# Experimental results describing Stegastes planiforms attack behavior towards Pterois volitans and native predators in the Cayman Islands and the Bahamas during 2011

**Website**: https://www.bco-dmo.org/dataset/653031
**Data Type**: experimental
**Version**: 1
**Version Date**: 2016-08-01

**Project**
» Mechanisms and Consequences of Fish Biodiversity Loss on Atlantic Coral Reefs Caused by Invasive Pacific Lionfish (BiodiversityLossEffects_lionfish)

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**Abstract**
Experimental results describing Stegastes planiforms attack behavior towards Pterois volitans and native predators in the Cayman Islands and the Bahamas during 2011

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## Coverage

**Spatial Extent**: **N**:24 **E**:-76 **S**:19 **W**:-80
**Temporal Extent**: 2011 - 2011

## Dataset Description

*Stegastes planiforms* attack behavior towards native groupers, grunts, surgeonfish, and invasive lionfish in the Bahamas and Cayman Islands. Attack behavior was categorized and counted.

**Related Manuscript: Kindinger, T.L. (2015)**

### Methods & Sampling

**Area of study and microhabitat assessment**

This study was conducted during July-August 2011, observing the behavioral response of 40 three spot damselfish: 20 in the Bahamas and 20 in the Cayman Islands. Damselfish in these two locations were chosen to be studied because of their difference in timing of the lionfish invasion: lionfish were first sighted in the

Bahamas in 2004 and in the Cayman Islands in 2008 (Schofield 2009). In the Bahamas, damselfish were studied at three sites in the shallow waters (sites were <4 m deep) of the Great Bahama Bank in the vicinity of Lee Stocking Island, which is part of the Exuma Cays. Study sites consisted of patch reefs composed of small coral heads and larger coral bommies surrounded by sand and seagrass beds. About 380 miles Southwest of Lee Stocking Island, damselfish behavior was observed off of Little Cayman Island at three deeper sites (6–12 m deep) located along the northern side of the island, just inshore of the Bloody Bay Wall. This area is characterized by continuous stretches of reef that includes coral heads of various sizes and large coral formations.

The benthic territories maintained year-round by three spot damselfish are less than 1 m2 and are easily identified by the algal gardens covering reef substrata that the damselfish cultivate (Brawley and Adey 1977). The underlying substrata of damselfish territories differed at sites both within and between the Bahamas and Cayman Islands. Since the type of habitat could potentially affect damselfish response by influencing an individual's ability to defend its territory, the microhabitat of each damselfish territory was characterized by recording the following four habitat categories: (1) low-relief dead coral rubble (mostly *Acropora cervicornis*), (2) low-relief continuous reef, (3) high-relief large coral bommies, and (4) high-relief continuous reef. Low-relief habitats lacked vertical structure, whereas high-relief habitats consisted of vertical structure over 1 m high, which could potentially interfere with the ability of damselfish to detect intruders.

**Experimental treatments and fish capture**

Each three spot damselfish was exposed to a series of treatments consisting of a single individual of (1) invasive lionfish, or the following native fishes, all of which are commonly found on reefs near three spot damselfish territories and are chased at varying degrees by damselfish (Thresher 1976; Robertson 1984): (2) herbivorous ocean surgeonfish (*Acanthurus bahianus*), a potential food competitor; (3) white grunt (*Haemulon plumierii*), a potential egg predator; and (4) coney grouper (*Cephalopholis fulva*), a mesopredator ecologically similar to lionfish and at larger sizes is a potential predator of three spot damselfish. At both study regions, 2-3 individuals were captured per fish species, which were rotated daily for experimental use based on each individual's appearance, apparent condition, and behavior. All fish were caught underwater from non-study sites using hand nets and the fish anesthetic quinaldine when needed. Body size of individual fish, ranging from 10 to 18 cm TL, was restricted to allow for ease of movement in bottles during the experiment. At these sizes, both lionfish and coney grouper were sufficiently large to pose a threat to small recruit fishes inhabiting damselfish territories (Albins 2013). Fish were maintained in flow-through aquarium tanks both prior to and between daily observational trials.

