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SHORT COMMUNICATION

NOTES ON THE BIOLOGY OF INVASIVE LIONFISH (*PTEROIS* SP.) FROM THE NORTHCENTRAL GULF OF MEXICO

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Introduction

The red lionfish (*Pterois volitans*) and devil firefish (*P. miles*) are scorpaenids native to the Indo—Pacific, but in the past 20 years have invaded the waters of the western central Atlantic (Morris and Whitfield 2009), including the wider Caribbean and southern Gulf of Mexico (GOM) (Aguilar—Perera and Tuz—Sulub 2010). Lionfish are predators on small fish and crustaceans (Morris and Adkins 2009) and have no known natural predators, so there is increasing concern about the potential ecosystem impacts of the lionfish on native organisms (Albins and Hixon 2011), particularly in light of their range extension to the northern GOM. Much of the initial knowledge regarding the invasive lionfish stems from research conducted in the south Atlantic where lionfish populations first became established (Donaldson et al. 2011), although the more recent proliferation of the species in the wider Caribbean has resulted in much additional knowledge from this region (Morris 2012).

Populations of invasive lionfish in North Carolina and the Bahamas show asynchronous oocyte development and are indeterminate batch spawners (Morris et al. 2011). Furthermore, actively spawning females were captured during all seasons of the year off North Carolina and the Bahamas (Morris et al. 2009) and have relatively low batch fecundity (Morris 2009). However, their ability to spawn throughout the year, as well as their strategy of producing a gelatinous egg mass has been hypothesized to maximize fertilization success (Morris et al. 2011) and may be key to their invasion success. Morris and Akins (2009) examined the diets of lionfish collected in the Bahamas and documented 41 different species of teleost fishes in gut contents, including many smaller fishes that are common prey items for economically important native species (e.g., groupers and snappers).

The first confirmed sightings of lionfish in the GOM occurred in 2010 (Schofield 2010), where they were reported in the southern GOM off the Yucatan Peninsula, Mexico (Aguilar—Perera and Tuz—Sulub 2010); in 2012 more than 1,500 lionfish were collected from northern GOM locations ranging from Florida to Texas (Fogg et al. 2013). However, other than visual observations (mostly from recreational divers), there is relatively little information on the biology and ecology of lionfish in the northern GOM. The life history of invasive species can vary as they colonize new habitats and areas (Bøhn et al. 2004); thus, biological parameters described for lionfish along the US southeast coast, the Bahamas, and the Caribbean may differ as the species invades the GOM. Recently, Fogg et al. (2013) provided information on length—weight and sex ratios of northern GOM lionfish. Here, we report biological data from 4 lionfish captured during fishery—independent sampling in nearshore GOM waters off Alabama in May 2012.

Materials and Methods

Lionfish were collected during routine groundfish surveys, as part of the Southeast Area Monitoring and Assessment Program (SEAMAP) in May 2012, with a 13 m otter trawl (51 mm stretched mesh) that was towed for 30 min at about 2.5 knots. At each collection station, water quality (temperature (°C), salinity and dissolved oxygen (mg/L)) were recorded from bottom water samples collected in Nisken bottles, and depth at the site (m) was recorded.

All species captured in the trawls were enumerated and identified to species; large trawl samples were subsampled for diversity and abundance for most species, but all penaeid shrimp, red snapper (*Lutjanus campechanus*) and lionfish were sorted from the trawl and processed. Lionfish were measured for total length (TL) and standard length (SL) (mm), weighed (g) and frozen on board the ship. In the laboratory, the fish were thawed, and the gonads and stomachs were removed and fixed in 10% neutral buffered formalin. Specimens were deposited in the Gulf Coast Research Laboratory Museum (accession numbers GCRL 36546 (station E1007) and GCRL 32547 (station E1108)). While *P. volitans* is more common along the southeastern United States and Bahamas than *P. miles*, morphological identification of the species is not accurate in this region (Hamner et al. 2007); genetic identification to species has not been done on these

