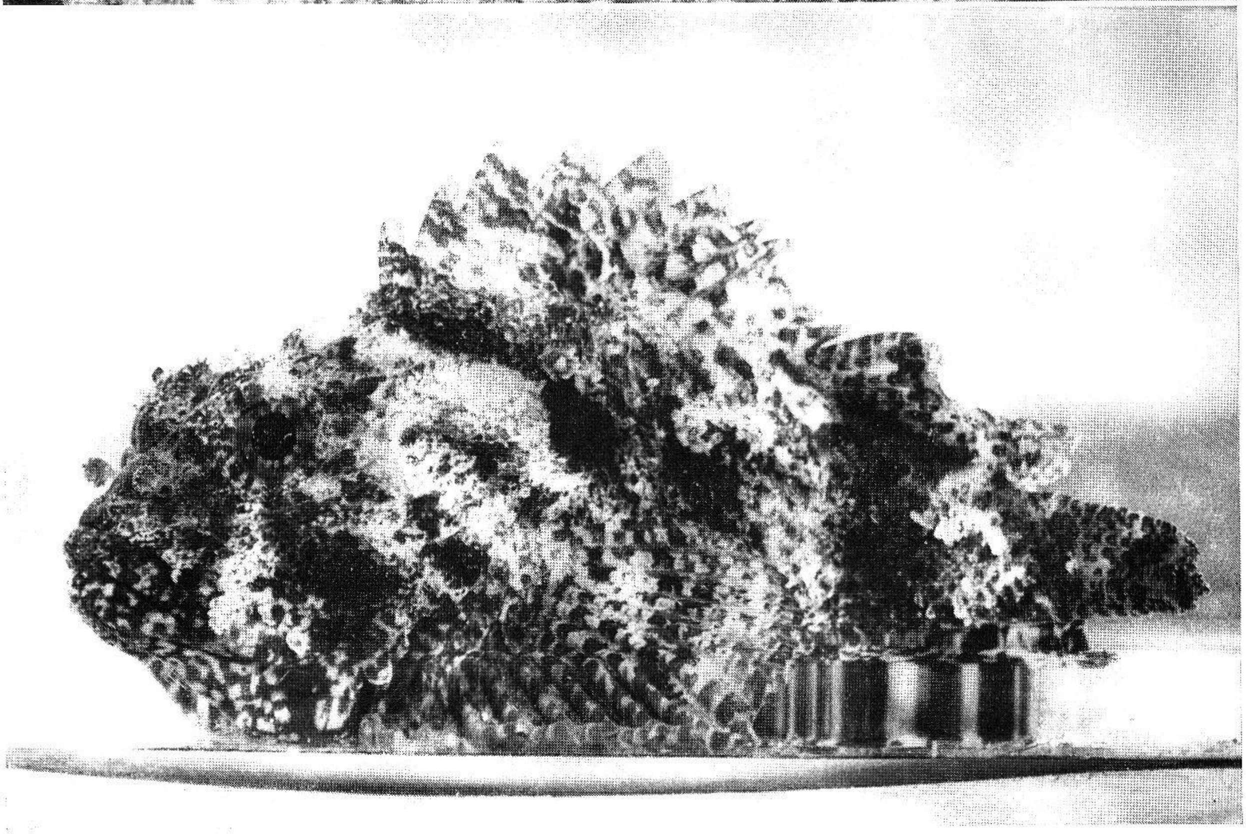

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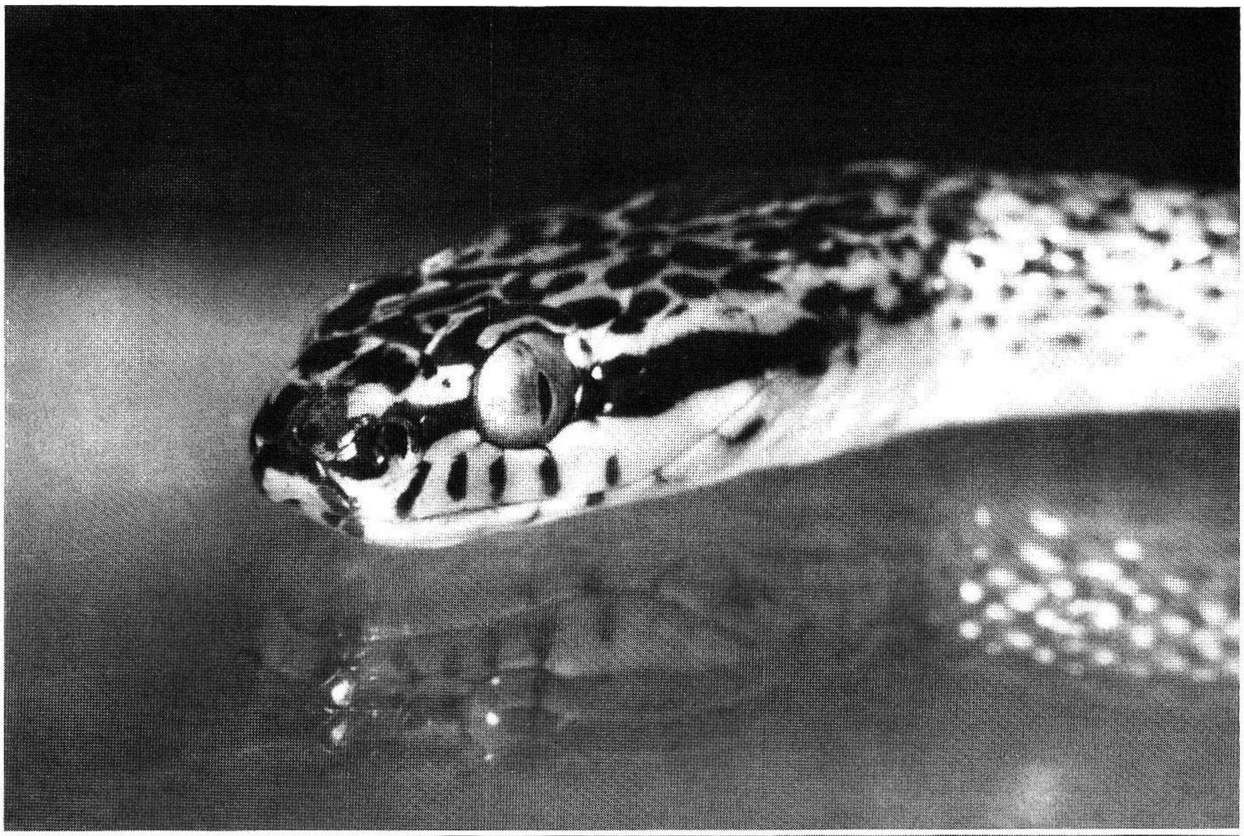
Fig. 15. Puffer, *Arothron (?) nigropunctatus* in its natural habitat. Body length approx. 9 cm. (By courtesy of Dr. med. F. Markwalder, Zürich.)

Fig. 16. Scorpionfish *Sebastapistes bynoensis*, somewhat resembling young stone fish. Size approx. 14 cm. Specimen collected off Dar es Salaam, near the harbour entrance, under bricks, about 80 cm below low tide level.

