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Review

Lionfish envenomation in Caribbean and Atlantic waters: Climate change and invasive species

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ABSTRACT

The concept of emerging diseases is well understood; however, the concept of emerging injuries is not. We describe the introduction of two species of lionfish, native to the Indian and Pacific Oceans, into the warm shallow coastal waters of the Western Atlantic Ocean and the Caribbean Sea. Lionfish thrive in the same coastal waters that attract recreational swimmers, snorkelers, and divers. Because lionfish have ornate colors, people often swim close to have a better look. Lionfish have venomous spines and, in a defensive reaction, frequently envenomate curious humans. The fish are voracious predators and disrupt the coral ecosystems of the Atlantic. Furthermore, their range is spreading through a combination of lack of natural predators and the expansion of hospitable warm waters into higher latitudes as part of climate change.

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Introduction

Standard definitions of an emerging infectious disease include the appearance of a disease in a new, geographically distinct area. This can happen in many ways, but usually one thinks of the introduction of a pathogen, vector, reservoir, or host into a previously nonendemic area (Morens and Fauci, 2013). Implicit within this concept, although largely overlooked, are emerging injurious diseases based on the spread of a biological hazard or natural toxin. Historical examples include the introduction and spread of ven-

omous fire ants in the southeastern United States (Tankersley, 2008), Africanized honey bees in the Americas (Ferreira et al., 2012), poisonous giant cane toads in Australia (Reeves, 2004), and brown tree snakes on Guam (Fritts et al., 1990).

No infectious particle or pathogen is involved; instead the injuries are due to intentional human actions (e.g., eating unripe akee fruit, *Blighia sapida*, in the Caribbean; Joskow et al., 2006), unintentional human actions (e.g., brushing against giant hogweed, *Heraclium mantegazzianum*, in several parts of North America; McGovern and Barkley, 2000), or a case of wrong place, wrong time (e.g., wild pig attacks wherever they have been introduced; Mayer, 2013). Introduced species disrupt native ecosystems in irrevocable and incalculable ways. Climate change is part of the destructive

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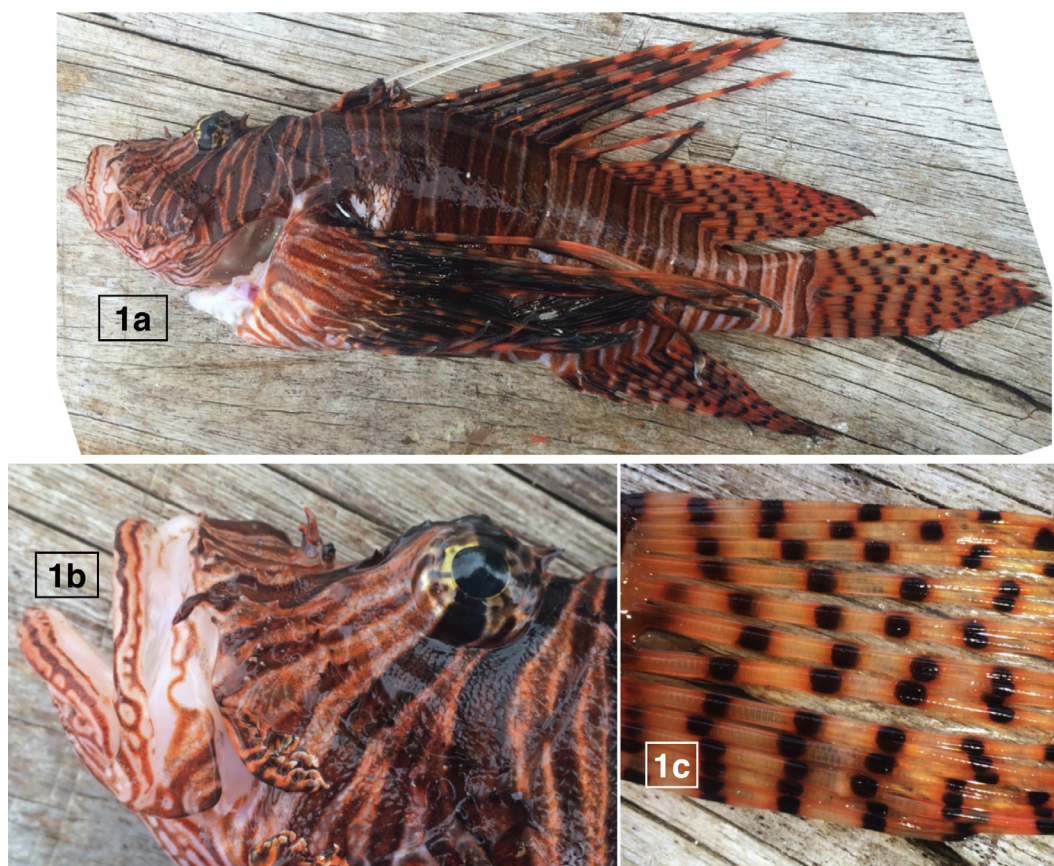


