Do Invasive Lionfish Affect the Diet and Condition of Native Mesopredators?

¿Cómó Puede la Presencia Invasive el Pez León Afectar la Dieta y el Estado de los Mesodepredadores Nativós?

Sont les Régimes et les États Physiologique des Mésoprédateurs Touchés par les Lionfish Envahissantes?

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EXTENDED ABSTRACT

One of the primary threats posed by invasive Indo-Pacific Lionfishes (*Pterois volitans* and *P. miles*) is the potential for competition with native predators. While previous studies have demonstrated overlap in resource use between Lionfish and other predators (O'Farrell et al. 2014), few have empirically measured the strength or effects of resulting interspecific competition (Raymond et al. 2014). On coral reefs in southeast Florida, one of the most likely competitors of Lionfish is a small grouper species, the Graysby (*Cephalopholis cruentata*). Lionfish and Graysby are similarly sized mesopredators, are both generalist foragers, and undergo comparable ontogenetic diet shifts from invertebrate to teleost prey (Shpigel and Fishelson 1989).

In conjunction with a Before-After-Control-Impact (BACI) Lionfish removal experiment, we examined the diet and condition of Graysby across a gradient of Lionfish biomass. Graysby, Lionfish, and native prey populations were repeatedly surveyed and sampled on twenty sites along a contiguous reef in Biscayne National Park near Miami, Florida. Graysby and Lionfish diet was analyzed using a combination of gut contents and bulk stable isotopes (δ^{13}C and δ^{15}N) from dorsal muscle tissue. Graysby condition was measured via several physiological indices, including the viscerosomatic index, Fulton's K, and muscle C:N ratio.

Due to high variability in the effectiveness of Lionfish removal treatments across sites, we could not analyze Graysby diet or condition using the experimental structure of the BACI study. Instead, sites were grouped based on mean Lionfish biomass into *below average* (n = 10 sites) and *above average* (n = 8 sites) categories. Importantly, linear regression showed no relationship between site averages of Graysby and Lionfish biomass (p = 0.460), enabling analysis across Lionfish biomass categories without considering variation in the strength of intraspecific Graysby competition.

Overall, Graysby muscle tissue had similar isotopic composition to muscle from cohabitant Lionfish, suggesting comparable resource use at a population scale and thus a potential for interspecific competition (Figure 1). Furthermore, δ^{15}N increased with standard length in both species at a similar rate, reflecting mutual ontogenetic diet shifts that could lead to competition across multiple life stages.

Dispersion of stable isotope values within a population provide a measurement of diet breadth, or the diversity of consumed prey (Bearhop et al. . 2004). Across our study region, dispersion of Lionfish stable isotopes was larger than measured in Graysby, indicating a broader or more general diet (np-DISP, F = 13.38, p = 0.001). However, this trend appears to be driven by Graysby sampled from sites with above average Lionfish biomass (Figure 2). Graysby isotopic dispersion shrank relative to Lionfish on sites with higher biomass of the invasive species, suggesting specialization or a restriction in diet (F = 7.00, p = 0.008). Lionfish isotopic dispersion did not differ across Lionfish biomass categories (F = 0.008, p = 0.931), ruling out the possibility that site-level variation in the isotopic environment was responsible for the apparent contraction in Graysby diet breadth.

The mean difference between Lionfish and Graysby δ^{13}C increased with Lionfish biomass from 0.280 $^{0}/_{00}$ (t = -3.99, p = 0.001) to 0.437 $^{0}/_{00}$ (t = -5.95, p = 0.001), indicating divergence in utilized food webs and possibly the subtle beginnings of resource partitioning. The proportion of stomachs containing invertebrates increased from 58% to 74%, although the difference was not significant (t = -0.5812, p = 0.5611). The proportion of Graysby stomachs containing teleost prey fell from 64% to 38% (t = 2.44, p = 0.014) with an increase in Lionfish biomass. However, linear regression showed no relationship between Lionfish biomass and the abundance (p = 0.903) or richness (p = 0.358) of fish smaller than 10cm on our study sites. Therefore, changes in Graysby diet associated with enhanced Lionfish biomass may stem from shifts in Graysby behavior or access to prey (interference competition) rather than variation in the teleost prey community itself (exploitative competition).

Despite an observed change in diet, there was no difference in Graysby viscerosomatic index (t = -0.587, p = 0.306), condition index (t = 0.722, p = 0.226), or C:N ratio (t = -1.109, p = 0.127) across Lionfish biomass levels. Combined with the lack of a relationship between Graysby and Lionfish biomass, our results suggest that interaction between the two species was not strong enough to negatively affect the physiology or population status of resident Graysby. Most likely, relatively low Lionfish densities and high prey abundance on our study sites prevented the emergence of broad scale effects of interspecific competition. Even so, based on the apparent similarity in resource use and shifts in Graysby diet associated with increased Lionfish biomass, competition between the two species remains a probable outcome under more extreme environmental circumstances.