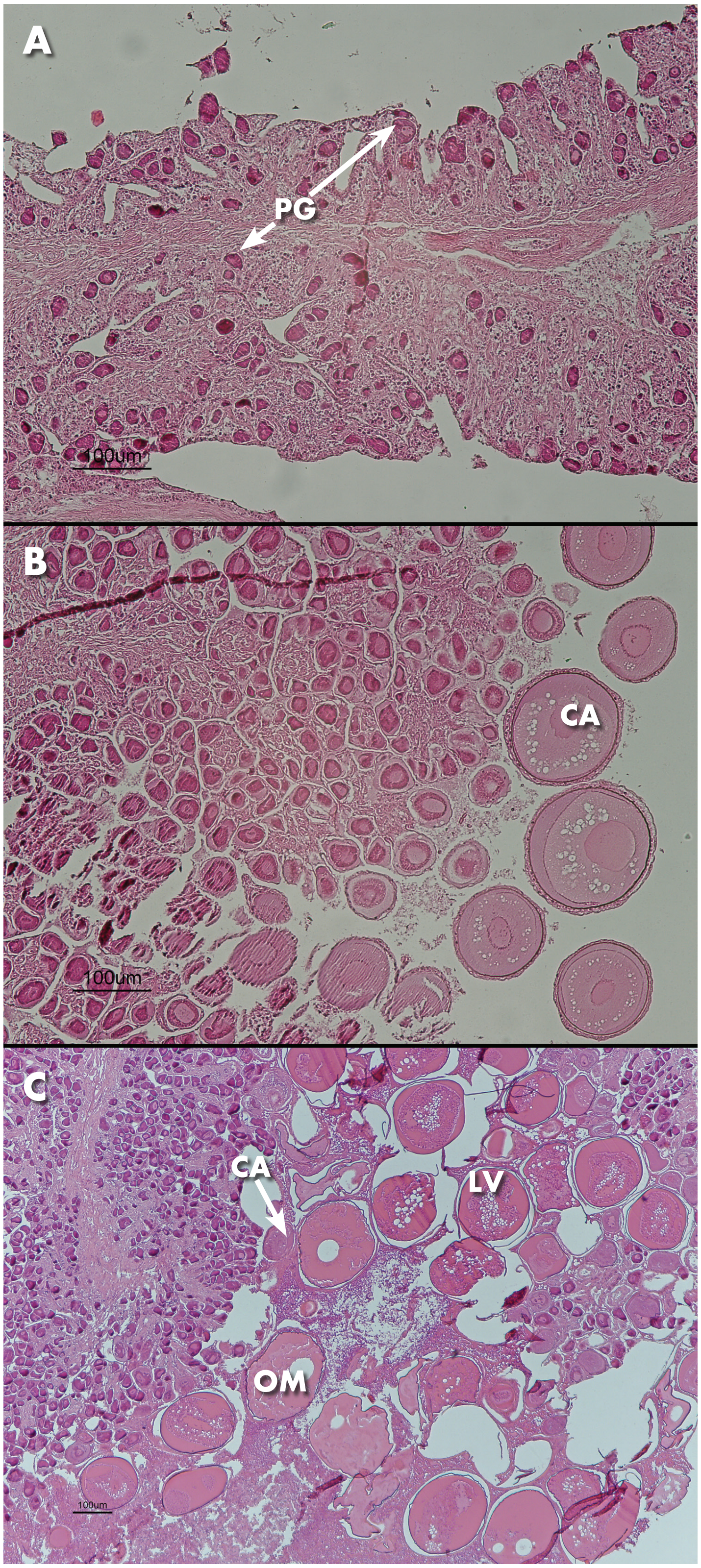

Figure 1. *Photomicrographs of ovarian tissue from lionfish captured on 30 May 2012 from the northcentral Gulf of Mexico.* ***A.*** *Immature (149 mm TL).* ***B.*** *Developing (188 mm TL).* ***C.*** *Spawning capable (213 m TL). CA – cortical alveolar oocyte; LV – late vitellogenic oocyte; OM – oocyte maturation; PG – primary growth oocyte.*

specimens, and therefore they are referred to collectively as lionfish in this paper.

Stomach contents were examined to determine abundance of prey items to the lowest possible taxonomic level. Gonadal tissue was rinsed overnight in running tap water, dehydrated in a series of graded ethanols, cleared in xylene substitute and embedded in paraffin following standard histological techniques. Tissues were sectioned at 4 µm, stained in Hematoxylin 2 and Eosin Y (Richard Allen Scientific), and gonadal maturity phases were assigned following Brown—Peterson et al. (2011).

