# The Critical Thermal Maximum of Lionfish (*Pterois volitans*)

Christer Aikens, Chelsey Frost, May Henderson, Sami Kreisler, Eddie Lopez, Nate Maynard , Dana White

Advisors: Krista Sherman and Christina Elmore

## Introduction

Lionfish are a venomous, predatory species endemic to the Indo-pacific. In their natural habitat, lionfish are found between 0 - 50 meters (Fishelson 1975). They are territorial and crepuscular species (Fishelson 1975), which means they feed at dawn and dusk.

Lionfish were introduced to the Atlantic Ocean in 1992 during Hurricane Andrew by the aquarium trade as an ornamental reef fish (Whitfield et al. 2002). Lionfish abundance has increased from their introduction to the Atlantic due to lack of natural predators and an exponential reproduction rate. As an invasive species, lionfish pose the potential threats of reducing biodiversity and recruitment of ecosystems (Albins and Hixon 2008). The Bahamas relies greatly on a fishing based economy (Danylchuk 2003) and lionfish reduce species composition and diversity that may result in negative ecological and economical impacts.

Previous thermal tolerance studies on P. volitans indicate that they experience a mean chronic lethal minimum temperature at 10°C and cease feeding at 16.1°C (Kimball et al. 2004). Therefore, temperature restricts the northern distribution of P. volitans but not its southern distribution. To date, there has been no research on the critical thermal maximum of lionfish across their life stages. **The purpose of our study was to determine the critical thermal maximum of lionfish relative to their body size.** This information can be used to help predict the southern distribution of lionfish thereby assisting with management strategies.

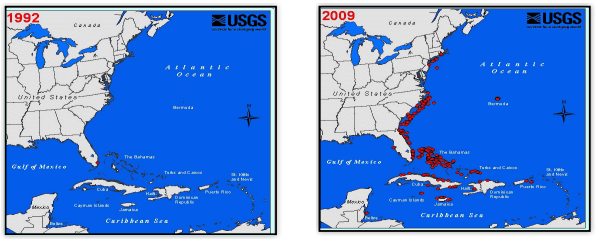


**Figure 1:** Diagram of the increased lionfish distribution over time (http://www.USGS.org).

## Methods

Study Site and Collection

Thirty-two lionfish ,(11 juveniles, 15 sub-adults, and 6 adults) were collected from shallow and deep water patch reefs in the Cape Eleuthera area, ranging in depth from 5 ft to 85 ft. Lionfish were collected between the months of February and May, 2009 using hand-held aquarium nets while scuba or free diving (Fig. 3). During transportation, water was changed every 10 minutes to maintain dissolved $O_2$ levels. Lionfish were kept in a tank at Cape Eleuthera Institute (C.E.I.) for experimentation.

Critical Thermal Maximum (CTMax) Testing

Lionfish were acclimated for a minimum of 24 hrs and were not fed before testing. Specimens were introduced to the testing container where the water temperature was raised by 0.2°C per minute until loss of equilibrium (Fig. 2). The water temperature, behavior, and color changes were recorded every minute and dissolved $O_2$ levels were recorded every 5 minutes.

Dissection

The wet weight (g), total length (mm), and standard length (mm) were recorded. Stomach contents and sex were also observed. Two tissue samples were taken from the dorsal musculature for stable isotope analysis and genetic testing.

Statistical analysis

Linear regression analysis was used to determine the relationship between body size (length and weight) and CTMax of lionfish. Analysis of variance (ANOVA) and the Tukey's test were used to assess significant differences between CTMax and life stage.

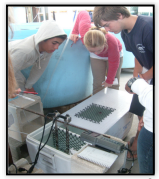

Figure 2. Equipment setup for thermal tolerance testing.

Figure 3. A student free diving to collect lionfish using a hand-held aquarium net.

Figure 4. Lionfish, *Pterios volitans*.

## Results

The total length of lionfish ranged between 120 mm and 360 mm ±56.33 mm. The results indicate that there was no correlation between CTMax and total length ($r^2$ = 0.15799, p-value = 0.101, Fig. 5). The CTMax ranged from 33.8 ˚C to 38.8 ˚C ±1.1˚C. The relationship between CTMax and wet weight was significant ($r^2$ = 0.05378, p-value = 0.024, Fig. 5) as indicated by the p-value, which was <.05. The weight ranged from 16 g to 876 g (±171.4 g). Sub adults had the highest mean CTMax, which was 37.3 ˚C (±1.0 ˚C) and adults had the lowest mean CTMax of 36.2 ˚C (±1.3 ˚C). Overall, there was no significant difference between CTMax and life stages (p-value = 0.101, Fig. 6). The mean CTMax of all lionfish sampled was 36.9 ˚C (±1.1 ˚C).

