Mem. Inst. Butantan
Simp. Internac.
33(1):1-26, 1966

1. VENOMOUS MARINE ANIMALS OF BRAZIL

BRUCE W. HALSTEAD

World Life Research Institute, Colton, California, U.S.A.

Our knowledge of the venomous marine animals of Brazil dates back to the Renaissance and the writings of Willem Piso and George Marcgrave, who published an excellent biological description of the venomous spotted eagle-ray *Aetobatus narinari* in their HISTORIA NATURALIS BRASILIAE in 1648. This particular description is noteworthy because it included a brief general description of the venom apparatus on the tail of the ray. Despite this early beginning of investigations on the venomous marine animals of Brazil, there was a gap of several centuries before these organisms received very much scientific attention. Some of the more comprehensive references by Brazilian workers that deal with the subject are by Diniz (1905) and Gonsalves (1907) on venomous fishes; Silvado (1911) on the noxious fishes of the Rio de Janeiro Bay; Fonseca (1917) on the venomous fishes of Brazil; Fróes (1932, 1933a, b) on venomous fishes and particularly the toadfish *Thalassophryne*; and various other workers, most of whose publications also deal with venomous fishes, viz: Carvalho, 1947; Costa, 1958; Fonseca, 1952; Santos, 1952. In view of this most auspicious occasion of the INTERNATIONAL SYMPOSIUM ON ANIMAL VENOMS in Commemoration of the Centennial of Vital Brazil here at the Instituto Butantan, it should be recognized that the Instituto Butantan has played a significant role in these studies on venomous marine animals.

In discussing the venomous marine fauna of Brazil, one must first take into consideration the vast coastal expanses of the country which extend from latitude 4°20'45" N. to latitude 33°45'09" S., or 38 degrees of latitude, a coastline of 4,603 miles. The river systems of Brazil are the most extensive in the world, and they exert a profound effect on the marine flora and fauna. The Brazilian marine fauna is comprised of tropical Atlantic and West Indian (or Caribbean) forms, as well as the temperate western Atlantic species. Caribbean species occur as far south as Bahia (Lagler, Bardach, and Miller, 1962).

It is the purpose of this paper to briefly review the phylogenetic distribution of the venomous marine animals of Brazil, the nature of their venom organs and venoms, the clinical effects which they produce, and the treatment of their stings. The term "venomous marine animal" is defined as a marine animal that is equipped with a venom apparatus, i.e., a traumagenic device associated with a poison or venom gland, capable of producing an envenomation. Organisms that are poisonous to eat have not been included in this discussion. The organisms have been arranged according to their phylogenetic position.

INVERTEBRATES

PHYLUM COELENTERATA: HYDROIDS, JELLYFISHES, SEA ANEMONES, CORALS.

Class **HYDROZOA**: Hydroids.

Family MILLEPORIDAE: *Millepora alcicornis* Linnaeus. Stinging coral or fire coral (USA). — Caribbean Sea, northern coast of Brazil.

Family OLINDIADIDAE: *Olindias sambaquiensis* Müller. Stinging medusa (USA), relojinho (Brazil). — Coast of tropical Brazil.

Family PENNARIIDAE: *Pennaria* cf. *tiarella* (Ayres). Stinging hydroid (USA). —Coast of Maine to Brazil.

Family PHYSALIIDAE: *Physalia physalis* Linnaeus. Portuguese man-o-war, bluebottle (USA), caravela (Brazil). — Tropical Atlantic.

Family PLUMULARIIDAE: *Lytocarpus philippinus* (Kirchenpauer). Feather hydroid (USA). — Circumtropical.

Family RHIZOPHYSIDAE: *Rhizophysa eysenhardti* Gegenbaur. Stinging hydroid (USA). — Warm waters of all oceans. *Rhizophysa filiformia* (Forskal). Stinging hydroid (USA). — Warm waters of all oceans.

Class **SCYPHOZOA**: Jellyfishes.

Family CARYBDEIDAE: *Carybdea alata* Reynaud. Sea wasp (USA). — Circumtropical. *Carybdea marsupialis* (Linnaeus). Sea wasp (USA). — Tropical Atlantic. *Tamoya haplonema* Müller. Sea wasp (USA). — Tropical Atlantic.

Family CHIRODROPIDAE: *Chiropsalmus quadrumanus* (Müller). Sea wasp (USA). — Tropical Atlantic.

Family LINUCHIDAE: *Linuche unguiculata* (Schwartz). Thimble jellyfish (USA). — Tropical Atlantic and Pacific Oceans.

Family LYCHNORHIZIDAE: *Lychnorhiza lucerna* Haeckel. Água viva (Brazil). — Coast of Brazil, French Guiana.

Family NAUSITHOIDAE: *Nausithoë punctata* Kölliker. Stinging alga (USA, juvenile form). — All warm seas.

Family PELAGIIDAE: *Chrysaora quinquecirrha* (Desor). Sea nettle (USA). Tropical Atlantic and Pacific Oceans.

Family ULMARIDAE: *Aurelia aurita* (Linnaeus). Moon Jelly (USA). — All warm seas.

Class **ANTHOZOA**: Corals and sea anemones. There are no reports of stinging anthozoans from Brazilian waters.

Biology — **HYDROZOA**: Included within the **HYDROZOA** are the hydroids (e.g., *Aglaophenia*), stinging or hydroid corals (e.g., *Millepora*), and the free-floating siphonophores (e.g., *Physalia*). The hydroids are generally found attached to a substratum in shallow waters, from low tide level down to depths of 1,000 meters or more. The ecological conditions in which hydroids are found are extremely variable and they fluctuate according to the species. Some species have a wide distribution, whereas others are restricted to definite latitudes. Generally, hydroids are more abundant in temperate and cold zones. The form of the colony may be radically altered by such environmental factors as wave shock, currents, and temperatures. Colonies usually are small or moderate in size, but some species may attain a length of 2 m. Because of the sessile habits of hydroids, commensalism with other animals is of frequent occurrence. Since hydroids attach themselves to pilings, rafts, shells, rocks, or algae, and display their fine moss-like growth, they are sometimes mistaken for seaweed. Colonial hydroids are comprised of two kinds of polyps or zooids: the feeding hydranth that takes in food for the colony, and the reproductive polyp or gonangium. The nutritive polyps have a crown of tentacles and a central mouth that leads into the stomach cavity to which all the other polyps are connected by the coenosarc which encloses the common enteron. The nematocysts nettle or stinging cells are restricted to the tentacles. Food is procured by the use of the nematocysts.

Hydroids reproduce by budding; the free-swimming, solitary medusae that separate from the reproductive polyp, produce ova that result in attached hydroids. Medusae are more difficult to obtain than are the plant-like hydroids, but they may be taken in fine-meshed plankton nets. The medusae may be likened to a tiny umbrella with a short handle, the manubrium, which contains the mouth. Tentacles provided with stinging cells hang from the velum or margin of the umbrella. Medusae swim in a jerky fashion by spasmodic contractions of the umbrella. In the medusae, the sexes are separate.

The order **HYDROCORALLINA** or hydroid corals of which *Millepora* is the best-known genus, is widely distributed throughout tropical seas in shallow water to the depth of 30 m. Hydroid corals are important in the development of coral reefs, for they form upright, clavate, blade-like, or branching calcareous growths, or encrustations over other corals and objects. They vary in color from white to yellow-green; because of their variable appearance, they are sometimes difficult to recognize. The order is characterized by a massive exoskeleton of lime carbonate, the surface of which is covered with numerous minute pores. There are two sizes of pores: the larger gastropores, which are 1 to 2 mm apart, and the smaller dactylopores, irregularly interspersed about the gastropores. The surface of the coral between the pores has a pitted appearance. The entire stony mass is traversed by a complex system of branched canals which communicate with the pores. From the gastropores protrude the feeding gastrozooids, equipped with a hypostome and capitate tentacles. Dactylozooids, extending from the dactylopores, are mouthless; however, they are provided with tentacles, which are believed to have a protective and tactile function. According to Hyman (1940), millepores have two or three types of powerful nematocysts located on the polyps, polyp bases, and in the general coenosarc. Apparently most of the *Millepora* have the ability to sting, but the venomousness of the sting varies from one species to the next (Boschma, 1948).

The order Siphonophores, of which *Physalia* is a pertinent example, is highly polymorphic free-swimming or floating colonies composed of several types of polypoid or medusoid individuals attached to a floating stem. Siphonophores are pelagic animals, inhabiting the surface of the sea. They depend largely upon currents, wind, and tides for their movement. They are widely distributed as a group, but most abundant in warm waters. The float or pneumatophore of *Physalia* is greatly enlarged, and it is represented by an inverted, modified, medusan bell, whereas the remainder of the coenosarc is correspondingly reduced. *Physalia* may attain a large size with a float 10 to 30 cm in length. From the underside of the float hang gastrozooids, dactylozooids, and the reproductive gonodendra with their gonophores or budding medusoids. The female gonophores are medusoid and may swim free, but the male reproductive zooid remains attached to the float. The gastrozooids or feeding polyps are without tentacles. Some of the tentacled dactylozooids are small; however, several of the large dactylozooids are equipped with very elongate "fishing" tentacles.

The number of fishing tentacles varies with the species of *Physalia*. In the Pacific form, *P. utriculus*, there is a single fishing tentacle; but in the Atlantic species, *P. physalis*, there are multiple fishing tentacles. Extending along the entire length of the large dactylozooid, a band of specialized tissue covers diverticulae of the gastrovascular cavity of the tentacle. These fishing tentacles or large dactylozooids may be found in the water to a depth of more than 30 m and, because of their almost transparent appearance, constitute a definite hazard to the unsuspecting swimmer. Upon contraction, the remainder of the tentacle shortens more completely than does the superficial band, and this causes the band to be thrown into loops and folds that are known as "stinging batteries". The nematocysts are contained in cnidoblasts located in the superficial epithelium of the battery. The toxin, a structureless fluid within the nematocyst capsule, bathes the surface of the nematocyst tubule (Lane, 1960).