**Model-bottle experiment**

Using a model-bottle study design (Myrberg and Thresher 1974), individual fish were presented in weighted, clear-plastic gallon bottles to haphazardly located adult damselfish (7–11 cm total length [TL]) in order to measure the relative behavioral responses exhibited by each focal damselfish. Bottle lids were replaced with secured mesh screening to allow for flow of both water and any fish chemical cues. An empty bottle was used as a control treatment. Each treatment was introduced in random order to individual damselfish territories. All fishes inside bottles were either resting or hovering upon introduction.

To measure damselfish aggression per treatment, each bottle was sequentially placed at 100, 50, and 0 cm away from the center of each territory. At each increment, damselfish behavior was observed from a distance of 3 m for 2 min, counting the number of times the focal damselfish made physical contact with the bottle (attack rate) and tallying which aggressive behaviors each damselfish displayed: (1) contact with the mouth while hovering in place directly next to the bottle (nip); (2) contact with the caudal fin while hovering in place directly next to the bottle (butt); (3) starting from a distance, swimming with force directly towards the bottle, making contact with mouth, and then quickly swimming away from the bottle (charge); and, (4) repeatedly charging the bottle multiple times (continuous attack). These categories encompass three spot damselfish behavior known to effectively exclude intruders (Thresher 1976). Avoidance behavior by damselfish was also noted, such as entering refuge sites within their territories (Helfman 1989).

Each bottle was then placed at the closest distance to the territory at which the damselfish had previously made no physical contact with the bottle, then gradually moved the bottle closer to the center of the territory until the damselfish approached the bottle and made physical contact. If the damselfish had previously attacked the bottle at 100 cm away from the territory, the bottle was placed at 150 cm where all damselfish ceased attacking the bottle, and gradually moved the bottle closer to the territory from there. This method provided a measurement of the "maximum distance of attack" (sensu Myrberg and Thresher 1974) per treatment.

**Data Processing Description**

**Statistical analyses**

All assumptions of normality and homogeneity of variance were not met based on residual analyses, and transformations failed to normalize the data. To test for a difference in damselfish response between the Bahamas and the Cayman Islands, nonparametric Wilcoxon signed-rank tests were used for repeated measurements of the attack rate and maximum distance of attack. Binary counts of whether individual damselfish attacked each treatment or not when placed inside damselfish territories (distance of 0 cm) were also compared between the two study regions using McNemar's test. Results from all tests revealed that damselfish response did not significantly differ between regions for all three response variables measured: (1) attack rate (Wilcoxon signed-rank test, n=40, V=5,857, P=0.1121); (2) maximum distance of attack (Wilcoxon signed-rank test, n=40, V=1,702, P=0.0902); and, (3) number of damselfish that attacked (McNemar's test, n=40, $\chi2$=0.2273, P=0.6336). Damselfish from both locations were thus combined during all subsequent statistical analyses.

With the exception of the surgeonfish treatment, there was no discernable difference in damselfish attack rates among treatments until bottles were placed directly in the center of damselfish territories (Online Resource 1), so the number of damselfish that attacked and the attack rate in response to each treatment measured only at this 0 cm distance were compared. The proportion of damselfish (out of 40 individuals) that attacked each treatment was compared using a nonparametric Cochran's Q test. The attack rate and maximum distance of attack were rank-transformed, and then tested for differences in response among treatments and among microhabitats of damselfish territories by performing one-way repeated measures analyses of variance (ANOVAs). Results from these ANOVAs were compared with the results from Friedman tests, and were found to provide consistent conclusions. Therefore, only results from the one-way repeated measures ANOVA were repored, because this provides a more robust analysis with greater statistical power compared to the Friedman test (Zimmerman and Zumbo 1993).

In addition, post-hoc pair-wise comparisons of all three response variables were performed among treatments and among microhabitats (when applicable) with Wilcoxon signed-rank tests. Reported p-values from these multiple comparisons were corrected using Holm's adjustment method, which does not assume independence of groups when controlling the familywise error rate (Holm 1979). All statistical tests were conducted using the statistical software R version 3.0.0 (R Development Core Team 2013) with the associated packages, car (Fox et al. 2009), nlme (Pinheiro et al. 2014), and RVAideMemoire (Hervé 2014).

