At the heart of the invasion: Exploring the use of heart rate loggers as a proxy for feeding rates of lionfish in their (un)natural habitat

Martina Cappellano, Natalie Edman, Katherine Kosoff, Laela Lunt, X Prince,
Hayden Stein, and Abby Wright
Advisors: Dr. Travis Van Leeuwen & Jodie Ball

Introduction

Invasive species are detrimental to the natural flow of ecosystems. Over the past 8 years, red lionfish (*Pterois volitans)* have rapidly invaded and spread throughout the Western Atlantic and Caribbean and are now one of the most harmful invasive species. Lionfish are voracious predators with the ability to tolerate a wide range of conditions. This species has grown exponentially since first discovered in the Bahamas in 2004 and continues to gravely impact Bahamian water to this day. These red and white-striped fish are covered with 13 venomous spines and are only about a foot in length. Lionfish have an astonishing 85% success rate while hunting (Green *et al*., 2011) ecologically and commercially important species.Their stomachs can expand up to 30 times its size, they can circumvent the mechanics prey use to identify a threat (McCormick and Allan, 2016), and they have few natural predators. Studies have shown that lionfish are capable of reducing reef fish recruitment by 79% and are able to outcompete native predators.

Green, Akins, and Côté (2009) found that lionfish in their non-native habitat, the Atlantic range, possess a varying feeding behavior in which the lionfish observed were most active during crepuscular periods (Green et al. 2011). This means that the rates for the amount of time lionfish spend active, hunting, the total distance they move, and their consumption rates are all at their peaks during sunrise and just before sunset (Green *et al.* 2011). This information is important to the Cape Eleuthera Institute research team in predicting the times of day lionfish are most likely to feed, and help us in our field research.

Because of the quantity of fish lionfish are consuming, as well as the ecosystems they are threatening, people are worried about the effect of their actions. The Bahamas heavily relies on tourism as part of their economy and for many jobs. If lionfish continue to impact the reefs at their current rate, tourism is likely to decline. If tourism declines, it will take a large economical toll on the Bahamas and impact the lives of many people. Therefore, in order to estimate the effects that lionfish are having on the reefs, our study aims to capture uninhibited feeding rates of lionfish in the wild. The two main objectives of the study are:

1. To determine the effect of three procedure types on the time to feeding in lionfish.
2. To use the time to feeding following the three procedures as an estimate to pre-program the heart rate loggers to approximate feeding rates in lionfish.

Figure 1. Lionfish physiology team around one of the Cape Eleuthera Institute (CEI) holding tanks used for housing lionfish after a successful capture day.

Figure 2. A red lionfish acclimating to the CEI lab.

Methods

Fish Collection

Lionfish were collected from patch reefs near Southern Eleuthera (N 24.82°, W 76.31°) by divers on SCUBA using clear nets and puncture proof gloves. Once a lionfish was netted, it was brought to the boat and held in a cooler until the boat returned to CEI. The water in the cooler was changed regularly, and all lionfish were kept in the same cooler. Upon return to CEI, the fish were tagged and transported to a holding tank. These tanks were large, circular, and designed to hold the lionfish while they were given time to acclimate to new conditions.

Lab Acclimation

We used feeding as a proxy for acclimation in order to find out how long it took for lionfish to adjust to their new surroundings. The lionfish were fed daily at the same time and were observed for five minutes to see whether or not they fed. Once the lionfish had fed three days consecutively, they were considered acclimated. After acclimation, the lionfish were tagged and underwent the same feeding acclimation process. The lionfish were then anesthetized and the time to feeding was measured again. Finally, we surgically implanted a heart rate logger into the lionfish and repeated the acclimation process. These acclimation times from every procedure were then added together to find a total acclimation time and ultimately, to determine the time to pre-program the data logger.

Tagging and Implantation

Divers then went back out to patch reefs to catch more lionfish. The divers caught lionfish using clear nets and scuba gear and brought the captured fish to the boat. Once on the boat the lionfish are anesthetized using clove oil and tagged. After the lionfish regain consciousness, they are placed back on the same patch reef they were collected from. Divers then went back to the same patch reefs a week later to determine recapture rates of the lionfish.

Figure 3. A lionfish being anaesthetized.

Figure 4. A lionfish being marked with an external tag.

