The Feeding Ecology of Invasive Lionfish (*Pterois volitans* and *P. miles*) in Bermuda

La Ecología Alimentaria del Invasiva Pez león (*Pterois volitans* y *P. miles*) en las Bermudas

L'écologie de l'Alimentation de Envahissantes Lionfish (*Pterois volitans* et *P. miles*) dans les Bermudes

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EXTENDED ABSTRACT

Introduction

Lionfish, native to the Indian and Pacific Oceans, were first sighted in the Atlantic Ocean off the Florida coast in 1985. Within fifteen years, they had reached the shores of Bermuda and in the years since their original invasion, their population has taken hold and grown considerably. As a generalist and opportunist predator, lionfish have a voracious appetite for anything and everything, and consume huge numbers of juvenile reef fish and invertebrates, as well as the adults of small species (Morris and Akins 2009). As such, it has been suggested that this invasion could cause significant ecological disruption if these fish are not controlled (Morris and Whitfield 2009). To better understand the consequences of this invasion on Bermuda's coral reef ecosystem, we are creating a model to predict their ecological impact. Necessary elements include an understanding of their feeding behavior, resource use, trophic position, and the community structure of their invaded habitat. We will investigate this through traditional stomach content analysis and the more innovative approach offered by stable isotope analysis of the lionfish, their prey, and other reef predators.

Methods

Between May 2013 and October 2014, lionfish were collected by researchers while conducting reef surveys and by other researchers conducting lionfish trap experiments. Lionfish were also collected opportunistically from local fisherman and recreational SCUBA divers. Lionfish were caught by pole spear, trap, hook and line, and vinyl collecting nets. Stomach contents of captured specimens were identified to the lowest taxon possible, counted, and measured for total length (TL) and weight. Volume of stomach contents were measured by water displacement using a graduated cylinder. These measurements were not adjusted to account for partial digestion of items, so it can be assumed that the contribution of each to the lionfish diet is underestimated. The dietary contribution of each item was be calculated as percent of occurrence (%F), volume (%V), and number (%N) (Hyslop 1980).

Muscle tissue samples were collected from all captured lionfish for use in the stable isotope analysis, as well as other predators caught recreationally or during other research activities. Additionally, undigested items from the stomach conditions were used if they were in near perfect condition. All samples were dried at 60°F for 48 hours (Munoz et al. 2011, Layman and Allgeier 2012), pulverized using a mortar and pestle, separated into ~ 0.85 µg lots, and sealed in tin capsules. Each sample was processed by continuous-flow isotope-ratio mass spectrometry using a EuroEA3028-HT to determine ratios of 15N/14N and 13C/12C. These ratios (R) were used to determine δ15N and δ13C as follows: $\delta X = [(R_{sample}/R_{standard})-1] \times 1000‰$ where X is the heavy isotope of nitrogen or carbon.

Results

In 2013 and 2014, approximately 500 lionfish were collected and dissected, ranging from 130 to 467 mm TL. Teleost fish represented 46.3% of the lionfish diet by occurrence (%F), 53.0% by number (%N), and 69.2% by volume (%V). Similarly, invertebrates represented 46.1%F, but made a lesser contribution otherwise, comprising 42.3% N and 26.3%V. Of the invertebrates, shrimp represented 29.4%F, 25.4%N, and 18.8%V, lobsters comprised 8.5%F, 10.3%N, and 1.6%V, crab comprised 7.6%F, 6.1%N, and 5.0%V, while octopus contributed 0.4%F, 0.3%N, and 0.9%V. Unidentified items accounted for 10.8%F, 4.7%N, and 4.5%V (Table 1). In total, 25.6% of stomachs were empty, primarily due to stomach eversion caused by barotrauma and the regurgitation of prey following capture. At this point, 28 different prey items have been identified to species. The single most common animal found within the diet of lionfish is the red night shrimp (*Cinetorhynchus rigens*), which represented 12.5%F, 11.3%N, and 16.9%V. This is likely underestimated as many shrimp could not be identified to the species level because of the extent of digestion.

Preliminary results from the stable isotope analysis suggest lionfish are a top predator with a broad resource base within the food web consisting of diverse and numerous species. Furthermore, the data suggests an overlap of resource use between lionfish and juvenile dusky sharks (*Carcharhinus obscurus*). It also appears that lionfish captured at deeper sites are feeding at lower trophic levels from sources likely derived from plankton (Figure 1). There was no apparent ontogenetic shift in trophic level ($\delta^{15}N$) or resource use ($\delta^{13}C$).

DISCUSSION

The results put forth here are preliminary, but reinforce that lionfish are a generalist, opportunistic predator with a broad ecological niche. Furthermore, the overlap in resource use suggests one mechanism beyond direct predation which could negatively affect the structure and function of the fish community. Overall, this emphasizes that the impact of lionfish in Bermuda could be substantial.

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Table 1. Dietary contribution of lionfish prey sorted by broad category.

Prey Identify	%F	%N	%V
Unknown	10.8	4.7	4.5
Fish	46.3	53.0	69.2
Invertebrates	46.1	42.3	26.3
Shrimp	29.4	25.4	18.8
Lobster	8.5	10.3	1.6
Crab	7.6	6.1	5.0
Octopus	0.4	0.3	0.9

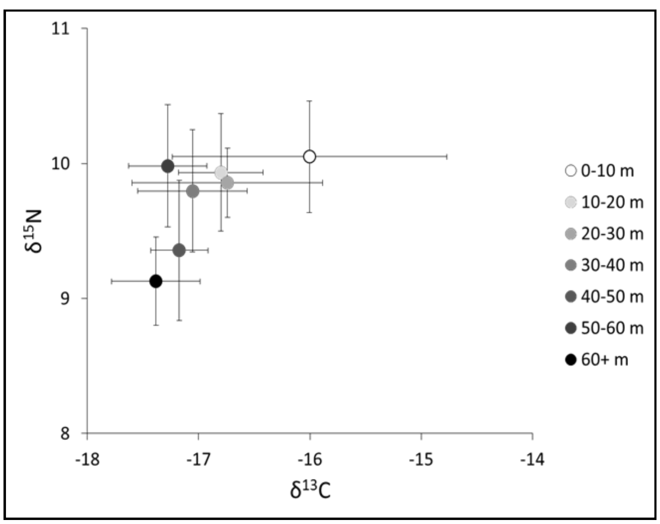

Figure 1. $\delta^{13}C$ and $\delta^{15}N$ bi-plot of invasive lionfish separated into 10-meter depth increments. Values are mean ± standard deviation.

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