Marine Envenomations Among Home Aquarium Hobbyists

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Citation

Abstract
It is estimated that 1.5 to 2 million people worldwide keep marine aquariums with 600,000 households in the United States alone. Although the American Association of Poison Control Centers estimates 40,000 to 50,000 marine envenomations occur worldwide each year, the actual number of envenomations that result from home aquarium specimens is unknown. This paper reviews the presenting symptoms and treatment options for envenomations from the most common and deadly marine specimens aquarists are likely to encounter. How lack of regulatory control over the marine ornamental industry places potentially dangerous marine specimens at the hands of the general public is also explained. The strikingly patterned lionfish accounts for most envenomations of home aquarists. Although death is rare, many specimens are capable of producing incapacitating pain of the affected limb. Lack of regulatory control over the marine exotic trade and the growing popularity of home aquariums may contribute to increasing envenomations among hobbyists, unsuspecting adults and children.

INTRODUCTION
It is estimated that 1.5 to 2 million people worldwide keep marine aquariums with 600,000 households in the United States alone. These tanks are stocked with wildlife extracted from the world's oceans, which contain approximately 2000 species of animals either venomous or poisonous to man. The strikingly patterned lionfish, with its delicate spines and vibrant, contrasting colors, account for most envenomations of home aquarists. While fatalities are rare, some exotic aquarium specimens have been reported to cause death in humans. Many specimens are capable of producing incapacitating pain of the affected limb. As home aquariums grow in popularity, hobbyists, unsuspecting adults and children are at risk for envenomation. Although the American Association of Poison Control Centers estimates 40,000 to 50,000 marine envenomations occur worldwide each year, the actual number of envenomations that result from home aquarium specimens is unknown.

Several factors contribute to under-reporting. Victims of marine envenomations who are unaware of the toxicity of some marine poisons may not seek medical attention. Meanwhile, treating physicians may not consult a poison control center and are under no legal obligation to report these injuries to state or federal agencies. In addition to this obstacle, much of the literature on marine envenomations takes the form of case reports instead of comprehensive reviews. Although much of the care for marine envenomations is supportive, some poisons require specific treatment.

This paper reviews the existing literature on marine envenomation focusing on species found in home aquaria. How the lack of regulatory control over the marine ornamental industry places potentially dangerous marine specimens at the hands of the general public is explained. The authors highlight important features of the most common and deadly marine specimens aquarists are likely to encounter. Finally, current concepts on the treatment of marine envenomations are discussed.

THE MARINE ORNAMENTAL INDUSTRY
An understanding of home aquarium envenomations begins by appreciating the availability of poisonous specimens. Authorities indicate the tropical marine trade industry is almost entirely unregulated. Existing regulations focus on the development and management of food fisheries and how extracting reef animals and plants from their habitats impacts the environment. Little attention has been paid to the consumer end of the trade and the lack of affirmative duty or obligation on wholesalers and retailers to disclose the dangers of owning some marine inhabitants.

Why the marine trade continues to fly under regulatory radar...
cannot be explained by the diminutive nature of the industry. In fact, the marine animal trade is highly profitable. The most comprehensive survey of the industry elicited responses from only one-fifth of wholesalers of marine animals, and documented the trade of 2,393 species of fish, coral and invertebrates between the years 1988 and 2001. Current estimates place the import value of marine animals and invertebrates between $200 and $300 million dollars annually.

Retailers in marine trade stock inventory by purchasing marine animals from domestic breeders or importing specimens from overseas. Breeders, using a process called aquaculture, raise and harvest fish and macro-invertebrates for sale. However, only one to ten percent of marine ornamental fish are captive-bred. The majority of marine specimens, including more exotic species, are collected from the wild. Commercial divers feel little legislative pressure to limit the extraction of ornamental fish from the oceans to non-poisonous specimens.

Existing laws do little to protect the unwary aquarist or discourage the adventurous marine enthusiast from purchasing poisonous marine animals. For example, the Animal Welfare Act regulates the sale of exotic animals such as lions and tigers, but does not apply to animals commonly kept as pets such as aquarium fish. Similarly, the Lacey Act only prohibits the trade and transport of animals in violation of state or federal law. The Act is only triggered when animals are illegally sold and transported that are already protected by State or Federal laws. In the end, an affirmative duty on retailers and wholesalers to disclose the dangers of owning particular marine species is absent.

