Educational Series

Lionfish in the Atlantic and Caribbean

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Introduction

Two species of lionfish, *Pterois volitans* and *Pterois miles*, are invasive fishes in the Western Atlantic Ocean, specifically the east coast of North America, the Bahamas, and the Caribbean. Both the populations and range of these fishes have expanded rapidly since they were first documented in 1985. It is most likely that the introduction of these fishes was made either accidentally or intentionally by individual(s) involved with the aquarium trade.

The lionfish's highly successful invasion of the Atlantic and Caribbean ecosystems, along with a lack of natural predators, makes it extremely unlikely that the populations will be eradicated. This article examines issues related to lionfish and other invasive aquatic species that have been introduced into waters around North America. It is important that marine aquarium hobbyists be aware of the potential consequences of releasing livestock into the wild.

What are Lionfish?

Classification

Order:	Scorpaeniformes
Suborder:	Scorpaenoidei
Family:	Scorpaenidae, the scorpionfishes and the
	rockfishes.
Subfamily:	Pteroinae, the lionfishes.
Genera:	Brachypterois
	Dendrochirus
	Ebosia
	Parapterois
	Pterois

Lionfishes are easily recognizable by their bars (vertical lines), tall dor-

sal fin spines, and enormous pectoral fins. Lionfishes belong to the family (biological classification) Scorpaenidae, a well-known family consisting of the scorpionfishes and the rockfishes. Collectively, the lionfishes (or firefishes) consist of five genera (singular: genus) and are all allocated to the subfamily Pteroinae (one of ten subfamilies in Scorpaenidae).

The most well-known genera in the marine aquarium hobby are *Pterois* and *Dendrochirus*, although *Parapterois* does enter the hobby on occasion (Rhyne et al., 2015). The bulk of the trade consists of two species: the red lionfish (*Pterois volitans*) and Miles' firefish (*Pterois miles*). These two species are also the two species that are now invasive in the Atlantic and Caribbean.

There are 10 known species in the genus *Pterois* and five in the genus *Dendrochirus*. Studies using DNA have shown that the *Pterois* and *Dendrochirus* genera are very closely related (Kochzius et al., 2003), and that some taxonomic corrections are necessary (the authors of the paper suggest that moving species of *Dendrochirus* to *Pterois* may be warranted).

In addition to their striking coloration and behaviors using their pectoral fins, lionfishes are revered for their venomous spines. Lionfishes come in a range of sizes, from the small (~4 inch) twospot turkeyfish (fu man chu, *Dendrochirus biocellatus*) to the larger red lionfish at about 1 foot. The record red lionfish (*Pterois volitans*) caught measured 18.5 inches total length. In addition to their value for the ornamental hobby, lionfishes are popular as food in some parts of the world. Their popularity as a food item in the Americas is increasing rapidly. Lionfish can now be found served from small beachside shacks to high-end, luxurious restaurants.

Origin of the Problem

Lionfish populations were first reported off the coast of Florida near Dania Beach in 1985 (FFWCC, 2015). It is not clear whether the introduction was accidental or intentional, but nevertheless the first breeding specimens most likely came from the aquarium trade. It is highly probable that hobbyists released aquarium lionfish into the ocean because they were shutting down tanks, the lionfish became too large for the aquarium, the lionfish were eating other tank inhabitants, or the owner simply lost interest in keeping the fish.

A commonly cited source of the introduction is from a tank on a seawall in Biscayne Bay, FL, that was smashed by Hurricane Andrew in 1992 (Courtenay, 1995). However, this information came "second hand" to the author, where informants thought that "six to eight" lionfish specimens observed in the bay in 1992 came from that tank (Morell, 2010). Dr. Courtenay maintains that if in 1992 lionfish did escape from that tank [which he doubts], then they are not the source of the current invasion, as other sightings have been reported prior to this event. Although, if lionfish did escape in 1992, they may have contributed to the already present small population.