According to Parker (1932), scores of these fishing filaments may extend down into the water from a single *Physalia*. Parker has observed that the nematocyst heads occur at regular intervals along the side of the filament opposite the point from which the main muscle plate takes its origin. Each full-sized head contains about 500 large nematocysts and about 2,000 small ones. In one extended filament measuring 9 m in length, the nematocyst heads were distributed at intervals of approximately 3 cm apart. According to these figures, each fishing filament contained about 750,000 nematocysts. When one considers the large number of fishing filaments on each *Physalia*, he finds a formidable venom apparatus.

When the animal is moving through the water, the fishing tentacles undergo a continuous rhythmic movement, alternately contracting and relaxing. Thus there is a constant sampling of the water beneath the pneumatophore. If the tentacle brushes against a prey organism, the nematocysts are stimulated, and they trigger the immediate release of the coiled nematocyst thread. The fully uncoiled thread may be several hundred times as long as the diameter of the parent capsule. The extreme length of the tubule, together with its chitinous barbs and spines, constitute a highly effective entanglement. If the tip of the cnidal thread penetrates the victim, the toxin is conveyed directly into the body of the prey through the hollow thread. Lane (1960) found that the thread can penetrate even a surgical glove.

Lane further observed that the magnitude of the response to contact with the victim is proportional to the area of contact between tentacle and prey. A small copepod may elicit the discharge of 20 to 50 adjacent nematocysts, whereas contact with a larger animal might evoke a discharge of several hundred thousand nematocysts. Gentle stimulation of the nematocyst results in a rapid release of the nematocyst thread, but does not dislodge the parent capsule from its position in the epithelium. Vigorous resistance by the prey results not only in greatly increasing the number of cnidae but also in disloding many of them from the epithelium. Dislodged nematocysts are replaced by cnidoblasts that differentiate outside the stinging battery but subsequently come to occupy a definitive position in the battery epithelium.

It is interesting that the loggerhead turtle, *Caretta caretta*, has been reported to feed on *Physalia*. The potency of the toxin and the ability of the *Physalia* nematocyst to penetrate even a surgical glove make this a gastronomic feat of no small accomplishment (Lane, 1960).

SCYPHOZOA: All Scyphozoans or jellyfishes are marine and the majority are pelagic. A few species are known to inhabit depths of 2,000 fathoms or more. In the adult stage, most jellyfishes are free swimming. Because their swimming ability is relatively weak, jellyfishes are greatly influenced in their movements by currents, tides, and wind. Scyphozoans are widely distributed throughout all seas. Many medusae reveal that they are affected by light intensity in that they surface during the morning and late afternoons and descend during the midday and in the darkness, whereas other react in just the opposite manner. A descension is usually made during periods of stormy weather. Swimming is accomplished by rhythmic pulsations of the bell, and this action determines the vertical rather than the horizontal progress of the animal. Jellyfishes display a remarkable ability to withstand considerable temperature and salinity changes. They are carnivorous, some of the larger species being capable of capturing and devouring large crustaceans and fishes. Jellyfishes display a wide variety of sizes, shapes, and colors; many of them are semitransparent or glassy in appearance and often have brilliantly colored gonads, tentacles, or radial canals. In some species, they may vary in size from a few millimeters to more than 2 m across the bell, with tentacles more than 36 m in length, as in *Cyanea capillata*.

Regardless of their size, jellyfishes are very fragile; many of them contain less than 5 percent of solid organic matter. Scyphomedusae have an eight-notch marginal bell, but lack a velum; the gonads are connected with the endoderm. Reproduction is by an alternation of generations, as in the hydroids, although the polyp stage is reduced. Jellyfishes have a complex system of branched radial canals, and numerous oral and marginal tentacles.

The cubomedusae are among the most venomous marine creatures known. The genera, *Chiropsalmus* and *Carybdea*, contain some of the more dangerous species of the group. They range in size from a small grape to that of a large pear. Cubomedusae are widely distributed throught all the warmer seas. They generally seem to prefer the quiet shallow waters of protected bays and estuaries and sandy bottoms, although some species have been found in the open ocean. During the summer months, the immature forms which stay on the bottom, reach maturity. The adults may then be found swimming at the surface. Light-sensitive cubomedusae, however, descend to deeper water during the bright sun of the middle of the day and come to the surface during early morning, late afternoon, and evening.

Morphology of the venom apparatus — The venom apparatus of coelenterates consists of the nematocysts or stinging cells which are largely located on their tentacles. These nematocysts are situated within the outer layer of tissue of the tentacle. Each of the capsule-like nematocysts is contained within an outer capsule-like device called the cnidoblast. Projecting at one point on the outer surface of the cnidoblast is the trigger-like cnidocil. Contained within the fluid-filled capsular nematocyst is the hollow, coiled, thread tube. The opening through which the thread tube is everted is closed prior to discharge by a lid-like device called the operculum. The fluid within the capsule is the venom. Stimulation of the cnidocil appears to produce a change in the capsular wall of the nematocyst causing the operculum to spring open like a trap door, and the thread tube conveying the venom is everted. The sharp tip of the thread tube penetrates the skin of the victim and the venom is thereby injected. When a diver comes in contact with the tentacles of a coelenterate, he brushes up against the cnidocils of literally thousands of these minute stinging organs.

Clinical characteristics — The symptoms produced by coelenterate stings vary according to the species, the site of the sting, and the person. In general, those caused by hydroids and hydroid corals (*Millepora*), are primarily local skin irritations. *Physalia* stings may be very painful. Sea anemones and true corals produce a similar reaction, but may be accompanied by general symptoms. Symptoms resulting from scyphozoans vary greatly. The sting of most scyphozoans is too mild to be noticeable, whereas *Carybdea* and *Chiropsalmus* are capable of inflicting very painful local and generalized symptoms. *Chiropsalmus* is probably the most venomous marine organism known and may produce death within 3 to 8 minutes in humans.

Symptoms most commonly encountered vary from an immediate mild prickly, or stinging sensation like that of a nettle sting, to a burning, throbbing or shooting pain which may render the victim unconscious. In some cases, the pain is restricted to an area within the immediate vicinity of the contact, or it may radiate to the groin, abdomen, or armpit. The area coming in contact with the tentacles usually becomes reddened, followed by a severe inflammatory rash, blistering, swelling, and minute skin hemorrhages. In severe cases, in addition to shock, there may be muscular cramps, abdominal rigidity, diminished touch and temperature sensation, nausea, vomiting, severe backache, loss of speech, frothing at the mouth, sensation of constriction of the throat, respiratory difficulty, paralysis, delirium, convulsions, and death.

Treatment — Treatment must be directed toward accomplishing three objectives: relieving pain, alleviating effects of the poison, and controlling primary shock. Morphine is effective in relieving pain. Intravenous injections of calcium gluconate have been recommended for the control of muscular spasms. Oral histaminics and topical cream are useful in treating the rash. Dilute ammonium hydroxide, sodium bicarbonate, olive oil, sugar, ethyl alcohol, and other types of soothing lotions have been used with varying degrees of success. Artificial respiration, cardiac and respiratory stimulants, and other forms of supportive measures may be required. There are no known specific antidotes.

Pharmacology — See Chemistry section.

Chemistry — Coelenterate venom contains a number of quaternary ammonium compounds, of which tetramine is the most active. The venom also contains 5-hydroxytryptamine, histamine and histamine releasers, and several proteins of relatively low molecular weight. The paralyzing and lethal effects of the toxin appear to be caused largely by the proteins which may act directly on cholinergic neurons. The localized dermatological signs and symptoms may be attributable to 5-hydroxitryptamine, histamine and histamine-releasing substances (Russell, 1965; Halstead, 1965). The chemistry of most coelenterate venoms has not been studied.

PHYLUM ECHINODERMATA: STARFISHES, SEA URCHINS, etc.

Family ARBACIIDAE: *Arbacia lixula* (Linnaeus). Sea urchin (USA), ouriço do mar (Brazil). — Tropical Atlantic and Mediterranean Sea.

Family DIADEMATIDAE: *Diadema antillarum* Philippi. Black sea urchin, needle-spined urchin (USA). — Tropical Atlantic, West Indies.

Family TOXOPNEUSTIDAE: *Lytechinus variegatus* Lamarck. Sea urchin (USA), ouriço do mar (Brazil). — West Indies, North Caroline, south to Brazil.

Biology — Sea urchins are free-living echinoderms, having a globular, egg-shaped, or flattened body. The viscera are enclosed within a hard shell or test, formed by regularly arranged plates, carrying spines articulating with tubercles on the test. Between the spines are situated three-jawed pedicellariae, which are of interest to the venomologist. In some species of sea urchins, the spines are also venomous. Tube feet are arranged in 10 meridian series rather than in furrows. A double pore in the test corresponds to each tube foot. The intestine is long and coiled, and an anus is always present. The gonads are attached by mesenteries to the inner aboral surface of the test. The mouth, situated on the lower surface, turns downward, and is surrounded by five strong teeth incorporated in a complex structure termed "Aristotle's lantern". Their power of regeneration is great, but autotomy, as observed in the asteroids, does not occur. By means of spines on the oral side of the test, sea urchins move slowly in the water. The tube feet are utilized to climb vertical surfaces. Some forms have the ability to burrow into crevices in rocks, while others cover themselves with shells, sand, and bits of debris.

Some urchins are nocturnal, hiding under rocks during the day and coming out to feed at night. Echinoids tend to be omnivorous in their feeding habits, ingesting algae, mollusks, foraminifera, and various other types of benthic organisms.