**DMO notes:**

- reformatted column names to comply with BCO-DMO standards

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## Data Files

| File |
|---|
| **DamselAttackBehavior.csv** (Comma Separated Values (.csv), 6.64 KB) MD5:92e7356329da8f00beb0ac696dfbb069<br>Primary data file for dataset ID 653031 |

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## Related Publications

Albins, M. A. (2012). Effects of invasive Pacific red lionfish Pterois volitans versus a native predator on Bahamian coral-reef fish communities. Biological Invasions, 15(1), 29–43. doi:10.1007/s10530-012-0266-1
*Methods*

Brawley, S. H., & Adey, W. H. (1977). Territorial behavior of threespot damselfish (Eupomacentrus planifrons) increases reef algal biomass and productivity. Environmental Biology of Fishes, 2(1), 45–51.

doi:10.1007/bf00001415 https://doi.org/10.1007/BF00001415
*Methods*

Fox, J., Bates, D., Firth, D., Friendly, M., Gorjanc, G., Graves, S., Heiberger, R., Monette, G., Nilsson, H., Ogle, D. (2009). CAR: Companion to applied regression, R Package version 1.2–16. http://cran.r-project.org/web/packages/car/index.html. August 2012
*Software*

Helfman, G. S. (1989). Threat-sensitive predator avoidance in damselfish-trumpetfish interactions. Behavioral Ecology and Sociobiology, 24(1), 47–58. doi:10.1007/bf00300117 https://doi.org/10.1007/BF00300117
*Methods*

Hervé, M. (2014). RVAideMemoire: diverse basic statistical and graphical functions. R package version 0.9–32
*Software*

Holm, S. (1979). A Simple Sequentially Rejective Multiple Test Procedure. Scandinavian Journal of Statistics, 6(2), 65-70.
*Methods*

Kindinger, T. L. (2014). Behavioral response of native Atlantic territorial three spot damselfish (Stegastes planifrons) toward invasive Pacific red lionfish (Pterois volitans). Environmental Biology of Fishes, 98(2), 487–498. doi:10.1007/s10641-014-0279-y
*General*

MYRBERG, A. A., & THRESHER, R. E. (1974). Interspecific Aggression and its Relevance to the Concept of Territoriality in Reef Fishes. American Zoologist, 14(1), 81–96. doi:10.1093/icb/14.1.81
*Methods*

Pinheiro, J.D., Bates, D., DebRoy, S., Sarkar, D. and the R Core Team (2014) nlme: linear and nonlinear mixed effects models. R package version 3.1–115.
*Software*

Robertson, D. R. (1984). Cohabitation of Competing Territorial Damselfishes on a Caribbean Coral Reef. Ecology, 65(4), 1121–1135. doi:10.2307/1938320
*Methods*

Schofield, P. (2009). Geographic extent and chronology of the invasion of non-native lionfish (Pterois volitans [Linnaeus 1758] and P. miles [Bennett 1828]) in the Western North Atlantic and Caribbean Sea. Aquatic Invasions, 4(3), 473–479. doi:10.3391/ai.2009.4.3.5
*Methods*

Thresher, R. E. (1976). Field Analysis of the Territoriality of the Threespot Damselfish, Eupomacentrus planifrons (Pomacentridae). Copeia, 1976(2), 266. doi:10.2307/1443946
*Methods*

Zimmerman, D. W., & Zumbo, B. D. (1993). Relative Power of the Wilcoxon Test, the Friedman Test, and Repeated-Measures ANOVA on Ranks. The Journal of Experimental Education, 62(1), 75–86. doi:10.1080/00220973.1993.9943832
*Methods*

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## Parameters

| Parameter | Description | Units |
|---|---|---|
| location | location of sampling | unitless |
| lat | latitude | decimal degrees |
| lon | longitude | decimal degrees |
| damsel_number | damselfish id number; 1-20 | unitless |
| bottle_treatment | type of predator fish within the bottle that was introduced to damselfish | unitless |
| charge | charging behavior exhibited (1=Yes 0=No): starting from a distance; swimming with force directly towards the bottle; making contact with mouth; then quickly swimming away from the bottle | unitless |
| nip | nipping behavior exhibited (1=Yes 0=No): contact with the mouth while hovering in place directly next to the bottle | unitless |
| butt | butting behavior exhibited (1=Yes 0=No): contact with the caudal fin while hovering in place directly next to the bottle | unitless |
| continuous_attack | continuous attacking behavior exhibited (1=Yes 0=No): repeatedly charging the bottle multiple times | unitless |