Lionfish collected by Florida Fish and Wildlife. Photo credit to Florida Fish and Wildlife. (https://www.flickr.com/photos/myfwcmedia/17256956091/in/photostream/)



A juvenile lionfish (*Pterois volitans*). Public Domain, WikiMedia [https://goo.gl/XtPKME]

Finally, invasive species have been transported great distances in freighter ballast tanks. Although it is highly improbable, it is possible that lionfish eggs or larvae could have been taken in with ballast water, survived a lengthy transoceanic voyage, and released in Atlantic waters only to grow into adult fish capable of reproducing.

Most genetic studies have revealed very low genetic diversity of lionfish in the Western Atlantic, compared to their native range (Betancur-R et al., 2011; Butterfield et al., 2015, Freshwater et al., 2009). The low genetic diversity supports that only a few individuals founded the Western Atlantic populations of lionfish, and supports the hypothesis that the lionfish originated from the aquarium trade.



Two filleted lionfishes showing very large ovaries. Image © Byron G. Boekhoudt, M.Sc., Officer in charge of Fisheries at the Department of Agriculture, Husbandry and Fisheries, Aruba. Image modified with permission.

Dispersal and Current Range

The natural range of the Mile's firefish (in blue) and red lionfish (in green) are the Indian and Pacific Oceans, respectively. The non-native range of these species include the Americas and the Mediterranean (in red). The American invasion started in Southern Florida and the red lionfish (*P. volitans*) is well established across the entire caribbean and western mid-Atlantic. Mile's firefish, on the other hand, did not spread as quickly as the red lionfish, and is mostly restricted to the Bahamas and eastern coast of the United States. Recently, a single specimen of *P. volitans* genetically linked to the Caribbean invaders was caught in Rio de Janeiro, Brazil (Ferreira et al. 2015), however there is no established population south of Venezuela.

From 1985 to 1999 sightings were restricted to Southern Florida. By 1999, the Florida population had grown large enough to reproduce substantially, resulting in their larvae being carried north with the Gulf Stream. The following year, in 2000, the first sightings outside of Florida were reported in South Carolina, North Carolina, and Bermuda. Between 2000 and 2004, populations established themselves along the east coast of the U.S., and the first sighting in the Bahamas occurred in 2004. Between 2004 and 2006, the lionfish spread southward in the Bahamas and in 2006 the first sighting in the Gulf of Mexico was reported in Florida (in Tampa).

In 2007, the invasion reached the Caribbean. Lionfish likely invaded the Caribbean through the Windward Passage, the waterway between the islands Cuba and Hispaniola. From that point on, lionfish spread both westward towards Central America and eastward towards the Lesser Antilles. Having reached Central America in 2008, larvae now likely rode the Gulfstream and colonized the Florida Keys, and became more prominent in the Gulf of Mexico. By 2012, the lionfish were well established across the Eastern Seaboard, the Bahamas, the Gulf of Mexico, and the entirety of the Caribbean. Lastly in 2014, a single specimen was caught in Rio de Janeiro, Brazil, suggesting that the Amazon River, which forms a freshwater barrier for many marine species, may not impede the southerly expansion of the lionfish.



Graphs and Link provided in the "Dispersal and Current Range" sections are credited to: the U.S. Geological Survey, Department of the Interior/USGS. (http://nas.er.usgs.gov/queries/SpeciesAnimatedMap.aspx?speciesID=963)



Map of native range of *Pterois volitans* (green) and *P. miles* (blue) adapted from Schultz (1986) and Randall (2005). Star in Mediterranean Sea denotes Lessepsian migration of *P. miles* via the Suez Canal (Golani and Sonin 1992). Non-native range of *P. volitans* and *P. miles* in the Americas is shown in red (from Schofield et al. 2012). Predicted future distribution of lionfish along coastal South America is shown in red hatching (Morris and Whitfield 2009).