Sea urchins are dioecious, hermaphroditism occurring only as a rare anomally. Sexual dimorphism is generally absent. Spawning usually takes place during the spring and summer in the Northern Hemisphere, but somewhat earlier in the more southern latitudes. The reproductive periods of echinoids have been discussed at great length by Hyman (1955). Several species of European and tropical echinoids serve as important sources of food to man. Only the gonads are eaten, either raw or cooked. The bathymetric range of echinoids is great, extending from the intertidal zone to great depths.

Morphology of the venom apparatus — The venom apparatus of sea urchins is believed to consist of their hollow venom-filled spines, and the globiferous pedicellariae. However, usually only one or the other is present within a single species of sea urchin.

The spines of sea urchins vary greatly from group to group. In most instances the spines are solid, have blunt, rounded tips, and do not constitute a venom organ. However, some species have long, slender, hollow, sharp spines, which are extremely dangerous to handle. The acute tips and the spinules permit ready entrance of the spines deep into the flesh, but because of their extreme brittleness, they break off readily in the wound and are very difficult to withdraw. The spines in *Diadema* may attain a length of a foot or more. It is believed that the spines of some of these species secrete a venom, but this has not been experimentally demonstratep. The aboral spines of *Asthenosoma* are developed into special venom organs carrying a single large gland. The point is sharp and serves as a means of introducing the venom.

Pedicellariae are small, delicate, seizing organs which are found scattered among the spines of the shell. There are several different types of pedicellariae. One of these, because of its globe-shaped head, is called the globiferous pedicellariae, and serves as a venom organ. They are comprised of two parts, a terminal, swollen, conical head, which is armed with a set of calcareous pincer-like valves or jaws, and a supporting stalk. The head is attached to the stalk either directly by the muscles, or by a long flexible neck. On the inner side of each valve is found a small elevation provided with fine sensory hairs. Contact with these sensory hairs causes the valves to close instantly. The outer surface of each valve is covered by a large gland which in *Toxopneustes* has two ducts that empty in the vicinity of a small tooth-like projection on the terminal fang of the valve. A sensory bristle is located on the inside of each valve. Contact with these bristles causes the small muscles at the base of the valve to contract, thus closing the valves and injecting the venom into the skin of the victim.

One of the primary functions of pedicellariae is that of defense. When the sea urchin is at rest in calm water, the valves are generally extended, moving slowly about, awaiting prey. When a foreign body comes in contact with them, it is immediately seized. The pedicellariae do not release their hold as long as the object moves, and if it is too strong to be held, the pedicellariae are torn from the test, or shell, but continue to bite the object. Detached pedicellariae may remain alive for several hours after being removed from the sea urchin.

Clinical characteristics — Penetration of the needle-sharp sea urchin spines may produce an immediate and intense burning sensation. The pain is soon followed by redness, swelling, and an aching sensation. Numbness and muscular paralysis have been reported. Secondary infections are not uncommon.

The sting from sea urchin pedicellariae may produce an immediate, intense, radiating pain, faintness, numbness, generalized muscular paralysis, loss of speech, respiratory distress, and in severe cases, death. The pain may diminish after about 15 minutes and completely disappear within an hour, but paralysis may continue for six hours or longer.

Treatment — Insofar as the venom is concerned, sea urchin stings should be handled in a manner similar to any other venomous sting. However, attention is directed to the need for prompt removal of the pedicellariae from the wound. When pedicellariae are detached from the parent animal, they frequently continue to be active for several hours. During this time they will introduce venom into the wound.

The extreme brittleness and retrorse barbs of some sea urchin spines present an added mechanical problem. Nielly (1881) recommended that grease be applied, stating that this would allow the spines to be scraped off quite easily. Cleland (1912), Earle (1940), and others, are of the opinion that some sea urchin spines need not be removed, as they are readily absorbed. Absorption of the spines is said to be complete within 24 to 48 hours. However, Earle (1941) later pointed out that the spines of *Diadema setosum* are not readily absorbed, and months later roentgenological examination may reveal them in the wound. It is recommended that the spines of *Diadema* be removed surgically.

Pharmacology — The only attempt to evalute the general pharmacological properties of globiferous pedicellarial venom of sea urchins has been made by Mendes, Abbud, and Umiji (1963). Saline extracts were prepared from homogenates of globiferous pedicellariae of *Lytechinus variegatus* and tested on accepted cholinergic effector systems, viz. guinea pig ileum, rat uterus, amphibian heart, longitudinal muscle of a holothurian, the protractor muscle of a sea urchin lantern, and the blood pressure of dogs. The response obtained was consistent with that of a dialyzable acetycholinelike substance which the researchers concluded to be in pedicellarial venom.

Chemistry — Unknown.

PHYLUM MOLLUSCA: SNAILS, BIVALVES, OCTOPUSES, etc. — There are no reports of human encounters with venomous mollusks in Brazilian waters.

PHYLUM ANNELIDA: SEGMENTED WORMS.

Family AMPHINOMIDAE: *Chloeia viridis* Schmarda. Sea mouse, bristle worm (USA). — Tropical America, both sides. *Eurythoë brasiliensis* Hansen. Bristle worm (USA). — Coast of Brazil. *Eurythoë complanata* (Pallas). Bristle worm (USA). — Circumtropical.

Biology — The polychaetes are divided into two major groups: the *Errantia*, which includes most of the free-moving kinds, and the *Sedentaria* or tube-dwelling and burrow-inhabiting species. The polychaetes that have been incriminated as toxic are largely errant forms.

Polychaetes have cylindrical bodies and are metameric, having numerous somites — each bearing a fleshy paddle-like appendage, or parapodia, that bears many setae. The head region has tentacles. There is no clitellum. Sexes are usually separate. There are no permanent gonads and fertilization is commonly external. Polychaetes have a trochophore larval stage, and there is a sexual budding in some species.

Most polychaetes are free living; a few are ectoparasitic. They have a bathymetric range from the tide line to depths of more than 5,000 meters. A few species are pelagic. Several of the polychaetes inhabit freshwater. Polychaetes are largely carnivorous. Some of the burrowing worms feed on bottom detritus, whereas the tube dwellers subsist on plankton. Generally, polychaetes spend their existence crawling under rocks, burrowing in the sand or mud, in and around the base of algal growths; or they construct tubes, which they leave at periodic intervals in search of food. The majority of polychaetes range in size from 5 to 10 cm. However, some of the syllids are only 2 mm in length; whereas the giant Australian species *Onuphis teres* and *Eunice aphroditois* may attain a meter or more in length.

Morphology of the venom apparatus — *Setae*: The members of the polychaete genera *Chloeia*, *Eurythoë*, *Hermodice*, and others, possess elongate pungent chitinous bristles or setae which project from the parapodia. The parapodia are a pair of lateral appendages extending from each of the body segments. The structure appears as a more or less laterally compressed fleshy projection of the body wall. Each parapodium is biramous; it consists of a dorsal portion, the notopodium, and a ventral part, the neuropodium. Each division of the parapodium is supported internally by one or more chitinous rods, termed acicula, to which are attached some of the parapodial muscles. Each of the distal ends of the two parapodial divisions are invaginated to form a setal sac or pocket in which the projecting setae are situated. Each seta is secreted by a single cell at the base of the setal sac. Generally the setae of polychaetes project some distance beyond the end of the parapodium. However, *Eurythoë* and *Hermodice* have the ability to retract or extend their setae to a remarkable degree. When the living worm is at rest, the setae appear to be quite short and barely in evidence; but when irritated, the setae are rapidly extended and the worm appears to be a mass of bristles.

The severity of symptoms reported in some of the clinical accounts lends credence to the belief that both *Eurythoë* and *Hermodice* possess venomous setae. The setae of both *E. complanata* and *H. carunculata* appear to be hollow, and at times seem to be filled with fluid. A seta of *E. complanata* has a series of retrorse spinules along the shaft, whereas the seta of *H. carunculata* is without spinules and has a needlelike appearance. The setae of *Chloiea* are said to be nonvenomous (Pope, 1963), but are listed as a "stinging" worm by others (Phillips and Brady, 1953; Steinbeck and Ricketts, 1941). Examination of histological sections of the parapodia of both species failed to reveal any glandular elements. However, the material examined was poorly preserved and it is quite possible that glandular structures might have been present and were not recognized. Final decision on this matter awaits further histological study.

Clinical characteristics — Bristle worm (*Chloeia*, *Eurythoë*, *Hermodice*) stings may result in an intense inflammatory reaction of the skin, consisting of redness, swelling, burning sensation, numbness, and itching. According to Mullin (1923), *Hermodice carunculata* is able to inflict a "paralyzing effect" with its setae. Contacts with the setae of bristle worms have been likened to handling the spines of prickly pear cactus or nettle stings. Severe complications may result in secondary infections, gangrene, and loss of the affected part. The clinical effects of bristle worm stings have also been discussed by Baird (1864), Paradice (1924), Levrat (1927), Roughley (1940, 1947), Pope (1947, 1963), LeMare (1952), Phillips and Brady (1953), Halstead (1956, 1959), and Gillett and McNeil (1962).

Treatment — The treatment of worm bites and bristle worm stings is largely symptomatic. There are no specific antidotes. Secondary infections may occur which require the use of antibiotic therapy. The setae of bristle worms can best be removed from the skin with adhesive tape, and the ammonia or alcohol should be applied to the area to alleviate the discomfort.

Pharmacology — Unknown.

Chemistry — Unknown.

VERTEBRATES

Venomous marine fishes are members of the phylum CHORDATA. The Brazilian marine fauna does not appear to be especially rich in venomous fishes. The families TRACHINIDAE, SIGANIDAE, SCATOPHAGIDAE, MONODACTYLIDAE, HISTIOPTERIDAE, and several of the more important genera of venomous SCORPAENIDAE are not represented in Brazilian waters.