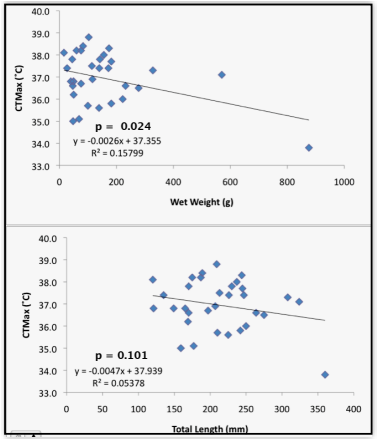


Figure 5. Comparison of CTMax and body size (total length mm and wet weight g) of lionfish, n = 32 using linear regression analysis.

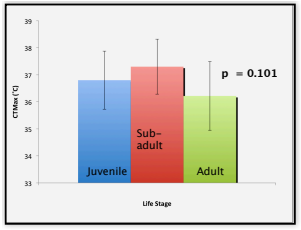


Figure 6. Comparison of mean CTMax of lionfish during their life stages using ANOVA. Error bars are reported as ± standard deviation.

Figure 7. Lionfish research group for Spring 2009.

## Discussion

The purpose of this study was to find and compare the CTMax of lionfish to their body size. The results did not support the initial hypothesis that body size has a significant relationship with CTMax. Wet weight had a significant relationship with CTMax, but overall body size did not. Previous studies have shown variable relationships between CTMax and body size (Mora and Maya 2006; Opsina and Mora 2004). Lionfish are medium bodied fish, which could affect the amount of time it takes for heat to diffuse through their body (Ospina and Mora 2004).

The information gathered will help to inform the Bahamian government about the distribution and habitat use of lionfish. Today, a network of five Marine Protected Areas (MPAs) has been proposed in the Bahamas (http://www.breef.org). 90% of the lionfish tested in our study were collected from reefs in one of the proposed MPAs (Fig. 8). This research will assist the Bahamian government to determine which habitats should be included in the MPAs. Knowing the lionfish CTMax will also allow future research to predict which habitats lionfish can live in according to their upper thermal limits.

The lionfish tested throughout this study were all collected from patch reefs. Future research should test lionfish from different habitats including creeks, flats, and mangroves to determine if habitat correlates with CTMax. Mora and Maya 2006 discovered that there is a direct relationship between acclimation temperature and CTMax. The acclimation temperature is derived from the ocean and varies significantly depending on the season. Additional research should examine the seasonal affects of acclimation temperature on the CTMax of lionfish. Continued research on lionfish ecology and biology is required to adequately assess potential impacts to the ecosystem.

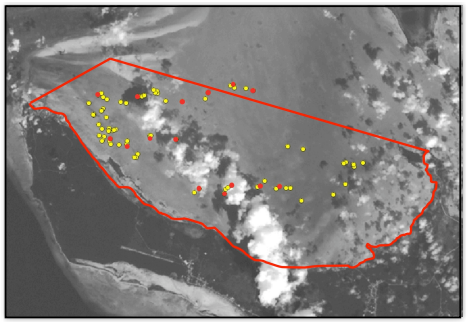

Figure 8. Proposed MPA off of South Eleuthera, Bahamas outlined in red with yellow dots representing reefs where lionfish were collected.

**Acknowledgements**

We would like to acknowledge our research advisors Krista Sherman and Christi Elmore for all of their assistance and guidance in the field and in the lab. We would like to acknowledge Karen Murchie for allowing us to use her equipment. Thanks to Laila Hassan-Hassein for all of her help in the lab. We would like to give another special thanks to Andrew Field and Nicoyas Higgs for their field assistance and scuba support. Finally we would like to acknowledge C.E.I. and the Island School for funding this project and use of the facilities.

**Literature Cited**

Albins, M.A. and , M.A Hixon. 2008. Invasive Indo-Pacific Lionfish (Pterois volitans) Reduce Recruitment of Atlantic Coral-Reef Fishes. Marine Ecology Progress Series 367:233-238.

Danylchuk, A. 2003. Fisheries Management in South Eleuthera, Bahamas: Can a Marine Reserve Help Save the 'Holy Trinity'? Proceedings of the Gulf and Caribbean Fisheries Institute 56.

Fishelson, L. 1975. Ethology and reproduction of pteroid fishes found in the Gulf of Aqaba (Red Sea), especially Dendrochirus brachypterus. Pubbl. Staz. Zool. Napoli. 39 Suppl. p. 635-656.

Kimball, M.E., Miller, J.M., Whitfield, P.E., Hare, J.A. 2004. Thermal tolerance and potential distribution of invasive lionfish (Pterois volitans/miles complex) on the east coast of the United States. Marine Ecology Progress Series 283:269-278.

Mora, C. and Maya, M. F. 2006. Effect of rate of temperature increase of the dynamic method on the heat tolerance of fishes. Journal of Thermal Biology 3: 337-341.

Ospina, A.F., Mora C. 2004. Effect of body size on reef fish tolerance to extreme low and high temperatures. Environmental Biology of Fishes 70:339-343.

Whitfield, P.E. and Hare, J.A. 2002. An integrated assessment of the introduction of lionfish (Pterois volitans/miles complex) to the western Atlantic Ocean. NOAA Technical Memorandum NOS NCCOS 2. 21.