Northern Gulf of Mexico Lionfish: Insights into Their Reproductive Life History

El Pez León en el Golfo de México de Norte: Discernimientos sobre su Vida Reproductive

Poissons Lions du Nord du Golfe du Mexique: Un Aperçu de Leur Cycle Reproducteur

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EXTENDED ABSTRACT

Invasive lionfish (*Pterois* sp.), first detected in the northern Gulf of Mexico (nGOM) in 2010, have quickly established themselves and are now being seen in higher densities compared to other invaded regions (Dahl and Patterson 2014). The negative effect of lionfish on the native ecosystems they have invaded is relatively well known (Albins 2012), but little has been documented in the nGOM as far as basic life history characteristics which would provide insights into their potential effects on the region.

From March 2012 through October 2014, more than 6,000 lionfish ranging from 40 - 434 mm total length (TL) have been collected throughout the nGOM in every month of the year. Although recreational divers account for the majority of our collections (~78%), commercial fishing operations (~18%), state and federal fisheries surveys (~3%) and the recent increase in hook and line captures (~1%) account for the rest of our sample collections. For future spatial comparisons within the nGOM, we have defined three distinct eco-regions (Southeast, Northeast, and West) as described in Fogg (2013). Most of the lionfish collected from the West region were collected at < 100 m from oil production platforms off of the coasts of Mississippi and Louisiana.

Due to the large number of samples collected at one time, lionfish were not always able to be processed fresh and needed to be frozen. It has been shown that freezing does not have an effect on gonad weight if processed within three weeks (Fogg et al. 2013). However, since ~65% of frozen samples in our study were frozen for > 3 weeks, it was necessary to determine if these finding were consistent over a longer time period. Fresh gonads were removed from 33 female lionfish and weighed (0.01g). Gonads were placed back into the body and frozen (24 hours). Frozen gonads were then removed, weighed, thawed and weighed again prior to being re-frozen within the body. Frozen and thawed gonad weights were not different (t-test; p = 0.519); therefore, it is not necessary to thaw gonads prior to weighing. Gonads will be weighed every 30 days for one year since 100% of our frozen samples have not been frozen for more than one year. To date, weights have been recorded for 30, 60, and 90days and are not significantly different (repeated measures ANOVA, all $p > 0.32$). This indicates we can use fresh or frozen gonad weights to calculate accurate Gonadosomatic Index values (GSI).

There is a significant positive correlation between GSI and gonad-free body weight (GFBW; r = 0.55 , p = < 0.001) in females, which questions the validity of using GSI as an accurate indicator of spawning preparedness in lionfish. When female lionfish were reclassified into two distinct reproductive classes, spawning capable lionfish showed no significant correlation (r = 0.02, p = 0.504), but non-spawning capable lionfish still showed a significant correlation (r = 0.56, $p <$ 0.001). Therefore, the mature, non-spawning female lionfish account for the relationship seen in pooled female GSI by fish size. However, female mean GFBW with pooled reproductive classes was fairly consistent across months with the exception of November and December, whereas females showed elevated GSI values from May through October (Figure 1A). Thus, GSI can be used to accurately determine monthly spawning preparedness.

Female lionfish had elevated GSI values from May - October when water temperature was elevated, suggesting a six month spawning season in the nGOM (Figure 1A). Additionally, female GSI was significantly different by month (all $p <$ 0.001). However, macroscopic female reproductive phases indicate spawning capable (SC) lionfish were present year-round and actively spawning (AS) lionfish were collected in all months except March and November (Figure 1B). This indicates that spawning is occurring in months where GSI may not be elevated. Spawning frequency, calculated from the proportion of AS to SC females, is estimated to be every 2.7 days (range: 1.7 – 12.0 days) in the nGOM.