Despite the fact that some of the earliest literature in biotoxicology deals with venomous fishes, the bulk of our knownledge on the morphology of the venom organs of fishes has been published during the past two decades. Unfortunately, most of this literature deals with European, North American, or tropical Indo-Pacific species. The only endemic Brazilian species that have been studied to any extent are members of the genus *Thalassophryne* of the family BATRACHOIDIDAE. The field of piscine venomology offers a vast field of untappped opportunity to the researcher. There is urgent need for a thorough systematic investigation of the venomous fishes of Brazil in particular.

Class **CHONDRICHTHYES**: SHARKS, RAYS, etc.

HORNED SHARKS — Venomous sharks are limited to those species which possess dorsal fin spines, namely, members of the families HETERODONTIDAE, SQUALIDAE, and DALATIIDAE. Although a number of species within these three families are suspected of having venom organs, only two species, *Hetodontus facisci* and *Squalus acanthias*, have been studied to even a limited extent, and only the latter is found in Brazilian waters. Clinical reports from horned sharks are based on *S. acanthias*, and most of these reports are from Europe.

Family SQUALIDAE: *Squalus acanthias* Linnaeus. Spiny dogfish (USA), galhudo (Brazil). — Atlantic and Pacific Oceans. *Squalus fernandinus* Molina. * Spiny dogfish (USA), galhudo (Brazil). — Circumpolar and widespread throughout boreal and cool temperate latitudes of the Southern Hemisphere.

Biology — Squalids are widely distributed throughout subarctic, temperate, tropical, and subantarctic seas.

Most dogfish are somewhat sluggish in their movements, traveling singly or in schools, and somewhat erratic in their migrations. Their bathymetric range extends from the surface to depths of 100 fathoms or more. They are not pelagic, preferring relatively shallow protected bays. The migration of squalids seems to be governed by thermal changes, showing a preference for water temperature from 7° to 15°C. Squalids are viviparous, giving birth to their young from late summer through the winter in some regions but earlier in others. Dogfish are voracious and include a variety of fishes in their diet: capelin, herring, menhaden, mackerel, hake, cod, haddock. They also feed on coelenterates, mollusks, crustaceans, and worms. Squalids have been used to a considerable extent for fertilizer and as a source of vitamins A and D. Dogfish are of considerable economic importance because of the damage that they do to fishing gear.

Morphology of the venom apparatus — The venom apparatus of horned sharks is comprised of the dorsal fin spines and the associated glandular tissue. The dorsal stings are situated adjacent to the anterior margins of each of the two spines in most of the horned sharks. Some of the dalatiid sharks have only a single somewhat rudimentary fin spine or the spines are entirely absent. Therefore, there is some question as to whether a true venom organ is present in this latter group.

The anterior fin spine in *Squalus acanthias* is only slightly curved anteroposteriorly, whereas the posterior spine is more curved and in lateral view is somewhat sabreshaped. The two sides are slightly convex and the longitudinally grooved posterior aspect of the spine forms the base of the triangle. The spine

* *Squalus fernandinus* is reported as venomous, but there is no information regarding the nature of its venom apparatus or venom.

is grooved only in its exposed portion, and the groove becomes more shallow toward the tip. The glandular tissue appears as a glistening white substance situated in the shallow posterior groove, or interdentate depression, of the spine.

Microscopic examination of the sting in cross section reveals it to be trigonal in shape and comprised of three principal layers: an outer layer of integument which covers a thick wall of hard vasodentine and an inner core of cartilage. Careful examination of the structure reveals that the glandular cells are situated in the epithelial portion of the integumentary layer in the area of the antero-lateral glandular grooves and in the interdentate depression. The glandular cells are sparsely scattered in the anteroglandular-groove area, but are heavily concentrated in the interdentate depression. The glandular cells are of two basic types. Some of these are polygonal-shaped, clear, finely granular cells having slightly pycnotic nuclei, which appear to be of the mucin type. However, the venom cells in hematoxylin and triosin preparations are oval-shaped, containing homogenous brown-staining material with accumulations of finely granular material. Venom production is apparently by a holocrine type of secretion. Morphological studies on *Squalus* have been conducted largely by Evans (1921, 1923, 1943).

Clinical characteristics — The symptoms consist of immediate intense, stabbing pain which may continue for a period of hours. The pain may be accompanied and followed by a generalized erythema and severe swelling of the affected part. Tenderness of the affected part may continue for several days. According to Coutière (1899), dogfish stings may be fatal. The only clinical reports are by Evans (1920, 1923, 1943).

Treatment — Wounds produced by spined sharks are usually of the puncture wound variety. Since shark spines do not have an enveloping integumentary sheat, and the bulk of the glandular tissue is located near the base of the spine, it would be a rare instance for the glandular tissue to become embedded in the wound of the victim. In the most instances, effects resulting directly from the action of the venom are of minor concern. Nevertheless it is advisable to irrigate the wound with saltwater and to do whatever debridement may be necessary if the tissues have been lacerated. If there is little or no bleeding, then moderate bleeding should be encouraged. The pain is usually mild in comparison with most stingray stings, but opiates may be needed. The extremity should be submerged in hot water for a period of 30 minutes or more at as high a temperature as the victim can tolerate without doing further injury. The addition of sodium chloride or magnesium sulfate to the water is optional. Suturing may be required. Antitetanus agents should be administered. Secondary infections from shark spines may sometimes occur, and antibiotic therapy may be needed. Elevation of the injured limb is recommended.

Pharmacology — Unknown.

Chemistry — Unknown.

Stingrays

Stingrays constitute an important group of venomous fishes in that they are probably the most common cause of fish stings. The Suborder MYLIOBATOIDEA includes the seven ray families: DASYATIDAE, stingrays or whiprays; POTAMO-

TRYGONIDAE, river rays; GYMNURIDAE, butterfly rays; UROLOPHIDAE, round stingrays; MYLIOBATIDAE, eagle or bat rays; RHINOPTERIDAE, cow-nosed rays; and MOBULIDAE, devil rays or mantas. (The caudal spines of the MOBULIDAE when present, are generally quite rudimentary and will not be considered further in this presentation). With the exception of the POTAMOTRYGONIDAE, which are confined to the rivers of South America, most stingrays are marine, inhabiting shallow coastal waters, bays, brakish water lagoons, but may enter river mouths and freshwater rivers. Most reports on stingray attacks and venom organs are based on either European or North American species. Very little is known regarding the venom organs of most of the stingray species of Brazil.

Family DASYATIDAE: *Dasyatis americana* Hildebrand and Schroeder. Southern stingray (USA), raia (Brazil.) — Western Atlantic, New Jersey to Rio de Janeiro, Gulf of Mexico. *Dasyatis centroura* (Mitchell). Roughtail stingray — Atlantic Ocean, Mediterranean Sea. *Dasyatis guttatus* Bloch and Schneider. Stingray (USA). — West Indies, Gulf of Mexico to southern Brazil. *Dasyatis sabina* (Lesueur). Atlantic stingray (USA). — Western Atlantic from Chesapeake Bay to Brazil, Gulf of Mexico. *Dasyatis sayi* (Lesueur). Bluntnose stingray. — Western Atlantic from New Jersey to southern Brazil.

Family GYMNURIDAE: *Gymnura altavela* (Linnaeus). Spiny butterfly ray (USA). — Tropical and temperate Atlantic Ocean. *Gymnura micrura* (Bloch and Schneider). Smooth butterfly ray (USA). — Western Atlantic from Chesapeake Bay to Brazil, Gulf of Mexico.

Family MYLIOBATIDAE: *Aetobatus narinari* (Euphrasen). Spotted eagle ray (USA). — Tropical and warm temperate waters of the Atlantic, Red Sea, Indo-Pacific. *Myliobatis freminvillei* Lesueur. Bullnose ray (USA). — Western Atlantic, from New York to Brazil.

Family RHINOPTERIDAE: *Rhinoptera bonasus* (Mitchell). Cownose ray (USA). — Western Atlantic, from southern New England to Brazil.

Family UROLOPHIDAE: *Urolophus jamaicensis* (Cuvier). Yellow stingray (USA). — Western tropical Atlantic.

Biology — Rays are common inhabitants of tropical, subtropical, and warm temperate seas. With the exception of the family POTAMOTRYGONIDAE, which is confined to freshwater, rays are essentially marine forms, some of which may enter brackish, of freshwaters, freely. Rays are swimmers of moderate depths, and are most common in shallow water. A deep sea species has recently been reported from the Central Pacific Ocean. Sheltered bays, shoal lagoons, river mouths, and sandy areas between patch reefs are favorite habitats of rays. They may be observed lying on top of the sand, or partially submerged, with only their eyes, spiracles, and a portion of the tail exposed. Rays burrow into the sand and mud, and excavate the bottom with the use of their pectoral fins, by which means they obtain the worms, molluscs, and crustaceans upon which they feed.

Morphology of the venom apparatus — The venom apparatus of stingrays is an integral part of the caudal appendage. The venom organs of stingrays have been divided into four anatomical types based upon their adaptability as a defense organ. This subject was discussed by Halstead and Bunker (1953).

Gymnurid type: This is the most weakly-developed type of stingray venom apparatus. The caudal appendage in gymnurid rays are cylindrical, tapering, and greatly reduced in size. The sting is small, seldom exceeding 2.5 cm in length, and usually situated in the middle or proximal third of the tail. The striking ability of the organ is relatively feeble.

Myliobatid type: The venom organs of myliobatid rays are better adapted as a striking organ than those found in gymnurid rays. The caudal appendage is cylindrical and tapers out to a long whip-like tail. The sting is generally situated on the proximal portion of the basal third of the tail and is moderate to large in size, ranging from about 5 to 12 cm or more in length. Although myliobatid rays can inflict serious wounds, the striking force of the sting is less than that of the dasyatid rays largely because of the proximal location of the sting on the caudal appendage.

