Predicted Effects of Invasive Lionfish on Fish Community Structure are not Apparent on the Mesoamerican Barrier Reef, Belize

El Pez León no ha Tenido un Efecto Detectable en la Comunidad de Peces de Arrecife en la Barrera Arrecife Mesoamericano en Belice

Les Effets Prévus de Poisson Lion Envahissantes sur la Structure des Communautés ne Sont pas Apparents sur la Barrière de Corail Mésoaméricaine, Belize

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EXTENDED ABSTRACT

Exotic predators can cause declines in the abundance and diversity of native prey and are believed to be a primary driver of biodiversity loss. Lionfish, generalist predators from the Indo-Pacific introduced to the Caribbean, are assumed to be negatively affecting Caribbean reef fish communities. However, evidence for such effects is largely from very small-scale experiments on artificial substrata and high lionfish densities (Albins and Hixon 2008, Albins 2013, 2015), while a relationship between fish communities and lionfish densities was not detected on natural reef habitats (Elise et al. 2014). Additionally, whether effects observed on patch reefs occur on contiguous reefs is largely unknown.

The purpose of this study was to measure the realized effects of the lionfish introduction on reef fish communities and whether reported short-term effects from controlled settings and at small spatial scales are evident at larger scales and on contiguous reef habitats. We quantified native reef fish abundance, species richness, and community composition at sixteen reefs along ~250 km of the Mesoamerican Barrier Reef in Belize from 2009 to 2013, including the onset of the invasion in Belize. We hypothesized that:

i) The abundance and species richness of small potential prey fish would be negatively related with lionfish abundance due to predation, and
ii) That a shift in small reef fish community composition would occur as lionfish can differentially reduce prey abundance by preying on species with certain morphological and behavioral traits (Green and Côté 2014).

We used generalized linear mixed effect models (GLMM) to evaluate the association between lionfish abundance (individuals/ha) and reef fish community metrics (abundance and richness) of small prey fishes (6 - 10 cm TL). We also evaluated such association with the abundance of small prey fish within the most abundant families. The number of years following the lionfish invasion, lionfish abundance, and reef complexity were coded as fixed effects and site was included a random effect. Changes in the community composition of small prey fish in response to year and lionfish abundance were also assessed using per-mutational multivariate analysis of variance (PERMANOVA).

Across all sites, the average lionfish abundance (mean ± SE individuals/ha) was 0.9 ± 0.7 in 2010, 16.3 ± 5 in 2012, and 11.1 ± 4.2 in 2013. The highest site-averaged lionfish abundance found during our study was 70 ± 29.2 individuals/ha. However, the total abundance and species richness of small fish showed no measurable association with lionfish densities (Fig. 1). Similarly, the density of the most abundant families was not related with lionfish densities (Figure 1). Instead, total and family-specific abundance and species richness of small fish was positively associated with time since invasion (Figure 1). In addition, small fish community composition was related with time but not lionfish abundance.

We found no evidence that lionfish have had a measurable effect reef fish populations or community structure on the Mesoamerican Reef, Belize. It is possible that more time and/or higher lionfish densities are necessary for their effects to be apparent on continuous reefs. Alternatively, the negative effects of lionfish could be small, and essentially undetectable, relative to other factors that influence the dynamics of reef fish populations such as abiotic reef characteristics, biotic interactions with native species, and human impacts. Nonetheless, the monitoring of not only lionfish densities, but also the apparent impacts, should be continued across the Mesoamerican Barrier Reef to aid in identifying sites where targeted removal efforts may be necessary. It is unlikely that lionfish can be completely extirpated from invaded reefs, but our study suggests this may not be necessary to prevent detectable impacts on reef fish communities.

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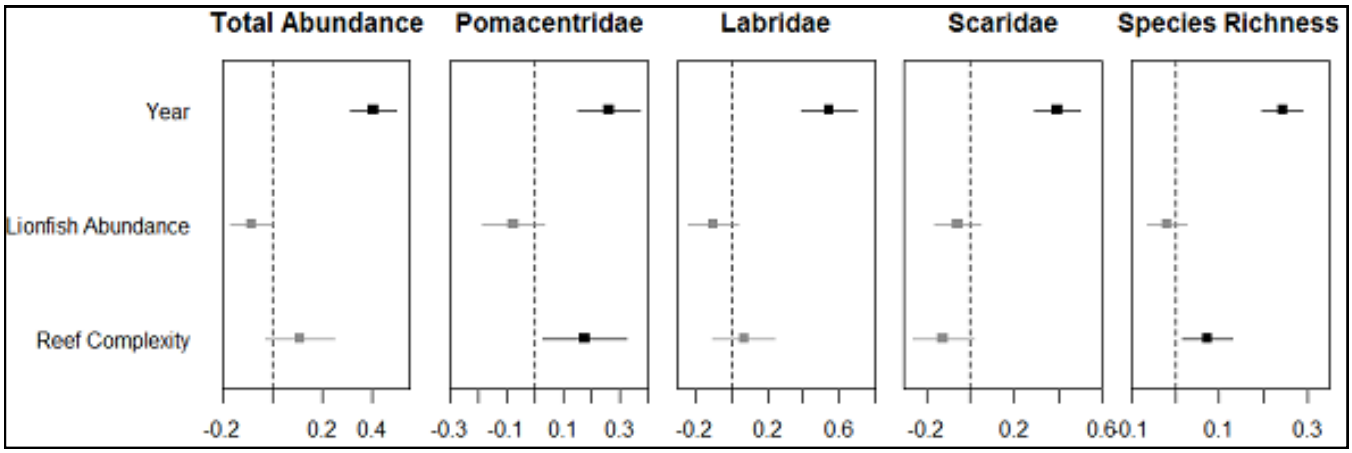

Figure 1. Coefficient estimates (mean ± 95% confidence interval) **for each model.** The abundance of all potential prey fish, the abundance of the most common families, as well as species richness of potential prey fish were each modeled with the predictors of interest (lionfish abundance and years since the lionfish invasion) as well as site-specific reef complexity. Significant coefficient estimates are shown in black while non-significant coefficients are shown in gray.