MODES OF ENVENOMATION

Most poisonous fish possess a spine covered by an integumentary sheath which terminates in venom containing glands. Generally, during envenomation, the loose integumentary sheath compresses a venom gland located at the base of the spine. Venom travels along the base of the spine into the wound. Nature varies the number and location of poisonous spines among fish and invertebrates. In the case of Lionfish, these spines are distributed among 12-13 dorsal spines, 2 pelvic spines and three anal spines. Starfish, on the other hands, may be covered with a variable number of poisonous spines. In the following sections, we present a description of venomous marine species most commonly collected by aquarists. Signs and symptoms of envenomation and a review of current treatment considerations are discussed so physicians can appreciate and be prepared to handle envenomations from the most common home aquarium specimens.

VENOMOUS MARINE FISH AND INVERTEBRATES

(LIONFISH, SCORPIONFISH, STONEFISH)

One classification system describes the Scorpaenidae family as three distinct groups. Arranged in order of increasing toxicity they are: Pterois (lionfish), Scorpaena (scorpionfish), and Synanceia (stonefish). Although ranking third in toxicity compared to stonefish and scorpionfish, lionfish are the most commonly encountered Scorpaenidae in the animal trade. In fact, the elongate spines and bold color pattern of the lionfish make them among the ten most common fish kept in home aquariums.

The true incidence of Scorpaenidae envenomations is unknown. Kizer found 45 lionfish envenomations reported to the San Francisco Poison Control Center over a five year period. Trestail documented 23 cases of lionfish envenomation reported to the Blodgett Regional Poison Control Center in Michigan. In all, 108 cases of lionfish envenomation were reported in the literature between 1976 and 2001. From these case reports it is impossible to know how often victims of envenomation go untreated and how often those treated go unreported. All that can be said of Scorpaenidae envenomations is that the frequency of case reports would indicate that lionfish envenomations are not uncommon.

Other common threads emerge from these case reports. First, almost all envenomations occur in the hands of aquarists while cleaning their fish tanks. Second, the sine qua non of Scorpaenidae encounters is intense pain at the site of envenomation. Other local symptoms include swelling, redness, bleeding, and joint pain. When systemic symptoms are reported they include nausea, anxiety, headache, disorientation, and dizziness of varying intensity. Just as striking as the predominance of local symptoms is the absence of fatalities. Finally, while many authors discuss the lethality of stonefish envenomations, substantiating actual fatalities remains difficult. Nonetheless, severe and incapacitating systemic and local effects are well described.

ECHINODERMS (STARFISH, AND SEA URCHINS)

The phylum Echinodermata includes a diverse group of marine animals that are slow moving and nonaggressive,
including three venomous classes: starfish (class Asteroidea), sea urchins (class Echinoidea), and sea cucumbers (class Holothuroidea)\(^\text{14}\). The name Echinodermata means spiny skin and describes a calcareous skeleton that takes the form of defensive plates or protective spines\(^\text{15}\). Injury and envenomation from Echinoderms occurs almost exclusively from accidental contact or careless handling\(^\text{16}\). Significant local and systemic effects are possible following Echinoderm envenomation from any of the three venomous classes. In this paper, we focus on the two classes common to the marine ornamental trade: starfish and sea urchins.

**STARFISH**

Starfish envenomation in humans is well described. The crown-of-thorns starfish (Acanthaster planci) accounts for the majority of human envenomations\(^\text{17}\). Acanthaster species possess numerous arms (7-23) which contain extremely sharp spines projecting from the dorsal surface\(^\text{18}\). Acanthaster envenomation has been associated with immediate excruciating pain and burning at the puncture site\(^\text{19}\). A single puncture may result in several hours of pain, discomfort, or limitation of joint movement for several weeks\(^\text{20}\). Other local effects include prolonged bleeding, ecchymosis, and soft tissue swelling\(^\text{21}\). Systemic symptoms including nausea, vomiting, headache, arthralgias, parasthesias, and muscular paralysis are difficult to substantiate\(^\text{22}\). Secondary granuloma formation and retained foreign body material are documented complications\(^\text{23}\).

**SEA URCHINS**

Sea urchins contain both specialized spines (long or short) and pedicellaria (pincer-like jaws) to deliver venom. Although various species contain both pedicellaria and spines, usually only one is venomous in any given species\(^\text{24}\). Severe, burning pain localized to the puncture site is the initial reaction to sea urchin envenomation. The pain may last several hours and re-appears with any pressure on the wound site\(^\text{25}\). Localized edema, erythema, warmth and bleeding may follow\(^\text{25}\). Systemic symptoms including nausea, vomiting, and paresthesia occur in more severe cases\(^\text{26}\). Long-spined urchins (Diadema and Echinothrix species) are capable of causing deeply penetrating injuries\(^\text{27}\). One of the most venomous species, the flowering sea urchin (Toxopneustes pileolus) has been reported to cause muscular paralysis, hypotension, and respiratory distress\(^\text{28}\).