Dasyatid type: The venom organs of dasyatid rays are better adapted as a striking organ than are those of myliobatid rays. The caudal appendage is cylindrical and tapers out to a long whip-like tail. The sting in some species may be very large, attaining 37 cm or more in length, and is located in the distal portion of the basal or middle third of the tail. The more distal location of the sting improves the striking force of the sting.

Urolophid type: The venom organs of urolophid rays are probably the most highly developed of any of the sting rays. The caudal appendage is relatively short, very muscular, and is not as a whip-like structure, but rather the tail becomes compressed distal to the sting and forms a more or less distinct caudal fin. The sting is usually located in the middle or distal third of the tail and is moderate in size, seldom exceeding 5 cm in length. The powerful muscular structure of the tail and the distal location of the sting make this a highly efficient defensive weapon.

Although there is considerable variation in the morphology of the venom organs of various stingray species there is a basic pattern which all of the species examined thus far appear to follow. For the purpose of this review only a general description of the stingray will be given.

The venom apparatus of stingrays consists of a bilaterally retroserrate spine and its enveloping integumentary sheath. The spine is an elongate tapering structure that ends in an acute sagitate tip. The spine is composed of an inner core of vasodentine which is covered by a thin layer of enamel. It is firmly anchored in a dense collagenous network of the dermis on the dorsum of the caudal appendage. The dorsal surface of the spine is marked by a number of shallow longitudinal furrows. These furrows are usually more pronounced on the basal portion of the spine and disappear distally. The serrate edges of the spine are termed the dentate margins. Medial to each dentate margin, on the ventral side, is a longitudinal groove, the ventro-lateral-glandular groove. The grooves are separated from each other by the median ventral ridge of the spine. Contained within the grooves of an "unsheathed" or traumatized sting is a strip of gray tissue. The tissue lying within the ventrolateral glandular grooves consists of glandular epithelium and blood vessels. This is the primary venom producing area of the sting. In most stingray species there is a thickened wedge-shaped portion of the integument on the dorsum of the caudal appendage ventral to the sting which is known as the cuneiform area. Toxicological studies of the cuneiform integument indicate that the glandular cells of this area also secrete venom.

Microscopic examination of histological cross sections of an intact sting reveals that it is roughly diamond shape and consists of a broad T-shaped dentinal structure completely enveloped by a layer of integument. The integument is comprised of two layers. The inner layer, the dermis, consists of areolar connective tissue and vascular channels. The outer layer, the epidermis, is composed of modified squamous epithelium containing many glandular cells. A cross section of the ventrolateral-glandular groove has been termed the glandular triangle. Glandular activity is generally most concentrated in the epidermis in the immediate vicinity of the ventrolateral-glandular grooves which is believed to be the principal site of venom production. There is no histological evidence of a venom duct. Venom production is by a holocrine type of lysis.

Clinical characteristics — Pain is the predominant symptom and usually develops immediately or within a period of ten minutes following the attack. The pain has been variously described as sharp, shooting, spasmodic or throbbing in character. The freshwater stingrays are reputed to cause extremely painful wounds. More generalized symptoms of fall in blood pressure, vomiting, diarrhea, sweating, rapid heart beat, muscular paralysis, and death have also been reported.

Stingray wounds are either of the laceration or puncture type. Penetration of the skin and underlying tissue is usually accomplished without serious damage to the surrounding structures, but withdrawal of the sting may result in extensive tissue damage due to the recurved spines. Swelling in the vicinity of the wound is a constant finding. The area about the wound at first has an ashy appearance, later becomes cyanotic and then reddened. Although stingray injuries occur most frequently about the ankle joint and foot as a result of stepping on the ray, instances have been reported in which the wounds were in the chest.

Treatment — The following recommendations are based on the clinical investigations of 1,725 cases of stingray attacks during the past 15 years by Russell (1953, 1965) and his associates, who have had more first-hand experience in this field than any other group.

Efforts of treatment should be promptly and vigorously instituted. The treatment is directed toward alleviating the pain, combating the effects of the venom, and preventing secondary infection. Successful results are in large measure dependent upon the rapidity with which treatment is instituted. The victim should immediately irrigate the wound with the cold saltwater at hand. This procedure facilitates removal of the venom, and the cold water tends to act as a vasoconstrictor thus reducing the amount of absorption of the poison, while serving as a mild anesthetic agent. A tourniquet may be applied immediately above the stab site but must be released every few minutes in order to preserve circulation. The wound should be explored carefully for evidence of pieces of the sting's integumentary sheath. All pieces of integumentary sheath must be completely removed or envenomation will continue and the results of the treatment will be greatly impaired. As soon as the wound has been thoroughly cleansed, the injured member should be soaked in hot water. The water should be maintained at as high a temperature as the patient can tolerate without producing further injury to the tissues. Soaking should continue for a period of 30 to 90 minutes. The addition of magnesium sulfate to the water is sometimes desirable because of its mild anesthetic properties. The addition of other anesthetic and antiseptic agents is optional. Following the soaking procedure, the wound should be debrided, cleansed, and closed with dermal sutures. The use of antitetanus agents is recommended. Antibiotic agents may be required. The use of intramuscular or intravenous demerol has been found effective in controlling the pain. The primary shock so often seen immediately following the injury usually responds satisfactorily to routine supportive measures. However, the secondary shock resulting directly from the action of the venom on the cardiovascular system may require immediate and vigorous therapy. Treatment should be directed toward maintaining cardiovascular tone and the prevention of any further complicating factors. Elevation of the injured member is advisable.

The use of potassium permanganate, ammonia, and cryotherapy (Mullins, Wilson, and Best, 1957) is not only useless but may even have adverse effects. They are not recommended for the treatment of stingray stings. For further reading on the treatment of stingray attacks see Bayley (1940), Evans (1943), Halstead and Bunker (1953), Russell and Lewis (1956), Halstead (1959), Russell (1959), and Halstead and Mitchell (1963).

Pharmacology — The most complete studies on the pharmacological properties of stingray venom have been conducted by Russell and his associates working primarily with the venom of *Urolophus halleri.*

Stingray venom has a deleterious effect on the vertebrate cardiovascular apparatus. The action on the blood vessels appears to be diphasic. Low concentrations of the venom give rise to simple peripheral vasodilatation or vasoconstriction. With massive doses the venom causes vasoconstriction without a preliminary period of dilatation. The most obvious effect, and perhaps the more important one, is that of vasoconstriction. This effect has been observed in all the blood vessels examined. Some of the most serious effects were those directly upon the heart. The most consistent change seen in the electrocardiographic pattern of cats that were injected with small amounts of the venom was bradycardia with an increase in the PR interval giving a first, second, or third degree atrioventricular block. The second degree block was usually followed by sinus arrest. Reversal of the small dose effect occurred within 30 seconds following the end of the injection. When cats were given larger amounts of the venom, they showed in addition to the PR interval change, almost immediate ST, T wave change indicative of ischemia, and in some animals, true muscle injury. High concentrations of the venom caused marked vasoconstriction of the large arteries and veins as well as the arterioles. The direct effects on the heart muscle are quite drastic. The venom produces changes in the heart rate and amplitude of systole, and may cause complete, irreversible, cardiac standstill. It appears that stingray venom affects the normal pacemaker. The new rhythm evoked following cardiac standstill is frequently irregular and is believed to be elaborated outside the sino-atrial node (Russell and van Harreveld, 1954; Russell, Barritt, and Fairchild, 1957).

Stingray venom depresses respiration. Although part of the respiratory depression is secondary to the cardiovascular changes, the venom may have a direct effect on the respiratory centers of the medulla.

Stingray venom produces many changes in the behavior of animals. Some of these changes can be attributed to the direct effects of the venom on the central nervous system. In mammals the venom occasionally produces convulsive seizures, but the mechanism of these seizures is not apparent. They may be due in part to cardiovascular failure. Seizure patterns were not reported in electroencephalograms from anesthetized animals (Russell *et al.*, 1958). The venom does not seem to have a deleterious effect on neuromuscular transmission (Russell and Long, 1960; Russell and Bohr, 1962). When the venom is injected into the lateral ventricles of mammals it produces transient apathy, astasia, and licking motions (Russell and Bohr, 1962). Mice injected with lethal doses of venom developed hyperkinesis, prostration, marked dyspnea, blanching of the ears and retina, and exophthalmos. These signs were followed by complete atonia, gasping respiratory movements, coma, and death. A similar syndrome was observed in cats and monkeys including ataxia, dilated pupils, increased salivation, micturation defecation, marked atonia, cyanosis, and hypoactive or absent deep and superficial reflexes. One monkey exhibited a conic-clonic generalized motor seizure accompanied by hypersalivation, twitching of the head, and marked dilatation of the pupils (Russell *et al.*, 1958; Russell, 1965).

Chemistry — There is very little information available regarding the chemistry of stingray venoms. The most specific data are those provided by Russell *et al.* (1958), Russell, Fairchild, and Michaelson (1958), and Russell (1965). The freshly prepared water extract of crude venom prepared from *Urobatis halleri* is described as clear, colorless, or faintly gray in color. The pH was 6.76. The crude extract loses its toxicity within 4 to 18 hours upon standing at room temperature but is more stable at lower temperatures or in 20 to 40 percent glycerol. The venom will not tolerate lyophilization. The total protein content was found to be approximately 30 percent, total nitrogen 3 percent, and total carbohydrate 3 percent. Ten amino acids have been found to be present. With the use of disc electrophoresis, they have identified 15 fractions in extracts from the venomous integumentary sheath of *U. halleri*. Extracts prepared from sponges that had been stabbed with fresh stings were found to contain 10 fractions. Further studies on these extracts using gel filtration (Sephadex G 100 and G 200) suggested that the toxic protein, or proteins, may have a molecular weight in excess of 100,000. The fraction of the toxin having the greatest lethality was found to have two or three distinct bands when subjected to disc electrophoresis. Crude venom extracts have been shown to contain serotonin, 5-nucleotidase, and phosphodiesterase. Protease and phospholipase activity were absent.