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## Deployments

**Cayman_Reef_Surveys_10-11**

| | |
|---|---|
| **Website** | https://www.bco-dmo.org/deployment/59048 |
| **Platform** | Cayman_Islands |
| **Start Date** | 2010-06-14 |
| **End Date** | 2011-08-29 |
| **Description** | Coral reefs were surveyed/studied near the Cayman Islands during the summers of 2010 and 2011 as part of the projects "Ecological Release and Resistance at Sea: Invasion of Atlantic Coral Reefs by Pacific Lionfish" and "Mechanisms and Consequences of Fish Biodiversity Loss on Atlantic Coral Reefs Caused by Invasive Pacific Lionfish" (NSF OCE-0851162 & OCE-1233027). |

**LSI_Reef_Surveys_09-12**

| | |
|---|---|
| **Website** | https://www.bco-dmo.org/deployment/59019 |
| **Platform** | Tropical Marine Lab at Lee Stocking Island |
| **Start Date** | 2009-05-30 |
| **End Date** | 2012-08-18 |
| **Description** | Locations of coral reef survey dives and sightings, or collections of the invasive red lionfish, Pterois volitans, near Lee Stocking Island, Bahamas for the projects "Ecological Release and Resistance at Sea: Invasion of Atlantic Coral Reefs by Pacific Lionfish" and "Mechanisms and Consequences of Fish Biodiversity Loss on Atlantic Coral Reefs Caused by Invasive Pacific Lionfish" (NSF OCE-0851162 & OCE-1233027). All dives were made from various small vessels (17' to 24' l.o.a., 40 to 275 HP outboard motors, 1 to 7 GRT). Vessel names include, Sampson, Orca, Potcake, Lusca, Lucaya, Zardoz, Parker, and Nuwanda. |

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## Project Information

**Mechanisms and Consequences of Fish Biodiversity Loss on Atlantic Coral Reefs Caused by Invasive Pacific Lionfish (BiodiversityLossEffects_lionfish)**

**Website**: http://hixon.science.oregonstate.edu/content/highlight-lionfish-invasion

**Coverage**: Three Bahamian sites: 24.8318, -076.3299; 23.8562, -076.2250; 23.7727, -076.1071; Caribbean Netherlands: 12.1599, -068.2820

The Pacific red lionfish (Pterois volitans), a popular aquarium fish, was introduced to the Atlantic Ocean in the vicinity of Florida in the late 20th century. Voraciously consuming small native coral-reef fishes, including the juveniles of fisheries and ecologically important species, the invader has undergone a population explosion that now ranges from the U.S. southeastern seaboard to the Gulf of Mexico and across the greater Caribbean region. The PI's past research determined that invasive lionfish (1) have escaped their natural enemies in the Pacific (lionfish are much less abundant in their native range); (2) are not yet controlled by Atlantic predators, competitors, or parasites; (3) have strong negative effects on populations of native Atlantic fishes; and (4) locally reduce the diversity (number of species) of native fishes. The lionfish invasion has been recognized as one of the major conservation threats worldwide.

The Bahamas support the highest abundances of invasive lionfish globally. This system thus provides an unprecedented opportunity to understand the direct and indirect effects of a major invader on a diverse community, as well as the underlying causative mechanisms. The PI will focus on five related questions: (1) How does long-term predation by lionfish alter the structure of native reef-fish communities? (2) How does lionfish predation destabilize native prey population dynamics, possibly causing local extinctions? (3) Is there a lionfish-herbivore-seaweed trophic cascade on invaded reefs? (4) How do lionfish modify cleaning mutualisms on invaded reefs? (5) Are lionfish reaching densities where natural population limits are evident?

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## Funding

| Funding Source | Award |
|---|---|
| NSF Division of Ocean Sciences (NSF OCE) | OCE-1233027 |

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