**BLUE-RINGED OCTOPUS (HAPALOCHLERA MACULOSA)**

The name Blue-ringed octopus is given to a group consisting of several different species (Hapalochlaena lunulata, Hapalochaena fasciata, Hapalochaena maculosa)\(^\text{29}\). At first blush, several features make the Blue-ringed octopus (H. Lunulata) an attractive marine aquaria specimen. First, they are small with an approximate length of 20 centimeters\(^\text{30}\). Second, superimposed on a dark brown to yellow body are brilliant blue rings which deepen when the animal is aroused\(^\text{31}\). Lastly, they are relatively inexpensive (around $30) and easy to obtain. It is no surprise that thousands of blue-ringed octopuses are imported into the United States and find their way into home aquaria each year.

The octopus has a small beak at the junction of its eight legs, and rather than manufacture ink, it makes poison in its salivary glands. Its bite may be almost imperceptible, and many victims only notice a tiny drop of blood at the site\(^\text{32}\). The toxin closely resembles tetrodotoxin (TTX) and can produce flaccid paralysis\(^\text{33}\). Early symptoms of envenomation include intraoral parasthesias, aphonia, diplopia, dysphagia, and ataxia. Increasing paralysis follows with cyanosis, respiratory failure, hypotension and death occurring in 25-50% of TTX envenomation\(^\text{34}\). Human fatalities from Blue-ringed octopus envenomation have been substantiated in the literature\(^\text{35}\). The potency of its venom and its popularity among home aquarists accounts for the attention the Blue-ringed octopus has received by the scientific community.

**PHARMACOLOGY OF VENOMS**

Much of the effort to characterize the biochemical activity of marine venoms has focused on venoms produced by stonefish and Blue-ringed octopus. The lethal effect of these venoms seems to reside in a signature protein unique to individual species within each family. Within the stonefish family, stonustoxin is the lethal protein from Synanceja horrida, trachynilysin from Synanceja trachynis and verrucotoxin from Synanceja verrucosa\(^\text{36}\). Like other animal venoms, stonefish venom exhibits hemorrhagic, hemolytic, and proteolytic enzymatic activity\(^\text{37}\). However, the only enzyme that has been isolated from stonefish venom is hyaluronidase\(^\text{38}\). Stonefish hyaluronidase has a potency many times higher than the enzyme from snake venom\(^\text{39}\). While hyaluronidase, through its ability to break down connective tissue, accounts for the significant necrosis associated with stonefish envenomation\(^\text{40}\), the protein which induces
vascular permeability and hypotension remains unknown. Since the discovery of tetrodotoxin (TTX) in puffer fish, TTX has been found in other marine creatures including the blue-ringed octopus. The neurotoxic effect of TTX is derived from its ability to bind voltage-gated sodium channels located on the surface of nerve cells. Not surprisingly, symptoms related to nerve function predominate every stage of TTX envenomation and manifest in a paresthesia to paralysis progression that culminates in death. The comparative toxicity of TTX places it at approximately 10,000 times more potent than cyanide. A single milligram, the amount that can be placed on the head of a pin, is enough to kill an adult. Despite the theoretical lethality of these marine venoms, anecdotal reports of fatalities far exceed substantiated cases of death due to marine envenomations.

PREHOSPITAL CARE

Access to marine aquaria, puncture wounds and extreme pain should arouse suspicion of a potential marine envenomation. Activities known to be associated with envenomations, such as cleaning marine aquariums, should be terminated to reduce the risk of further exposure. Identification or description of potential marine species responsible for the envenomation should be obtained. Prehospital providers should irrigate the wound with clean water, establish intravenous access in the unaffected extremity, administer oxygen, and transport the victim to the nearest medical facility. Prehospital personnel should recognize serious systemic symptoms and institute CPR and treatment for anaphylaxis. Routine principles of wound care should be employed including removal of constricting clothing, rings, and watches. Gentle removal of visible spines, the application of direct pressure to control bleeding and the administration of analgesia may also be indicated. Immersion of the affected extremity in hot water (45 °C) may inactivate heat labile venom and provide temporary relief.

EMERGENCY DEPARTMENT CARE

Victims of marine envenomations require supportive care and sometimes the administration of antivenom. Although CPR and other resuscitation measures take precedent, these interventions are rarely required. Initial history should include a description of the marine species kept by the aquarists with particular attention to the species thought to be responsible for the envenomation. Other historical information should include prehospital first-aid measures, coexisting medical conditions, and drug and horse serum allergies.