Class **OSTEICHTHYES**: Catfishes, Scorpionfishes, Toadfishes, etc.

Catfishes — The suborder SILUROIDEA includes a group of fishes having a wide variety of sizes and shapes. Their body shape may vary from short to greatly elongate, or even eel-like. The head is extremely variable, sometimes very large, wide or depressed, again very small. The mouth is not protractile but the lips are sometimes greatly developed, usually with long barbels, generally with at least one pair from rudimentary maxillaries, often one or more pairs about the chin, and sometimes one from each pair of nostrils. The skin of these fishes is thick and slimy, or with bony plates. There is an absence of true scales. About one thousand species are included within this group, most of which are found in the fresh-water streams of the tropics, but a few species are marine. Considering the large number of catfish species, amazingly little is known regarding the morphology of their venom organs or the nature of their venom. Most of the published literature on catfish venom organs deals with North American freshwater species. Papers on these species have been published by Reed (1900, 1906, 1907, and 1924), and Halstead, Kuninobu, and Hebard (1953). There are no reports on the venom apparatus of any Brazilian catfish.

Family ARIIDAE: *Genidens genidens* (Cuvier and Valenciennes). Catfish (USA), mandi (Brazil). — Brazil. *Netuma barbus* (Lacépède). Sea catfish (USA), bagre marinho (Brazil). — East coast of South America, from Guianas to Argentina. *Scideichthys albicans* (Cuvier and Valenciennes). Catfish (USA), bagre marinho (Brazil). — Brazil.

Biology — The ariid catfishes are a large group of subtropical and tropical marine fishes which are worldwide in distribution. They are active fishes and unlike their freshwater counterparts in that they are constantly on the move, frequently in large schools. They resemble most other catfishes in appearance but differ from other species in that the anterior and posterior nostrils are close together, the latter covered by a valve. Sea catfish have an interesting habit in which the male catfish incubates their eggs by placing them in its mouth. The male places up to 50 eggs or more in his mouth for a period of two months. After the eggs are hatched out, the young fish remain in the mouth for an additional period of two weeks.

Morphology of the venom apparatus — The venom apparatus of catfishes consists of the dorsal and pectoral stings and the axillary venom glands. The dorsal and pectoral spines are comprised of modified or coalescent soft rays which have become ossified, and so constructed that they can be locked in the extended position at the will of the fish. The mature dorsal spine is a stoutly-elongate, compressed, tapered, slightly arched, osseous structure bearing a series of retrorse dentations along the anterior and posterior surfaces, and having an acute sagittate tip. The spine is generally enveloped by a thin layer of sparsely pigmented skin, the integumentary sheath, which is continuous with that of the softrayed portion of the fin. There is no external evidence of a venom gland. The shaft of the pectoral spine is similar to the dorsal spine in its general morphology.

Microscopic examination reveals that the level of the middle third, the sting may be divided into three distinct zones: a peripheral integumentary sheath, an intermediate osseous portion, and a central canal. The integumentary sheath is comprised of a relative thick outer layer of epidermis and a thin layer of dermis. The glandular cells which comprise the venom gland are most concentrated at the anterolateral and posterolateral margins of the sting where they are sometimes clumped two or three cells deep within the epidermal layer. The venom glands of most of the catfish species that have been studied appear as a cellular sheet wedged between the pigment layer and the stratified squamous epithelium of the epidermis. The microscopic anatomy of the dorsal and pectoral stings are similar in appearance. The axillary pore, which is the outlet of the axillary gland, is located just below the vertical center of the posthumeral process of the cleithrum. The gland is enclosed within a capsule of fibrous connective tissue, and is divided into three or four lobes which are further subdivided into a variable number of lobules. The lobules are composed of large secretory cells. It is believed that this gland may contribute to the venom supplied to the pectoral stings in those species of catfishes in which the axillary gland is present.

Clinical characteristics — The pain is generally described as an instantaneous stinging, throbbing, or scalding sensation which may be localized or may radiate up the affected limb. Some of the tropical species, such as *Plotosus*, are capable of producing violent pain, which may last for 48 hours or more. The area about the wound becomes pale immediately after being stung. The pallor is soon followed by a cyanotic appearance, and then by redness and swelling.

In some cases the swelling may be very severe, accompanied by numbness and gangrene of the area about the wound. Shock may be present. Improperly treated cases frequently result in secondary bacterial infections of the wound. Some species of catfishes may produce wounds which may take weeks to heal, but in most instances the wounds are of minor consequence. Deaths have been reported from the stings of some of the tropical catfishes.

Treatment — Symptomatic. There are no specific antidotes. Follow the same procedure as used in the treatment of stingray wounds.

Pharmacology — Unknown.

Chemistry — Unknown.

SCORPIONFISHES — The vast family of SCORPAENIDAE closely resemble the sea basses from which they are distinguished by a suborbital stay which is present in the scorpionfishes. The suborbital stay joins the other bones of the head to form a coat of mail which covers the whole head. The excessive number of spines about the head are characteristic of the members of this family. Scorpionfishes vary greatly in their form and coloration. A few species may attain large size and many are considered to be valuable food fishes. Representatives of the family are widely distributed throughout all tropical and temperate seas, and several species occur in Arctic waters. The family SCORPAENIDAE, as the name implies, includes some of the most dangerous species of venomous fishes known.

Family SCORPAENIDAE *: *Scorpaena brasiliensis* Cuvier. Barbfish (USA), peixe escorpião (Brazil). — Western Atlantic, from Virginia to Bahia (Brazil). *Scorpaena grandicornis* Cuvier and Valenciennes. Lionfish, long-horned scorpionfish (USA), peixe-escorpião (Brazil). — Western Atlantic, Florida to Brazil. *Scorpaena plumieri* Bloch. Spotted scorpionfish, sculpin (USA), peixe-escorpião (Brazil). — Western Atlantic, from Massachussetts to Brazil.

Biology — Members of the genus *Scorpaena* are for the most part shallow-water bottom dwellers, found in bays, along sandy beaches, rocky coast line, or coral reefs. Their habit of concealing themselves in crevices, among debris, under rocks, in seaweed, together with their protective coloration which blends them almost perfectly into their surrounding environment, makes them difficult to see. Scorpaenids are generally captured by hook and line, and in many regions they are a popular and important food fish. When they are removed from the water they have the defensive habit of erecting their spinous dorsal fin and flaring out their armed gill covers, pectoral, pelvic, and anal fins. The pectoral fins, although dangerous in appearance, are unarmed. Hinton (1962) and Breder (1963) have reported observations on the defensive behavior of *Scorpaena guttata* and *S. plumieri* respectively. Whenever an object comes in close proximity to *S. guttata*, the dorsal spines are immediately erected and the fish moves swiftly toward the object so as to deliver a sharp blow to the object with the side of its head or with its dorsal sting. In the case of *S. plumieri* it was observed that the fish was generally quiescent, but when touched with a stick, it would settle

* Although only three species of scorpaenids are listed here, it is believed that any members of the genus *Scorpaena* inhabiting Brazilian waters are venomous. The species given in this list are the only three species listed in venomological literature.

down tightly on the sand and sometimes arch its back. The head of the fish was directed slightly downward and the opercula expanded. If the intrusion continued the fish would suddenly change its stance and expose large yellow patches on the pectoral fins. Prior to this, all of the exposed surface of the fish was somewhat drab, but with the change in stance the pectorals would be suddenly flipped over displaying the brightly colored undersurface. The pale dots near the base of the pectorals became a bright iridescent blue, and the inter-radial light-colored patches along the margin to mid-part of the fins were bright yellow. The dark area around the blue spots became an intense black and the fin margin gray. If the provocation continued, the fish would repeatedly ram or butt the intruding object.

Morphology of the venom apparatus — The venomous members of the family SCORPAENIDAE can be classified into three basic types on the basis of the morphology of their venom organs: (1) *Pterois* or zebrafish type; (2) *Scorpaena* or scorpionfish type; and (3) *Synanceja* or the stonefish type. Only the *Scorpaena* type are found among the Brazilian scorpionfishes. Unfortunately no one has described the venom apparatus of a Brazilian scorpionfish. Therefore one can only assume that the venom apparatus of *Scorpaena brasiliensis*, *S. grandicornis*, and *S. plumieri* resemble that of *S. guttata*, the California scorpionfish, which has been studied in detail. The following description is based on the studies of Halstead, Chitwood, and Modglin (1955). The venom apparatus includes 12 dorsal spines, 3 anal spines, 2 pelvic spines, their associated venom glands, and their enveloping integumentary sheaths. If the integumentary sheath is removed, a slender, elongate fusiform strand of grey or pinkish tissue can be observed lying within the glandular grooves on either side of the spine. Microscopic examination of cross sections of venom glands reveals a cluster a large polygonal glandular cells with pinkish-grey, finely granular cytoplasm located in the dermal layer within the anterolateral glandular grooves. The large venom-producing cells have a pinnate, heart-shaped arrangement, and vary greatly in size and morphology.