Oocyte diameter size frequency plots showed a unimodal distribution of oocyte diameters and no oocytes ≥500µm in the ovary of a SC fish. However, the ovary from an AS female showed a bi-modal distribution, with a second mode of oocyte diameter frequencies occurring ≥ 500µm. Therefore only oocytes ≥ 500µm, corresponding to oocytes undergoing final maturation, were counted for batch fecundity (BF) estimates. A mean BF of 23,959 ± 2,249 eggs (maximum BF of 94,973 eggs) was estimated for 58 females captured year-round (no samples March and November). Although there was a significant relationship between BF and total length (TL; (BF = 283 * TL – 51,673), $p < 0.001$, $r^2 = 0.22$), there was no significant relationship between relative batch fecundity (RBF) and TL (p = 0.835; $r^2 < 0.001$), indicating RBF adjusts for TL and can be used to estimate reproductive output. Mean RBF was calculated as 83.8 ± 6.5 eggs/g GFBW (range: 12.5 - 203.5). Therefore, assuming a year-round spawning frequency of 2.7 days, we estimate that a mean sized mature female lionfish of 230 mm TL would be capable of producing 1,779,942 eggs/year.

There are many similarities in the reproductive biology of lionfish between this study and previous studies from Little Cayman Island (Gardner 2014) and North Carolina, South Carolina, and the Bahamas (Morris 2009) (Table 1). However, while our BF estimates were similar to reports from Little Cayman Island and North Carolina, our study presents more data, a larger range, and a maximum batch fecundity more than two fold higher than previously reported. It is noteworthy that even though the nGOM is a warm temperate environment, lionfish reproductive biology is very similar to that reported in the tropics. Data produced in this study will be used in conjunction with other life history parameters to aid in the development of management plans.

KEY WORDS: Invasive, fecundity, *Pterois*, Scorpaenidae, Gulf of Mexico

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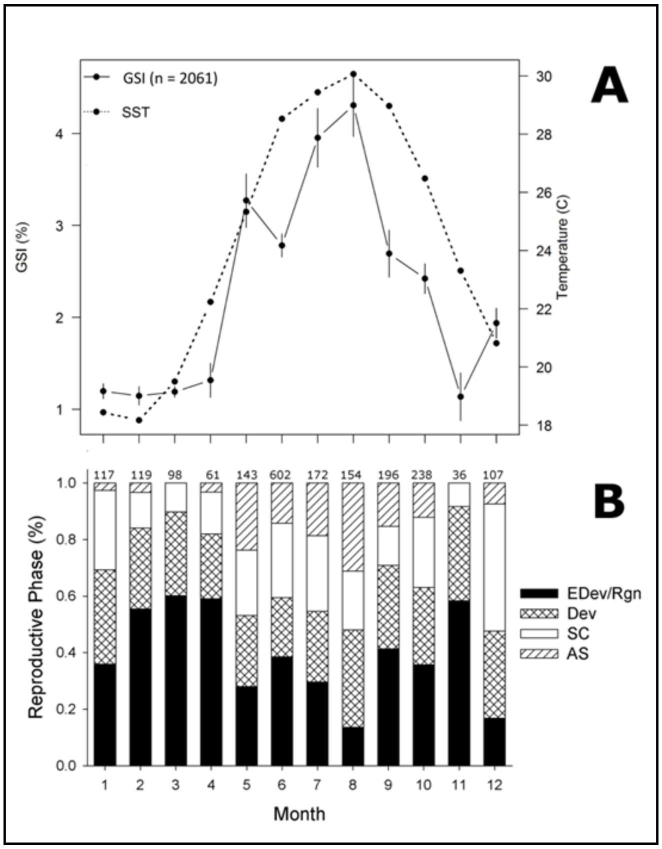

Figure 1 A. Monthly (mean ± SE) sea surface temperature (n = 11 buoys) and Gonadosomatic Index (GSI) values for female lionfish (*Pterois* sp.) in the northern Gulf of Mexico. **B.** Proportion of reproductively active females in four distinct reproductive phases. AS – Actively Spawning, SC – Spawning Capable , Dev - Developing, EDev/Rgn – Early Developing / Regenerating. Numbers indicate monthly sample sizes.

Table 1. Comparison of four lionfish (*Pterois* sp.) reproductive life history parameters in three invaded regions.

	Northern Gulf of Mexico (This study)	**Little Cayman Island (Gardner 2013)**	**NC, SC, and Bahamas (Morris 2009)**
Batch Fecundity Range	1,684 - 94,973 (n = 58)	1,800 - 41,945 (n = 19)	10,790 - 41,392 (n = 3)
Peak Spawning Seasonality (GSI > 2.0)	May through October	Year around	-
Actively Spawning Fish (Months)	10	12	10
Spawning Frequency	2.7 days	2.4 days	3.6 days : Bahamas 4.1 days : North Carolina