The site of envenomation should be examined for the presence and number of puncture wounds, retained spines, edema, erythema, and ecchymosis. Considering the LD50 of stonefish venom and the average dose per spine reveals six intact spines contain a dose lethal to a 60 kg man. Puncture wounds surrounded by a ring of cyanotic tissue, vesicle formation, rapid tissue sloughing and hypesthesia have been associated with Scorpaenida envenomation. Early excision of blisters has been advocated based on the notion that blisters may contain residual active venom effecting on-going dermal necrosis. Some experts support the use of compressive bandages applied proximal to the site of envenomation to limit toxin spread by lymphatic and venous channels. However, this intervention has not been routinely adopted in the literature regarding other venomous animal bites. Limb elevation, to reduce edema, and early mobilization, to mitigate joint stiffness, have been recommended by some authors.

No specific laboratory tests are recommended for the management of marine envenomations. Since retained spines continue to release venom diligence in their detection is warranted. The spine's calcareous nature facilitates their exclusion by a variety of imaging techniques including: plain radiographs, ultrasound and fluoroscopy.

Recommendations for analgesia are influenced by the pharmacology of the venom, location of the envenomation, and degree of pain. The thermolabile component of several marine venoms is the basis for heat treatment as the initial intervention for envenomations caused by a variety of venomous spine species. There seems to be general consensus in the literature that the affected limb should be immersed in water warmed to approximately 45 degrees Celsius. Overall, the effectiveness of heat treatment appears to be approximately 75%. Regional anesthesia with a long acting agent such as bupivacaine offers reliable, prompt, and prolonged anesthesia. Regional anesthesia also reduces the risk of accidental thermal burn from heat immersion and facilitates procedures such as spine removal, irrigation and wound debridement and exploration. Parental analgesics may be indicated when wound location prohibits regional analgesia or for persistent pain. A marine animal injury is an indication for tetanus prophylaxis and should be considered in light of the patient's immunization history. The efficacy of antibiotic prophylaxis for marine puncture wounds remains a
topic of debate. Although marine bacterial infections have been associated with significant morbidity, a universal approach to prophylaxis has not been adopted.\textsuperscript{51}

**ANTIVENOM**

Specific antivenom is available for Stonefish envenomations and indicated when severe pain, systemic symptoms, paralysis or multiple punctures are present. The antiserum is derived from horse serum. While the intramuscular (IM) route is well settled, intravenous administration remains controversial. In general, one ampule (2000U) of Australia Commonwealth Serum Laboratories (CSL) of Melbourne Stonefish Antivenom is given IM for puncture wounds from one or two spines. For three to four spine envenomations two vials are administered. Known allergy to horse serum remains a contraindication for stonefish antivenom. There is no antivenom available for TTX from octopus envenomation.

**SAFETY**

Prevention should take precedence in any discussion regarding poisonous ornamental fish and home aquaria. Since most envenomations occur while cleaning a home aquarium, precautions aimed at minimizing exposure to dangerous marine specimens should be employed. Partitioning fish and invertebrates from areas of the aquarium undergoing maintenance should be routine. Furthermore, avoidance of toxic species in homes and offices containing or frequented by young children, the chronically ill, or compromised individuals should be strongly considered. Marine aquarium enthusiasts should purchase marine animals from a well informed dealer and inquire about the potential toxicity of animals prior to purchase.

If an actual envenomation occurs, victims should activate local emergency medical services, wash the wound with clean water, and have knowledge of basic field interventions such as soaking the affected extremity in warm water while pursuing definitive medical attention. In the event an actual exposure to marine toxin is questionable, or questions arise regarding how to proceed, we recommend contacting the local Poison Control Center for advice.

**CONCLUSION**

Despite trafficking potentially deadly marine specimens, the ornamental fish trade remains largely an unregulated industry. As the popularity of marine aquaria continues to grow, emergency physicians can anticipate encountering patients envenomated by fish and invertebrates purchased from local pet stores. Although substantiated fatalities are rare, this statistic may change, as more and more poisonous specimens are shipped to countries with better reporting mechanisms. Emergency physicians should report marine envenomations to their local Poison Control Center. Only through such reporting can we monitor the actual risk trafficking poisonous marine specimens poses to the public. Further work in the ornamental fish trade should include efforts to fill the gaps in state and federal laws regulating the sale of poisonous marine animals.

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