Clinical characteristics — Stings from scorpionfishes vary from one species to the next, but generally the introduction of scorpaenid venom immediately produces an intense throbbing pain. Within a few minutes the area about the wound becomes ischemic and then cyanotic. The pain becomes progressively more severe and may radiate to the groin or axilla. The intensity of the pain may be comparable to that produced by renal colic and may continue for several hours. Within a short period of time the affected part becomes swollen, erythematous, and indurated. Profuse perspiration, pallor, dyspnea, restlessness, nausea, vomiting, diarrhea, loss of consciousness, and extreme tachycardia are commonly present. Abscesses, necrosis, and sloughing of the tissues about the wound have been reported. Bayley (1940) and Colby (1943) state that a maculopapular or scarlatiniform rash over the body may occur. Cecca (1902) cites a case which resulted in peripheral neuritis, paralysis, and muscular atrophy due to a sting by *Scorpaena nera*. Secondary bacterial infections, tetanus, and primary shock are frequent complications which must be considered. According to Blanchard (1890), Coutiere (1899), Scott (1921), and Colby (1943), scorpionfish stings may result in death.

Treatment — Scorpionfish sting should be treated in the same manner as stingray envenomations.

Pharmacology — There are no reports available on the pharmacology of the venom of Brazilian scorpionfishes.

Chemistry — There are no reports available regarding the venom of Brazilian scorpionfishes.

TOADFISHES — The BATRACHOIDIDAE, or toadfishes, are a group of small bottom fishes which inhabit the warmer waters of the coasts of America, Europe, Africa, and India. Toadfishes are of little commercial value and are not generally considered as food fishes, although they are eaten in some countries. The flesh is said to be fine-flavored, but the fishes are small in size and bony. According to Taschenberg (1909), the liver of some of the batrachoids is poisonous to eat. However, the greatest interest of these fishes to biotoxicologists is their unique and highly developed venom organs.

Family BATRACHOIDIDAE: *Marcgravichthys cryptocentrus* (Valenciennes). Toadfish (USA), niquim-niquim, sapo (Brazil). — Brazil. *Thalassophryne amazonica* Steindachner. Brazilian toadfish (USA), pocomon, niquim-niquim, sapo (Brazil). — Mouth of the rivers Negro, Amazon and Xingu (Brazil). *Thalassophryne branneri* Starks. Toadfish (USA), niquim-niquim, sapo (Brazil). — Brazil. *Thalassophryne punctata* Steindachner. Toadfish (USA), niquim-niquim, sapo (Brazil). — Brazil.

Biology — Batrachoid fishes, with their broad, depressed heads and large mouths, are somewhat repulsive in appearance. Most toadfishes are marine, but some are estuarine or entirely fluviatile, ascending rivers for great distances. They appear to enjoy turbid water. Regardless of the type of water in which they are found, batrachoids are primarily bottom fishes. They hide in crevices, burrows, under rocks, debris, among seaweed, or lie almost completely buried under a few centimeters of sand or mud. Fróes (1932, 1933a) stated that the Brazilian species of *Thalassophryne* has the habit of covering itself with a thin layer of sand or mud, but with careful observation one can usually detect the outline and protruding eyes of the fish as one wades along in the clear shallow water of sandy beaches. Toadfishes are quite hardly and are able to live for several hours after being removed from the water. According to Goode (1884), the bottom temperature of the water frequented by these fishes would appear to range from 10°C to 32°C. Toadfishes tend to migrate to deeper water during the winter months where they remain in a somewhat torpid condition.

They also are experts at camouflage. Their ability to change their color to lighter or darker shades at will and their mottled pattern make these fishes difficult to see.

Most toadfishes tend to be somewhat sluggish in their movements, but when after food they can dart out with surprising rapidity. They are somewhat omnivorous in their eating habits but seem to prefer among other things, crabs, mollusks, worms, and small fishes. Toadfishes are said to be quite vicious and will snap at almost anything upon the slightest provocation. Although they are not capable of producing a severe wound, they can inflict a bite that is not readily forgotten. When they are disturbed or their dorsum touched, they immediately erect their dorsal spines and flare out their opercular spines in defiance. Toadfishes do not school, but they are gregarious and tend to congregate together. For additional information regarding the habits of these interesting fishes, the excellent works of Gill (1907) and Gudger (1910) are recommended.

Morphology of the venom apparatus — The venom apparatus of toadfishes consists of two dorsal fin spines, two opercular spines, and their associated venom glands. In the case of *Thalassophryne dowi*, which can be considered as typical of the group, there are two dorsal spines which are enclosed together within a single integumentary sheath. The dorsal spines are slender and hollow, slightly curved, and terminate in acute tips. At the base and tip of each spine is an opening through which the venom passes. The base of each dorsal spine is surrounded by a glandular mass from which the venom is produced. Each gland empties into the base of its respective spine. The operculum is also highly specialized as a defensive organ for the introduction of venom. The horizontal limb of the operculum is a slender hollow bone which curves slightly, and terminates in an acute tip. Openings are present at each end of the spine for the passage of venom. With the exception of the extreme distal tip, the entire opercular spine is encased within a glistening, whitish, puriform mass. The broad rounded portion of this mass is situated at the base of the spine, and tapers rapidly as the tips of the spine is approached. The pyriform mass consists of a tough sac-like outer covering of connective tissue in which is contained a soft, granular, gelatinous-like substance having the appearance of fine tapioca. This mass is the venom gland. The gland empties into the base of the hollow opercular spine which serves as a duct.

Microscopic examination of the venom glands shows strands of aerolar connective tissue, large distended polygonal cells filled with finely granular secretion, and vascular channels. In some instances the polygonal cells will appear to have undergone complete lysis and there remain only areas of amorphous secretion. The microscopic anatomy of the dorsal and opercular venom glands are essentially the same.

Clinical characteristics — The pain from toadfish wounds develops rapidly, is radiating and intense. Some have described the pain as being similar to that of a scorpion sting. The pain is soon followed by swelling, redness, and heat. No fatalities have been recorded in the literature. Little else is known about the effects of toadfish venom.

Treatment — Toadfish stings should be handled in a manner similar to stingray envenomations.

Pharmacology — The only published reports on toadfish venom are those by Fróes (1933). Injections of the venom into guinea pigs and chicks resulted in mydriasis, ascites, paralyses, necrosis about the injection site, convulsions and death. The author believes that the venom of *Thalassophryne* has both proteolytic and neurotoxic properties.

Chemistry — Unknown.

MISCELLANEOUS VENOMOUS FISHES — There does not appear to be any data available on other kinds of venomous fishes in Brazilian waters.

LITERATURE

1. *Baird, W.* — Description of a new species of annelide belonging to the family AMPHINOMIDAE. *Trans. Linnean Soc. London*, **24**:449-450, pl. 45, 1864.

2. *Bailey, H. H.* — Injuries caused by scorpion fish. *Trans. Roy. Soc. Trop. Med. Hyg.*, **34**(2):227-230, 1 pl., 1940.

3. *Blanchard, R.* — *Traité de zoologie medicale.* Paris, J. B. Baillière et Fils, 1890, **2**:638-695.

4. *Boschma, H.* — The species problem in *Millepora*. *Zool. Verhandel. Rijksmus. Natuur. Hist.*, Leiden, (1), 115 p., 13 figs., 15 pls., 1948.

5. *Breder, C. M., Jr.* — Defensive behavior and venom in *Scorpaena* and *Dactylopterus*. *Copeia*, **4**:698-700, 2 figs., 1963.

6. *Carvalho, J. P.* — Peixes venenosos. *Seleções agrícolas*, **2**(12):10-15, 1947.

7. *Cecca, R.* — Sugli effetti tossici delle punture di alcuni pesci. *Clin. Med. Ital.*, **41**:82-87, 1902.

8. *Cleland, J. B.* — Injuries and diseases of man in Australia attributable to animals (except insects). *Australasian Med. Gaz.*, **32**:269-272, 1912.

9. *Colby, M.* — Poisonous marine animals in the Gulf of Mexico. *Trans. Texas Acad. Sci.*, **26**:62-69, 1943.

10. *Costa, J. F.* — *Intoxicação com o peixe de Fernando de Noronha. Território Federal de Fernando de Noronha.* Rio de Janeiro, Imprensa Nacional, 1958, pp. 104-105.

11. *Coutière, H.* — *Poissons vénimeux et poissons vénéneux.* 221 p., Paris, The Agrég. École Supérieure de Pharmacie de Paris, Carré et Naud, 1899.

12. *Diniz, A.* — Peixes venenosos. Tese, Fac. Medicina da Bahia, Salvador, 1905, 82 p.

13. *Earle, K. V.* — Pathological effects of two West Indian echinoderms. *Trans. Roy. Soc. Trop. Med. Hyg.*, **33**(4):447-452, 2 figs., 1940.

14. *Earle, K. V.* — Echinoderm injuries in Nauru. *Med. J. Australia*, **2**(10):265-266, 1941.

15. *Evans, H. M.* — The poison of the spiny dog-fish. *Brit. Med. J.*, **1**(3087):287-288, 5 figs., 1920.

16. *Evans, H. M.* — The poison organs and venoms of venomous fish. *Brit. Med. J.*, **2**(3174):690-692, 2 figs., 1921.

17. *Evans, H. M.* — The defensive spines of fishes, living and fossil, and the glandular structure in connection therewith, with observations on the nature of fish venoms. *Phil. Trans. Roy. Soc. London*, **212**:1-33, 14 figs. 3 pls., 1923.

18. *Evans, H. M.* — *Sting-fish and seafarer.* 180 pp., 31 figs., London, Faber & Faber Ltd., 1943.

19. *Fonseca, O.* — Estudos sôbre peixes venenosos do Brasil. *Brasil Médico*, **31** (11/12):90-91, 97-99, 1917.

20. *Fonseca, F.* — *Animais peçonhentos.* Instituto Butantan, São Paulo, 1952.

21. *Fróes, H. P.* — Sur un poisson toxiphore brésilien: le "niquim" *Thalassophryna maculosa*. *Rev. Sud-Amer. Méd. Cir.*, **3**(11):871-878, 1932.

