Interactions Between the Caribbean Spiny Lobster, *Panulirus argus*, and Invasive Lionfish, *Pterois volitans*: Who Displaces Whom?

Interacciones Entre la Langosta Caribe, *Panulirus argus*, y el Pez León Invasor, *Pterois volitans*: ¿Quién Desplaza Quién?

Les Interactions Entre la Langouste Blanche des Caraïbes, *Panulirus argus*, et le Rascasse Volante Invasive, *Pterois volitans*: Qui Déplace Qui?

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ABSTRACT

The Caribbean spiny lobster fishery is the most valuable in the Caribbean. There are concerns that invasive lionfish could affect the profitability of the industry through displacement of lobster from traps (condominiums), but the ecological interactions between the two species are poorly understood. Previous research has demonstrated an inverse relationship between lionfish abundance and number of lobster in condos; however, assessing which species governed this displacement is poorly understood. We experimentally examined behaviors of lionfish and lobster competing for an artificial shelter. In trials, lobsters were introduced to the arena 48 hours before the introduction of either a lionfish or a trophically equivalent native fish, the graysby grouper *Cephalopholis cruentata*. Reciprocal experiments (i.e., fish before lobster) and single-species control trials were also conducted. Lobsters spent significantly less time inside of the shelters, and more time roaming when a lionfish was present, indicating the lobsters were displaced from the shelter. However, shifts in lobster behavior were observed in the presence of the native mesopredator, the graysby. The potential increase of mesopredators coupled with the rapid lionfish invasion both could be negatively affecting the habitat use of lobster, resulting in negative ecological and socioeconomic impacts particularly for countries with large lobster fisheries such as The Bahamas.

KEY WORDS: Displacement, lionfish, lobster, mesopredator, shelter

INTRODUCTION

The lionfish, *Pterois volitans*, is a venomous, predatory reef fish endemic to the Indo-Pacific. Lionfish have become an invasive species of critical concern in the Western Atlantic, Caribbean and Gulf of Mexico (Albins and Hixon 2011, Schofield 2009). Lionfish were first seen in the Bahamas in 2004 and are now one of the most abundant predators on coral reefs in the archipelago (Green and Côté 2009). Lionfish are negatively affecting local marine environments through increased predation and competition with native reef species. The effect of predation by lionfish significantly decreases the abundance and species richness of small, economically and ecologically important fishes (Albins 2013, Green et al. 2012).

The people of The Bahamas depend largely on marine resources, particularly the lobster fishery, for their livelihoods (Danylchuk 2003). This commercial fishery is the most important in The Bahamas and the largest in the Caribbean (Chávez 2009). The Bahamas Department of Marine Resources reported 4 million tons of lobster caught in 2010, valued at 67 million dollars. However, a recent study found an inverse relationship between the abundance of lionfish and lobster found in lobster shelter traps (condos). Specifically, when lionfish were present in traps the density of lobster was lower (Henderson and Côté 2012). The displacement of lobster from condos could have large negative socioeconomic consequences for The Bahamas, and the greater Caribbean.

The aim of the study was to investigate the process underlying habitat displacement between the Caribbean spiny lobster and the lionfish. It was hypothesised that the in-lab trials would show when an invasive lionfish was present a lobster would be displaced from the shelter structure. Displacement would be evident by a reduction in the time lobster spent in the shelter and behavioural differences, such as increased roaming. However, we did not expect to observe similar effects when the lobster was in the presence of a trophically similar native species, *Cephalopholis cruentata* (graysby).

MATERIALS AND METHODS

This study took place at the Cape Eleuthera Institute in South Eleuthera, The Bahamas. Condo structures were replicated in 750 l tanks measuring 72 cm radius x 86 cm depth. The three species used in the study were *P. argus, P. volitans and C. cruentata.* The sizes of individuals were standardized based on the average size of species on the reefs of South Eleuthera. Individuals were introduced to a tank with a single condo for 48 hours before trials started to allow individuals to

acclimate. Control trials of single individuals were replicated six times for each species. Treatments included lobster plus invasive and lobster plus native fish. The order in which the species were introduced to the tank was switched to test for priority effects, each treatment replicated six times (the reciprocal trials were pooled as no significance differences were found in species behaviour with order of introduction to the tank). Infrared cameras were used to record the trials. The video footage was recorded continuously for 24 hours, but we sampled the hour post dusk, an hour across mid-night, an hour before dawn, and an hour across mid-day for our analysis. These hours were analysed to identify behaviours for both species and location as a measure of displacement of habitat. In total thirty-six trials, equating to 144 hours, were conducted and analysed (note an additional six trials of the lobster plus graysby were still to be run). Prior to statistical analyses, homogeneity of variances was assessed by Levene's test, and transformations were applied to normalise the data. However, heteroscedasticity was still apparent therefore a non-parametric Kruskal-Wallis test was performed to assess treatment differences.

RESULTS

The amount of time lobsters spent in a shelter decreased significantly by 20.31% ($H = 4.87_{(1)}$ $p = 0.027$) when a lionfish was present. However, the same was true when the native graysby was present in the tank (see Figure 1). The behaviour analysis showed the amount of time lobster spent roaming increased by more than 50% on average when a lionfish was present. Similarly, when the native graysby was introduced roaming also increased. There was no significant change in lobster behaviour, in terms of resting or conflict interactions, in the presence of a native species compared to that of the presence of the invasive. However, the response to an agonistic interaction with a lobster by the native and invasive differed significantly ($H = 15.12_{(1)}$ $p = 0.000$) as the invasive spent significantly larger amounts of time rapidly swimming away (darting) from the lobster.

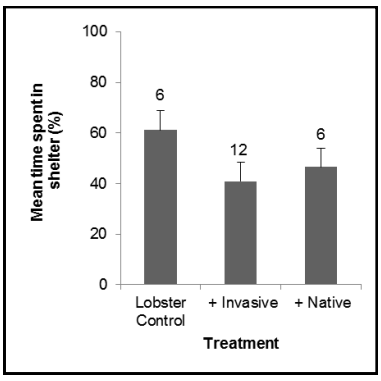

Figure 1. The mean percentage time Caribbean spiny lobster, *Panulirus Argus*, spent inside an artificial shelter, when alone or accompanied by the invasive lionfish, *Pterois volitans,* or the native graysby, *Cephalopholis cruentata* (+SE). N values are noted above each bar.

DISCUSSION

This study identified a reduction in time spent in a shelter and an increase in roaming behaviour by lobster when a mesopredator or invasive lionfish were present, indicating displacement of lobster from a shelter by both species. The overfishing of large-bodied predators and herbivores has shown to result in the competitive release of mesopredators such as graysby (Mumby et al 2012). This increase of mesopredators coupled with the rapid lionfish invasion could be negatively affecting the habitat use of lobster. Interestingly, all agonistic conflicts were initiated by the lobster towards the other species. The response to this conflict was different as the graysby spent very little time evading the lobster, compared to the lionfish. These results suggest a more discordant relationship between lobster and lionfish than between lobster and graysby.

Further work is required to assess this displacement and assess if this displacement occurs for both artificial and natural habitat. In-situ observations of condo and reef use by these species should be conducted. Additionally, experiments of a shelter choice design would be informative. If displacement is determined, research that focuses on the ecological and economic impacts of this should be assessed and the encouragement of lionfish as alternative fisheries promoted.

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