Future directions for this study include analysis of stable isotopes in Graysby and Lionfish eye lenses, which can be delaminated and sequentially sampled to provide a chronological trophic history for individual fish (Wallace et al. 2015). By examining Graysby eye lenses from the subset of BACI study sites where removals caused a large and rapid decrease in Lionfish biomass, it may be possible to describe shifts in a single fish's diet resulting from weakening interspecific interaction. This ongoing study can clarify how Lionfish affect native mesopredators, a pertinent question for conservation, management, and invasive species ecology. Our future results will also refine understanding of the strengths and limitations of eye lens analysis, a novel and potentially powerful technique for ecological research.

LITERATURE CITED

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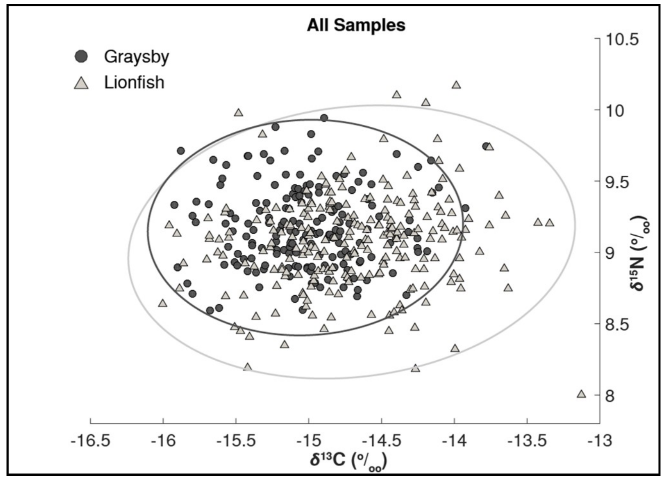

Figure 1. Stable isotope values from muscle tissue of all sampled Lionfish (n = 228) and Graysby (n = 172), expressed in δ notation. 95% confidence ellipses were plotted around the isotope values of each species. Graysby $\delta^{13}C$ was 0.318 $^{0}/_{00}$ lower than Lionfish (np-t-test: t = 6.51, p = 0.001). Graysby $\delta^{15}N$ was 0.097 $^{0}/_{00}$ higher than Lionfish (np-t-test: t = -3.06, p = 0.003). Lionfish isotope dispersion was larger than Graysby, determined by a np-MANOVA on residuals generated by a np-Dispersion test (F = 13.38, p = 0.001).