Lionfish Behavior

Lionfish are slow moving fish that rely on stalking prey, usually at night. However, Atlantic lionfish that have been caught late in the daytime have often been found with freshly eaten fish in their stomachs, indicating they are successful daytime hunters. Their bright coloring and venomous spines warn would-be predators, while their large pectoral fins are used to corral prey.

They find their home in mangroves, on reefs, on hard bottoms, and around manmade features, such as, piers and shipwrecks. As long as an appropriate food supply is present, they are able to make a living in just about any warm water marine environment.

One report indicates that lionfish adapt their behavior to avoid being caught in areas where they are culled in an effort to reduce their population (Côté, 2014). It seems that they hide deeper in the reef, and are more likely to avoid divers in areas where lionfish are removed. This phenomenon makes eradication even more challenging.

Adaptation to living in the Atlantic

The waters of the Caribbean Sea, Gulf of Mexico, and Atlantic Coast of the southern U.S. offer water conditions similar to the native range of these fish. The north-flowing Gulf Stream delivers warm water to mid-Atlantic and New England coasts, allowing lionfish to exist as far north as Narragansett Bay in Rhode Island during the warmer months. Although they commonly inhabit reefs and shallow areas, lionfish have been sighted at depths up to 1,000 feet. With an abundant food supply, oceanographic features similar to their natural range and few predators, lionfish have established themselves as permanent inhabitants of the Western Atlantic.

Effect on Native Species

Researchers are working to understand the longterm effect lionfish will have on native fish and invertebrate populations in the Atlantic. Invasive animals always change ecosystems, sometimes causing massive changes in both native and other invasive species populations. Comparisons between the Bahamas (mostly *P. volitans*) and reefs in Kenya (*P. miles*) have shown that in the Bahamas, the lionfish occur both in greater densities and also grow larger (Darling et al., 2011). However, when



A trio of Miles firefish (*P. miles*) hunting at night in Red Sea, Egypt. Notice how the pectoral fins are spread to corral the prey, and the inclined position of the (upper left) individual ready to strike. The small prey fish can be seen right under the shadow of the upper left lionfish. Image © Derek Keats. (https://www.flickr.com/photos/dkeats/6406268933/in/photostream/)

they accounted for four other species of lionfish in Kenya, the densities between the Bahamas and Kenya were similar (Darling et al., 2011), suggesting that competition between different lionfish species may be a factor in controlling the densities of any given lionfish species.

It has been suggested that groupers may act as a biological control for lionfish. Researchers have found some evidence supporting this. In well protected marine reserves, with high densities of groupers, lionfish numbers tend to be lower (Mumby et al., 2011). However, grouper populations have been severely reduced as a result of overexploitation by humans. The numbers of grouper are so low that they will not effectively function as biological controls at their current densities (Mumby et al., 2011), and a large scale study across the Western Atlantic have found no evidence of native predators having any influence on lionfish densities (Hackerott et al. 2013).

In the Bahamas researchers determined that lionfish tend to favor crustaceans when they are smaller, and switch almost exclusively to fish prey as adults. On average, as adults, their prey consisted of mainly fishes (78%) and crustaceans (14%). The top family of native fishes that they preyed upon were gobies, wrasses, grammas, cardinalfishes, angelfishes, basses, blennies, silversides, mullets, and filefishes (Morris and Akins, 2009). In another study (Green et al. 2012) in the Bahamas, researchers found that between 2004 and 2010, the lionfish densities increased to a point where lionfish constituted almost 40% of the predators on a reef in terms of mass (weight).



Various images of the gut contents of lionfish. The prey items are often too digested for positive identification. But in these images we can see a freshly eaten bicolor damselfish (upper left), a newly recruited yellowhead jawfish (upper right), silversides (bottom left), and a squirrelfish (bottom right). Images © Byron G. Boekhoudt, M.Sc., Officer in charge of Fisheries at the Department of Agriculture, Husbandry and Fisheries, Aruba. Image modified with permission.