17 

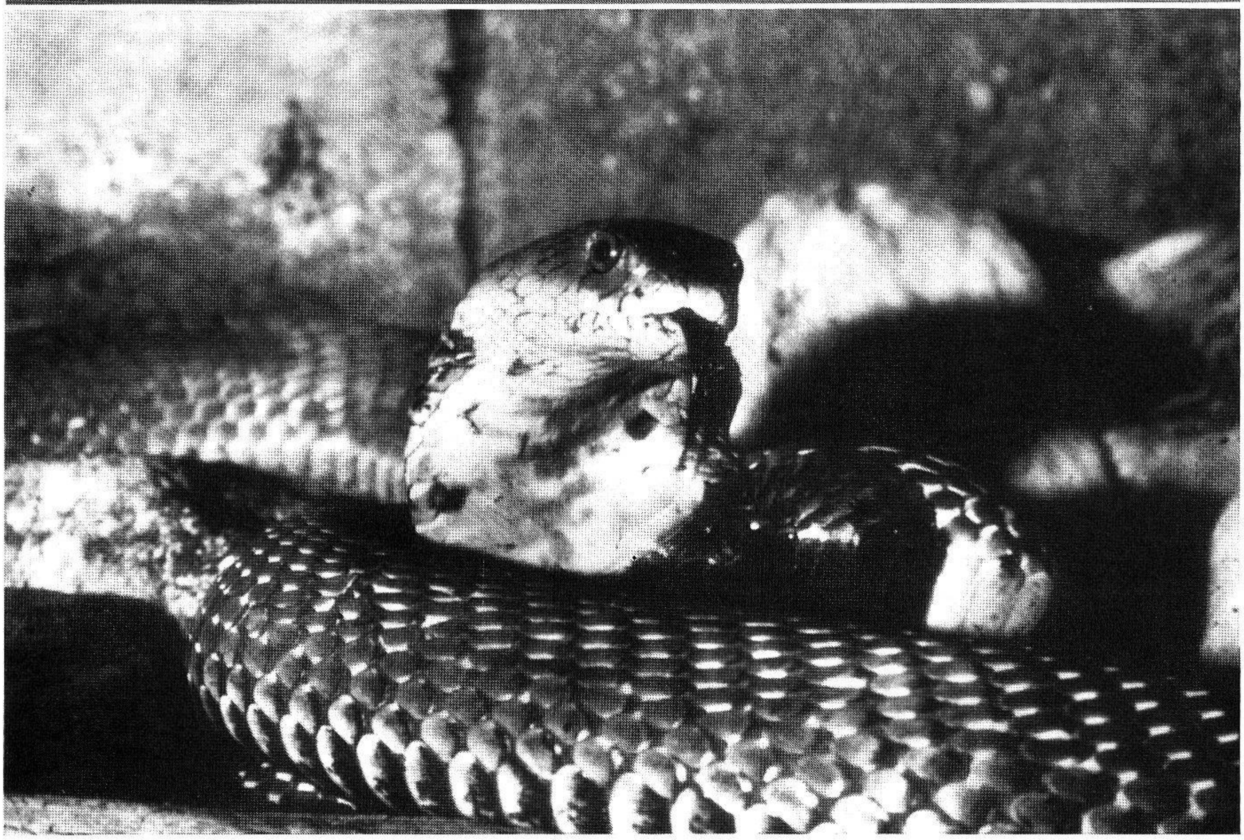
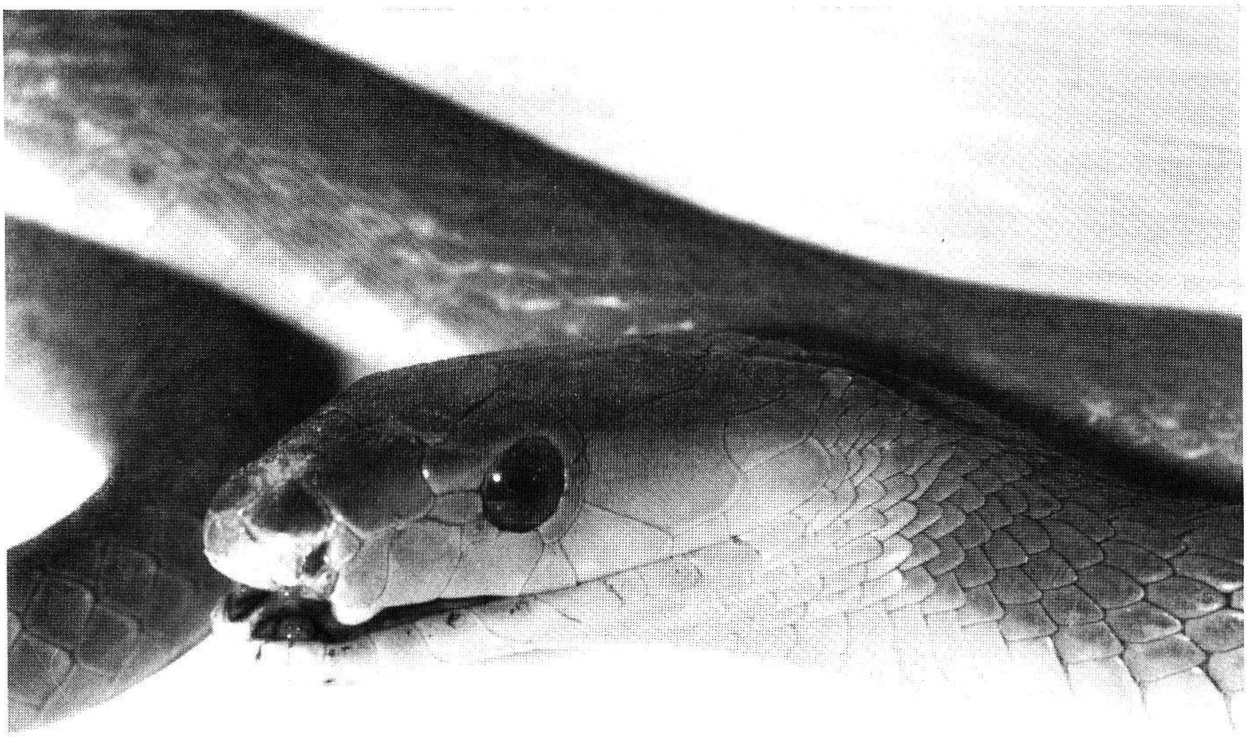
18 

Fig. 17. Hemirhagerrhis kelleri, an opisthoglyph snake, harmless to man. Adult body length approx. 55 cm.