22. *Fróes, H. P.* — Peixes toxíferos do Brasil. *Bahia Médica*, **4**(4):69-75, 1933.

23. *Fróes, H. P.* — Studies on venomous fishes of tropical countries. *J. Trop. Med. Hyg.*, **36**:134-135, 2 figs., 1933.

24. *Gill, T.* — Life histories of toadfishes (BATRACHOIDIDA), compared with those of weevers (*Trachinus*) and stargazers (*Uranoscopids*). *Smithsonian Misc. Coll.,* **48**(1697):388-427, 21 figs., 1907.

25. *Gillet, K. & McNeil, F.* — *The Great Barrier Reef and adjacent isles.* 209 p., 168 pls., Sidney (Australia), Coral Press Pty. Ltd., 1962.

26. *Gonsalves, A. D.* — *Peixes venenosos.* Rio de Janeiro, 1907.

27. *Goode, G. B.* — *The fisheries and fishery industries of the United States.* 2 vols., Washington, D.C., Govt. Printing Office, 1884.

28. *Gudger, E. W.* — Habits and life history of the toadfish (*Opsanus tau*). *Bull. U.S. Bur. Fish.,* **1908**(28):1071-1109, pls. 107-113, 1910.

29. *Halstead, B. W.* — Animal phyla known to contain poisonous marine animals. In: E. E. Buckley & N. Porges, ed., *Venoms,* Washington, D.C., Am. Assoc. Adv. Sci., 1956, p. 9-27.

30. *Halstead, B. W.* — *Dangerous marine animals.* 146 p., 88 figs., Cambridge, Cornell Maritime Press, 1959.

31. *Halstead, B. W.* — *Poisonous and venomous marine animals of the world. Invertebrates.* Washington, D.C., U.S. Government Printing Office, 1965, vol. I.

32. *Halstead, B. W., & N. C. Bunker* — Stingray attacks and their treatment. *Am. J. Trop. Med. Hyg.,* **2**(1):115-128, 12 figs., 1953.

33. *Halstead, B. W., Chitwood, M. J., & F. R. Modglin* — The venom apparatus of the California scorpionfish, *Scorpaena guttata* Girard. *Trans. Am. Microscop. Soc.,* **74**(2):145-158, 15 figs., 1955.

34. *Halstead, B. W., Kuninobu, L. S., & H. G. Hebard* — Catfish stings and the venom apparatus of the Mexican catfish, *Galeichthys felis* (Linnaeus). *Trans. Am. Microscop. Soc.,* **2**(4):297-314, 6 figs., 1953.

35. *Halstead, B. W. & Mitchell, L. R.* — A review of the venomous fishes of the Pacific area. In: H. L. Keegan & W. V. Mac Farlane, ed., *Venomous and poisonous animals and noxious plants of the Pacific region,* New York, Pergamon Press, 1963, p. 173-202, 16 figs.

36. *Hinton, S.* — Unusual defense movements in *Scorpaena plumieri mystes. Copeia,* (4):842, 1962.

37. *Hyman, L. H.* — *The invertebrates:* PROTOZOA *through* CTENOPHORA. 726 p., 221 figs., New York, McGraw-Hill Book Co., 1940, vol. I.

38. *Hyman, L. H.* — *The invertebrates:* ECHINODERMATA. *The coelomate bilateria.* 763 p., 280 figs., New York, McGraw-Hill Book Co., 1955, vol. IV.

39. *Lagler, K. F., Bardach, J. E., & Miller, R. R.* — *Ichthyology.* 545 p., New York, Wiley and Sons, 1962.

40. *Lane, C. E.* — The toxin of *Physalia* nematocysts. *Ann. N.Y. Acad. Sci.,* **90**(3):742-750, 5 figs., 1960.

41. *Le Mare, D. W.* — Poisonous Malayan fish. *Med. J. Malaya,* **7**(1):1-8, 1 pl. 1952.

42. *Levrat, E.* — Les réactions cutanées vis-à-vis de certains animaux marins. *Toulouse Méd.,* **28**(7):194-202, 1927.

43. *Mendes, E. G., Abbud, L., & S. Umiji* — Cholinergic action of homogenates of sea urchin pedicellariae. *Science,* **139**(3553):408-409, 1963.

44. *Mullin, C. A.* — Report on some polychaetous annelids; collected by the Barbados — Antigua expedition from the University of Iowa in 1918. *Univ. Iowa Studies Nat. Hist.*, **10**(3):39-45, pls. 5-6, 1923.

45. *Mullins, J. F., Wilson, C. J., & W. C. Best* — Cryotherapy in the treatment of stingray wounds. *Southern Med. J.*, **50**(4):533-535, 1957.

46. *Nielly, M.* — Animaux et vegetaux nuisibles. In: M. Nielly, *Éléments de pathologie exotique*, Paris, Delahaye & Lecrosnier, 1881, p. 709-710.

47. *Paradice, W. E.* — Injuries and lesions caused by the bites of animals and insects. *Med. J. Australia*, **2**:650-652, 2 figs., 1924.

48. *Parker, G. H.* — Neuromuscular activities of the fishing filaments of *Physalia*. *J. Cellular Comp. Physiol.*, **1**:53-63, 2 figs., 1932.

49. *Phillips, C., & Brady, W. H.* — *Sea pests-poisonous or harmful sea life of Florida and West Indies.* 78 p., 38 figs., 7 pls., Miami, Fla., Univ. Miami Press, 1953.

50. *Pope, E. C.* — Some sea animals that sting and bite. *Australian Mus. Mag.*, **9**(5):164-168, 5 figs., 1947.

51. *Pope, E. C.* — Some noxious marine invertebrates from Australian seas. In: J. W. Evans, chmn., Proc. First International Convention on Life Saving Techniques, Part III. Scientific section, suppl. *Bull. Post Grad. Comm. Med.*, Univ. Sidney, 1963, p. 91-102, 2 figs.

52. *Reed, H. D.* — The structure of the poison glands of *Schilbeodes gyrinus*. *Proc. Am. Assoc. Adv. Sci.*, 49th Mtg., p. 232-233, 1900.

53. *Reed, H. D.* — Notes on the poison organs in fishes. *Science*, **24**:293, 1906.

54. *Reed, H. D.* — The poison glands of *Noturus* and *Schilbeodes*. *Am. Naturalist*, **41**:553-566, 5 figs., 1907.

55. *Reed, H. D.* — The morphology of the dermal glands in *Nematognathus* fishes. *Z. Morphol. Anthropol.*, **24**:227-264, 32 figs., 1924.

56. *Roughley, T. C.* — Where nature runs riot. On Australia's Great Barrier Reef marine animals grow to unusual size, develop strange weapons of attack and defense, and acquire brilliant colors. *Nat. Geogr. Mag.*, **77**(6):823-850, 33 figs., 1940.

57. *Roughley, T. C.* — *Wonders of the Great Barrier Reef.* 282 p., New York, Charles Scribner's Sons, 1947.

58. *Russell, F. E.* — Stingray injuries: a review and discussion of their treatment. *Am. J. Med. Sci.*, **226**:611-622, 3 figs., 1953.

59. *Russell, F. E.* — Stingray injuries. *Public Health Repts.*, **74**(10):855-859, 1959.

60. *Russell, F. E.* — Marine toxins and venomous and poisonous marine animals. *Adv. Marine Biol.*, **3**:255-383, 1965.

61. *Russell, F. E., Barritt, W. C., & M. D. Fairchild* — Electrocardiographic patterns evoked by venom of the stingray. *Proc. Soc. Exp. Biol. Med.*, **96**:634-635, 1957.

62. *Russell, F. E., & V. C. Bohr* — Intraventricular injection of venom. *Toxicol. Appl. Pharmacol.*, **4**:165-173, 1962.

63. *Russell, F. E., Fairchild, M. D., & Michaelson* — Some properties of the venom of the stingray. *Med. Arts Sci.*, **12**(2):78-86, 3 figs., 1958.

64. *Russell, F. E., & R. D. Lewis* — Evaluation of the current status of therapy for stingray injuries. Venoms. *Am. Assoc. Adv. Sci.*, (44):43-53, 3 figs. 1956.

65. *Russell, F. E., & Long, T. E.* — Effects of venoms on neuromuscular transmission. In: H. R. Viets, ed., *Miasthenia gravis*, Springfield, Charles C. Thomas, 1960, p. 101-116, 3 figs.

66. *Russell, F. E., Panos, T. C., Kang, L. W., Warner, W. M., & T. C. Colket* — Studies on the mechanism of death from stingray venom. A report of two fatal cases. *Am. J. Med. Sci.*, **235**:566-584, 1958.

67. *Russell, F. E., & A. van Harreveld* — Cardiovascular effects of the venom of the round stingray, *Urobatis halleri*. *Arch. Internat. Physiol.*, **62**(3):322-333, 6 figs., 1954.

68. *Santos, E.* — *Nossos peixes marinhos (vida e costumes dos peixes do Brasil).* Rio de Janeiro, F. Briquiet & Cia., 1952.

69. *Scott, H. H.* — Vegetal and fish poisoning in the tropics. In: W. Byam & R. G. Archibald, ed., *The practice of medicine in the tropics*, London, Henry Frowde and Hodder & Stoughton, 1921, **1**:790-798, 2 figs.

70. *Silvado, J.* — *Peixes nocivos da baía do Rio de Janeiro.* Rio de Janeiro, 1911.

71. *Steinbeck, J., & Ricketts, E. F.* — *Sea of Cortez. A leisurely journal of travel and research.* 598 p., 40 pls., New York, The Viking Press, 1941.

72. *Taschenberg, E. O.* — *Die giftigen Tiere.* 325 p., 64 figs., Stuttgart, Ferdinand Enke, 1909.