Fig. 1. Lionfish (*Pterois volitans*) caught by spear along the Caribbean coast of Turneffe Atoll, Belize, Central America, on January 4, 2015, showing its ornate coloring of the (A) body, (B) face, and (C) fins.

calculus because it enables invasive species to spread rapidly and successfully into additional areas where natural enemies never evolved (Hulme, 2017; Mainka and Howard, 2010).

Approximately 30 years ago, lionfish (Fig. 1), a flamboyantly colored fish native to the Indian and Pacific Oceans, were introduced into South Florida's coastal waters. Lionfish have venomous spines, and because their populations are exploding along the warm waters of the eastern (or Atlantic) coast of the Americas, they are now locally abundant among some coral reefs where, of course, recreational swimmers, snorkelers, and divers are also abundant. Because the fish are attractive and slow swimming, people try to swim closely to observe or reach out to them. Consequently, there are increasing numbers of contact envenomations (National Oceanic and Atmospheric Administration, 2020).

Case report

A healthy young man was cleaning a freshly caught lionfish that he had speared along the coral reefs of Turneffe Atoll, on Belize's Caribbean coast, when a dorsal spine nicked the skin on the back of his left hand. Within minutes, excruciating pain and paresthesias, starting in his hand, began to ascend his forearm. He immersed his hand and forearm in hot water for 30 minutes and the pain subsided considerably. The next day, he was pain-free, but his hand remained edematous (Fig. 2), tender to pressure, and dyesthetic to light touch. He did not take any antibiotics or analgesics and reported that this was a rather typical lionfish spine injury, which he had experienced at least five times in the past.

Discussion

The dozen or so species of lionfish (*Pterois* spp.) are native to the warm waters of the Indian and Pacific Oceans. Lionfish are native to the Indo-Pacific Oceans where they are common reef predators, feeding mainly on a variety of fish and invertebrates. Two species (the red lionfish, *Pterois volitans*, and the common lionfish, *Pterois miles*) were detected about 30 years ago along South Florida's Atlantic coast (Butterfield et al., 2015). Their introduction into those waters is likely the result of several intentional but naïve releases of aquarium fish. In the Atlantic Ocean, lionfish feed on large quantities of a wide number of species of fish. Lacking natural predators or competitors in the newly colonized waters, lionfish



Fig. 2. Marked edema of patient's left hand where an accidental lionfish envenomation occurred 1 day earlier while he was cleaning a lionfish for human consumption.



Fig. 3. Current distribution of lionfish in the waters of the Caribbean Sea, Gulf of Mexico, and Atlantic Ocean (Source: [www.nas.er.usgs.gov/viewer/omap.aspx?SpeciesID=963](https://nas.er.usgs.gov/viewer/omap.aspx?SpeciesID=963)).

have proliferated nearly unchecked, causing much damage to reef ecosystems. As climate change continues to raise temperate-zone ocean temperatures, this typically tropical fish is extending its range both north and south into mid-latitude coastal areas. Because lionfish are newly introduced species, they have no predators or natural enemies to check their expansion as they colonize new areas (Fig. 3; Côté and Green, 2012; Grieve et al., 2016; Needleman et al., 2018; Schofield et al., 2012).