Results

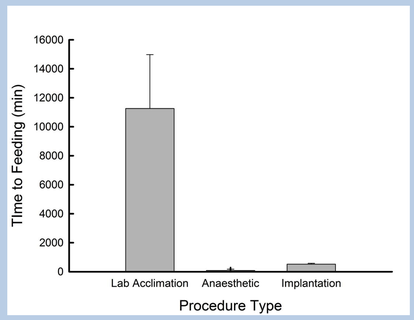

Figure 5. The amount of time in minutes it took the lionfish to feed after the three different procedure types that were performed on the fish: lab acclimation, anesthetic, and implantation. Error bars represent 95% CI. **Note: The significant effect of lab acclimation on time to feeding.**

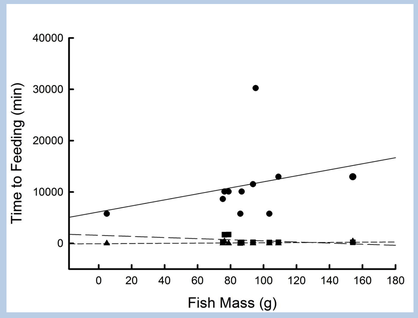

Figure 6. The correlation between time to feeding and fish mass for the three different procedure types: lab acclimation (circle, solid), implantation (square, medium dashed), and anesthetic (triangle, small dashed). **Note: The strong correlation between time to feeding and fish mass for lab acclimation.**

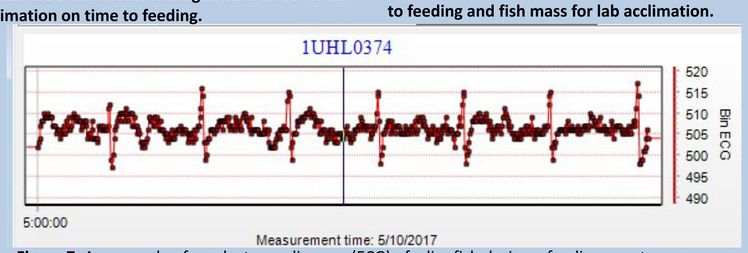

Figure 7. An example of an electrocardiogram (ECG) of a lionfish during a feeding event over a one minute span.

The limiting factor in the acclimation period (time to feed) of a lionfish is the movement of fish from the wild into the laboratory (fig. 5). It took the lionfish an average of 11,528.18 (8 days) ± 3718.29 min (95% CI) to feed following this stressor. It took the fish an average of 80.35 ± 91.44 min (95% CI) to feed after the anesthetic procedure and an average of 516.22 ± 367.54 min (95% CI) to feed after the implantation of the heart rate logger (fig. 5).

Interestingly, there was a significant correlation between mass and time to feed for the lab acclimation procedure with larger fish taking considerably longer to feed than smaller fish (fig. 6). However, there was no similar size effect for the other two procedure types- implantation of the heart rate logger and following anesthesia (fig. 6).

Discussion

Our study suggests that the capture of fish from the wild and transfer to the laboratory was the greatest stressor to the lionfish. Due to capture, handling, and the introduction to a new environment, our study suggests that the stress of this process far exceeds the stress induced by the anesthetic and surgery procedures. Therefore, we suggest that studies interested in comparing "normal" behavior of fishes should consider the effect of lab acclimation in their studies.

It is also important to note that lab acclimation was influenced by the mass of the fish, as larger fish took longer to acclimate. Because the size of the animal is generally positively associated to the age of the individual fish, this result is likely due to the increased fat stores in the larger fish, and therefore a lower motivation to feed. Given this result, we suggest a longer pre-program period in larger fish to achieve the best chance of capturing a feeding event with an implanted logger.

Heart rate loggers are a novel technology and are a welcomed addition to aquatic science. However, our study suggests a considerable amount of work is needed before they could be widely implemented. In addition to the variation in the data recordings, we found that the recapture rates of our species was low. Therefore, given the current expense of these loggers and the necessity to retrieve the loggers in order to download the data, the use of heart rate loggers in the wild to capture uninhibited feeding rates is unlikely feasible at this time.

Figure 8. A lionfish tagged on the reefs around Cape Eleuthera.

Future Studies

Our study provides information on lionfish acclimation times and feeding rates in the laboratory. In the future, we aim to continue our study of lionfish recapture rates on patch reefs. With this information, we will one day replicate this study on patch reefs. We aim to complete this study in a natural environment so that we can have accurate rates of a lionfish's heart rate during a feeding event. This data collected from patch reefs will be vital to understanding uninhibited feeding rates of lionfish on Bahamian coral reefs.

Literature Cited

McCormick, M. I., & Allan, B. J. M. (2016). Lionfish misidentification circumvents an optimized escape response by prey. *Conservation Physiology, 4,* 10.1093/conphys/cow064.

Green, S.J., & Akins, J. L., & Côté, I.M. (2011). Foraging behaviour and prey consumption in the Indo-Pacific lionfish on Bahamian coral reefs. *Marine Ecology Progress Series*, *433*, pp. 159-167.

Clark, T.D., & Sandblom, E., & Hinch, S.G., & Patterson, D. A., & Frappell, P. B., & Farrell, A. P. (2010). Simultaneous biologging of heart rate and acceleration, and their relationships with energy expenditure in free-swimming sockeye salmon (Oncorhynchus nerka). *Journal Composition of Physiology B*, *180*, pp. 673-684.

Acknowledgements

We would like to acknowledge Clay Steell, Dr. Kate Kincaid, Hannah Hauptman, Daisy Buzzoni and Giulia Cardoso for their guidance and support. Funding was provided by a NSERC grant to SJC at Carleton University