Fig. 18. Spitting Cobra, *Naja nigricollis.* Adult body length approx. 200 cm.



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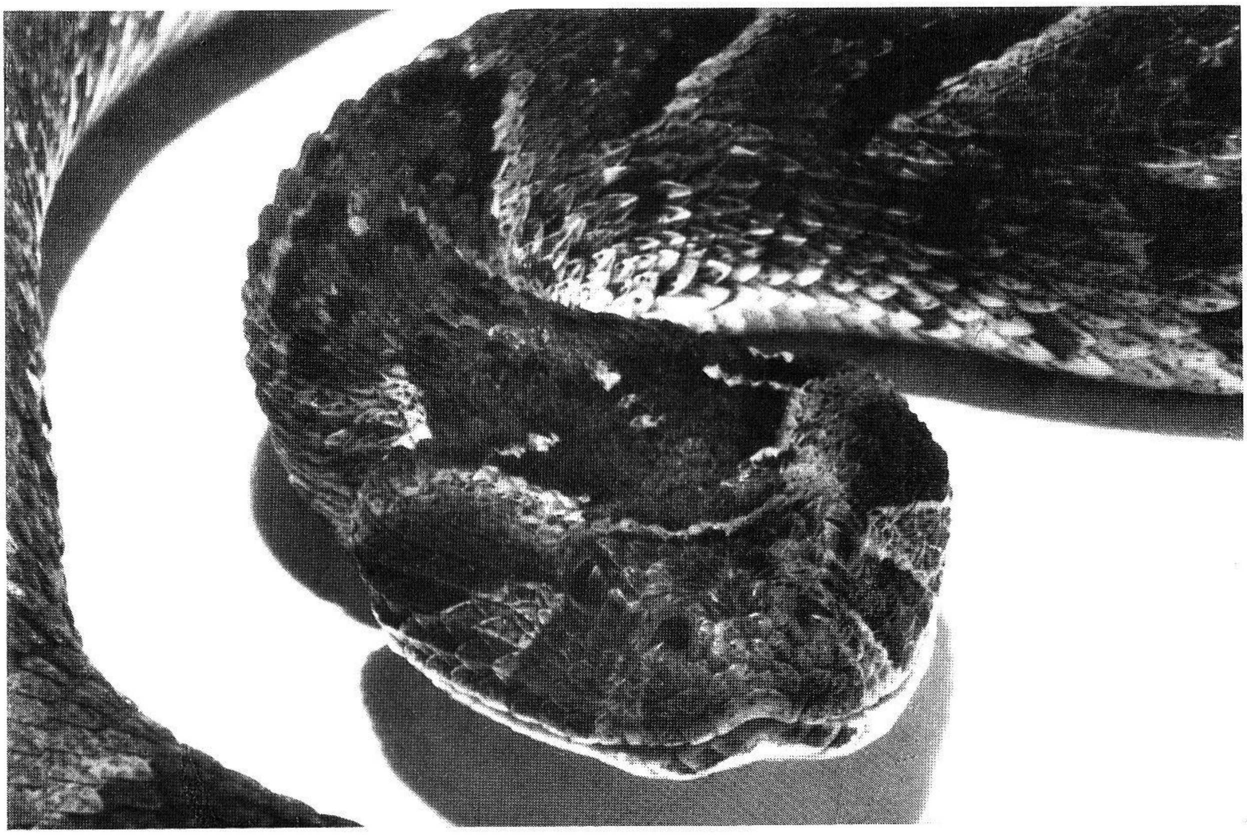

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Fig. 19. Dendroaspis angusticeps, the Green or Common Mamba. Adult body length approx. 240 cm. Left fang hidden in mucous sheath, below and somewhat behind nasal orifice.

Fig. 20. Bitis lachesis, Puff Adder. Body length approx. 100 cm, diameter of cross section in neck region approx. 3 cm. Note "triangular" shape of head as compared to other snakes.