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With their abundance and with 4 out of 5 settling fish being eaten, it is not hard to imagine the great effects that lionfish are having in the Western Atlantic. Lionfish derbies and culling by people have been shown to be effective means of controlling lionfish populations, and their undesired negative effects. In the Cayman Islands, it was shown that regular culling reduced not only the overall abundance, but also the mean size of lionfish (Frazier et al., 2012). Furthermore, it has been shown that culling can halt reductions in native prey declines, and even reverse some of the declines (Green et al. 2014).

What You Can Do to Help

Researchers are working to understand the longterm effect lionfish will have on native fish and invertebrate populations in the Atlantic. Invasive animals always change ecosystems, sometimes causing massive changes in both native and other invasive species populations. Comparisons between the Bahamas (mostly *P. volitans*) and reefs in Kenya (*P. miles*) have shown that in the Bahamas, the lionfish occur both in greater densities and also grow larger (Darling et al., 2011). However, when they accounted for four other species of lionfish in Kenya, the densities between the Bahamas and Kenya were similar (Darling et al., 2011), suggesting that competition between different lionfish species may be a factor in controlling the densities of any given lionfish species.



Speared Lionfish. Credit to CameliaTWU (https://www.flickr.com/photos/ cameliatwu/8575333503)

1. Report the presence of the fish to the United States Geological Survey by visiting the Non-indigenous Aquatic Species web page at http:// nas.er.usgs.gov/SightingReport.aspx. Data collected by the USGS is used to help determine the range and population of invasive lionfish. It's a good idea to visit the site in advance of a possible fishing trip so you know what sort of information the USGS would like to collect about each fish.

2. Do not release the fish back into the ocean. Every reproductive female that's removed from the ocean reduces the number of potential future fish. Every lionfish of either sex reduces predation pressures on native species.

3. Eat it. Lionfish are reported to be delicious and a number of cookbooks exist to help you clean and prepare it (Thornburgh, 2011). Due to zoonotic and other concerns, only eat wild collected Lionfish.

Effect on Aquarium Trade

On August 1st, 2014 the Florida Fish and Wildlife Conservation Commission approved new rules that forbid the import of lionfish (any species of the genus Pterois) into the state of Florida, Florida Rule Nr 68B-5.006 Lionfish. Accordingly, eight of the 10 species of Pterois that are traded (Rhyne et al., 2015), are unavailable to the hobbyists in Florida. Furthermore, revisions that went into effect December 1st, 2014 also forbid the breeding of lionfish in Florida, and the possession of eggs or larvae in captivity for any purpose other than destruction. However, one can apply for a "Conditional/Prohibited/Nonnative species permit" to possess eggs and larvae. Lionfish caught in Florida can still be legally traded within the state, and also exported to other states. Lastly, if scientists decide that the genus Dendrochirus is indeed invalid, and all species of *Dendrochirus* get moved into the genus *Pterois*, all those species will also become illegal for import into Florida. The aquarium trade is responsible for approximately one third of all aquatic invasive species in fresh and marine environments (Oskin, 2013). Hobbyists have released a wide variety of plants, fish and invertebrates into coastal waters causing ecosystem damage. As another notable example of the powerful effect of an invasive species, the release of the macroalgae *Caulerpa taxifolia* has had a profound impacts in areas of coastal California, overtaking native seagrass and kelp beds by crowding out these important native plants (Woodfield, 2008). The release of *Caulerpa* was most certainly related to the aquarium trade.

Resources

Florida Fish and Wildlife Conservation Commission: http:// tinyurl.com/FloridaLionfish

Lionfish-Hunting.com: Resource for fishing, cleaning and cooking lionfish

Reef.org Lionfish Research Program: http://www.reef.org/ lionfish

USGS Non-indigenous Aquatic Species page: http://tinyurl.com/USGSNASLionfish

References

References can be found on the web article: http://masna.org/masna-programs/lionfish-education/

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