The venomous spines of the lionfish pose a hazard throughout their range, whether they are endemic or exotic. Lionfish are members of the scorpionfish family (Scorpaenidae), known for several types of venomous fish, such as the stonefish, whose venom can be lethal to humans. The lionfish subfamily, Pteroinae, has five genera of ornately colored predatory fish, whose distinctive dorsal and pectoral fins are armed with spines that can administer an exquisitely painful venom (Galloway and Porter, 2019; Mouchbahani-Constance et al., 2018).

The venom is produced and stored in specialized glands at the base of the spines but naturally bathes the spine (Fig. 4). When the fish feels threatened, it adopts a head-down, tail-up defensive posture and raises its spines into a fan-like plane. The lionfish retracts the spine's epidermal covering, and the merest brush of the spine against human skin will induce an immediate searing pain. The pain is caused heat-labile peptide neurotoxins that have mostly sensory effects (pain) and relatively mild neuromuscular effects (Galloway and Porter, 2019; Mouchbahani-Constance et al., 2018). The pain resolves naturally over several days, but its resolution can be hastened by immersing the affected region, most commonly a hand or finger, in hot water (nonscalding, approximately 40–45 °C) for 30 to 90 minutes to denature the toxin (Atkinson et al., 2006; Diaz, 2015; Perkins and Morgan, 2004).

Other direct effects of the envenomation include swelling (Fig. 1). Indirect effects include the introduction of other marine

pathogens, such as *Vibrio vulnificus* or *Mycobacterium marinum*. Some sources recommend antibiotic prophylaxis with doxycycline or fluoroquinolone after a lionfish sting, as well as verifying tetanus immunization status (Diaz, 2015).

Several other marine injuries can induce pain that is seemingly out of proportion to the observed swelling. Nevertheless, lionfish envenomations rarely require a differential diagnosis because nearly all events are the result of a person deliberately reaching toward the fish. Other painful marine injuries include encounters with other members of the scorpionfish family, weever fish, stin-



Fig. 4. Two dorsal spines with epidermal sheaths retracted manually. The spines are not hollow; thus, they do not deliver the venom in a needle-like fashion, but instead, the venom is exuded by glands at the base of the spine and travels distally along the spine's outer grooves (Galloway and Porter, 2019).

grays, sea urchins, cone snails, and coelenterates/cnidarians (e.g., box jellyfish, coral, man-of-war). Of these, few inflict puncture-type injuries in temperate waters along North America's east coast. Furthermore, the immediate treatment for painful puncture-type marine envenomations consists of immersion in hot water to denature the toxin (Atkinson et al., 2006; Diaz, 2015; Perkins and Morgan, 2004).

Lionfish are invasive species that feed voraciously on native reef dwellers, upsetting the balanced ecosystem. Several efforts are underway to limit their further invasions north and south along the Atlantic seaboard. Divers, for example, may be offered bounties on each dead lionfish they bring back to shore. Because lionfish are tasty, many environmentalists encourage their capture and consumption (Aguilar-Perera, 2012; Boehrer, 2017; MacGregor, 2018), although lionfish can bioaccumulate ciguatoxins, which is another hazard they bring with them (Hardison et al., 2018).

Conclusion

Although this is a case report of a minor, self-resolving injury, it serves as a cautionary tale of the dermatologic consequences of anthropogenic effects on our planet. Our species threatens the global environmental balance in five broad ways. Climate change, the theme of this issue, is one way. The other ways are overexploitation of resources, habitat disruption, introduction of invasive species, and pollution (Pelletier and Coltman, 2018).

The careless disposal of one or more live lionfish into Florida's warm waters allowed a voraciously carnivorous species to enter a new but salubrious habitat, free from competitors and predators. Lionfish thrive in these waters but at great cost to the indigenous species, and the range of lionfish continues to expand as ocean temperatures rise. A small sign of this cascade of anthropogenic events will be the growing number of people who, while visiting the temperate beaches of the East Coast, have painful encounters with this venomous fish (National Oceanic and Atmospheric Administration, 2020; Needleman et al., 2018; Schofield et al., 2012).

This also serves as a cautionary tale of the potential medical hazards when one type of anthropogenic injury to our planet, the introduction of invasive species, is compounded by another type of anthropogenic injury, climate change.

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Study Approval

The author(s) confirm that any aspect of the work covered in this manuscript that has involved human patients has been conducted with the ethical approval of all relevant bodies.

Conflict of Interest

None.

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