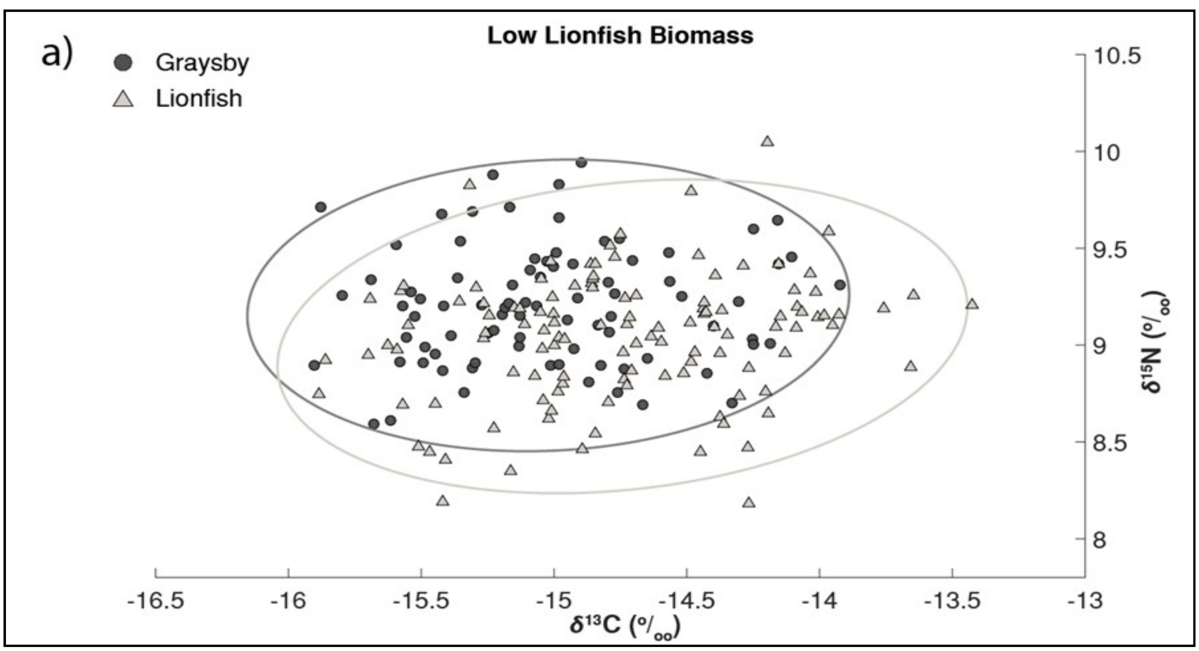

Figure 2a. Stable isotope values from muscle tissue of Lionfish (n = 118) and Graysby (n = 85) sampled from study sites with below average Lionfish biomass, expressed in δ notation. 95% confidence ellipses were plotted around the isotope values of each species. Graysby $\delta^{13}C$ was 0.280 $^{0}/_{00}$ lower than Lionfish (np-t-test: -3.99, p = 0.001). Graysby $\delta^{15}N$ was 0.157 $^{0}/_{00}$ higher than Lionfish (np-t-test: t = 3.482, p = 0.001). Lionfish isotope dispersion was not different than Graysby, determined by an np-MANOVA on residuals generated by a np-Dispersion test (F = 2.87, p = 0.088).

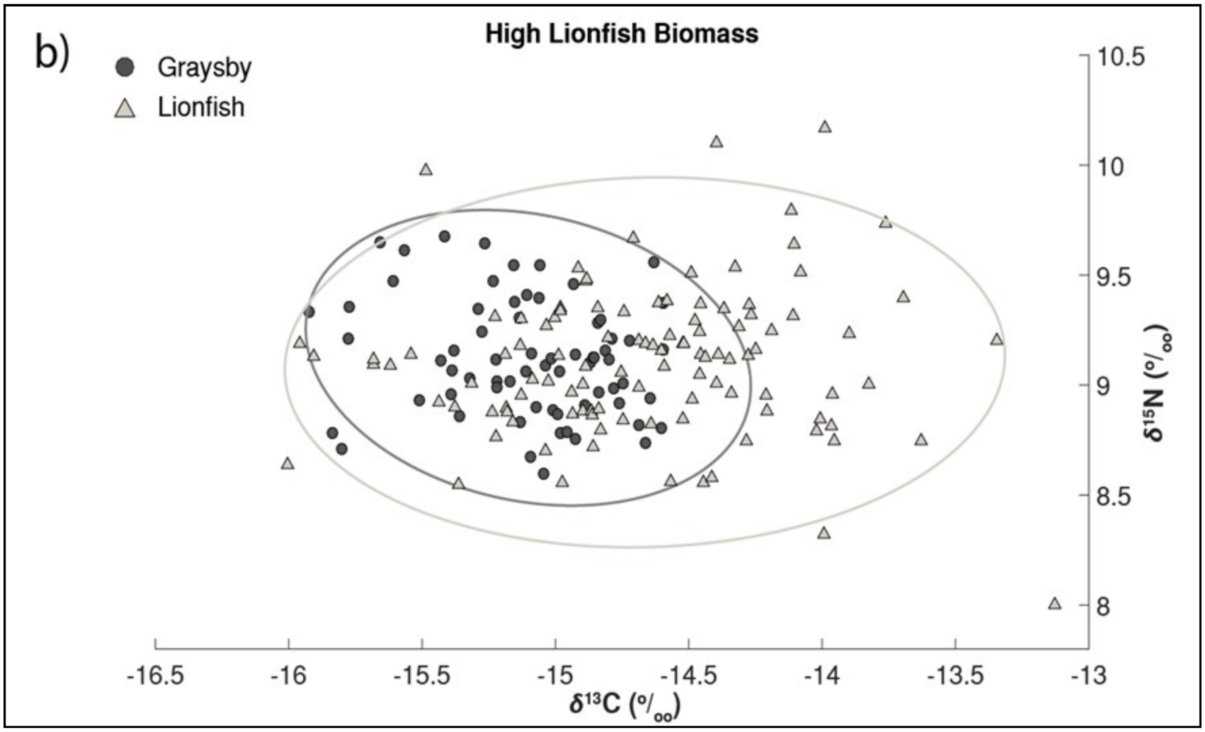

Figure 2b. Stable isotope values from muscle tissue of Lionfish (n = 110) and Graysby (n = 67) sampled from study sites with above average Lionfish biomass, expressed in δ notation. 95% confidence ellipses were plotted around the isotope values of each species. Graysby $\delta^{13}C$ was 0.437 $^{0/}{}_{00}$ lower than Lionfish (np-t-test: t = -5.95, *p* = 0.001). Lionfish isotope dispersion was larger than Graysby, determined by an np-MANOVA on residuals generated by an np-Dispersion test (F = 13.1, *p* = 0.003).