Results

Lionfish were captured at SEAMAP stations E1108 (29°46.38'N, 88°15.98'W) and E1007 (29°46.52'N, 87°46.83'W) on 30 May 2012 at 1000 and 1500 CDT, respectively. These relatively shallow water (35 m) stations are about 50 km south of the mouth of Mobile Bay, AL. Two lionfish were captured at each station, and ranged in size from 149—213 mm TL (Table 1). Only the gender of the largest fish captured could be determined macroscopically.

TABLE 1. *Biological data for lionfish captured in 30 May 2012 in the northcentral Gulf of Mexico. U = unknown.*

ID	TL (mm)	SL (mm)	Weight (g)	Sex
E1108–1	188	137	88.7	F
E1108–2	149	102	31.8	F
E1007–1	213	161	138.7	F
E1007–2	162	118	52.1	U

Water quality characteristics were similar at both stations (Table 2). Bottom topography of both stations showed some structure; the trawl net tore at station E1007, indicating the presence of hard reef substrate. The species composition of native fishes taken in the same collections (Table 3) also suggests stations E1108 and E1007 had hard bottom substrates.

Stomach content analyses revealed prey material in 3 of the 4 specimens, including fish. However, all prey material had been digested to the point that positive identification of individual items was not possible to the family or species level. Histological analysis revealed that 3 of the 4 lionfish were females; the gender of the fourth fish is unknown due to lack of macroscopic identification of gonadal tissue. The smallest fish captured (149 mm TL) was an immature female, with scattered primary growth (PG) oocytes throughout the ovary (Figure 1A). A larger female (188 mm TL) was in the developing phase, with cortical alveolar (CA) oocytes (Figure 1B), which indicates the beginning of gonadal recrudescence. The largest fish captured (213 mm TL) was a female in the spawning capable phase, exhibiting late vitellogenic oocytes (Vtg3) as well as some oocytes

TABLE 2. *Water quality parameters of SEAMAP stations in the northcentral Gulf of Mexico where lionfish were captured on 30 May 2012. Depth of both stations is 35 m.*

Parameter	Station E1108	Station E1007
Bottom Temperature (°C)	21.8	22.9
Bottom Salinity	35.7	35.8
Bottom Dissolved Oxygen (mg/L)	5.9	7.2

just beginning to enter oocyte maturation (OM; Figure 1C). Asynchronous oocyte development is evident in the spawning capable female, indicating this is a batch spawning species. The presence of this fish suggests that lionfish are most likely spawning in the northcentral GOM.

Discussion

Despite the proliferation of lionfish in the GOM since 2010, little biological data has been reported on the species from the region. Recent information on length—weight relationships and sex ratios of northern GOM lionfish (Fogg et al. 2013) provides insights into the growing lionfish population. Spearfishing divers have collected most of the lionfish specimens in the northern GOM from reefs and rigs (A. Fogg, pers. comm., National Marine Fisheries Service, Pascagoula, MS); however, the data we present off Alabama are based on specimens collected during a fishery—independent SEAMAP trawl survey. We collected lionfish over or near hard bottom with relief, as evidenced by both the species composition of other fishes collected in the same trawl (see Table 3) and by the torn net at station E1007 that was undoubtedly damaged by bottom structure.

Invasive lionfish are known to inhabit reefs along the southeast Atlantic coast and in the Caribbean, where their impacts on native fish fauna and the food web are detrimental (Albins and Hixon 2008, 2011, Morris et al. 2009, Arias—Gonzales et al. 2011). They feed mostly on small—bodied teleost reef fish in the Bahamas (Morris and Atkins 2009), and food web models with and without lionfish suggest that lionfish have a detrimental effect on small carnivorous and herbivorous fishes (Arias—Gonzales et al. 2011). Although the stomach contents of the 4 fish we examined were inconclusive since they were mostly digested, clearly lionfish from the northcentral GOM are eating teleost fish. Lionfish show active feeding during the mornings in the Bahamas (0800—1100 h, Morris and Akins 2009). However, partially digested and unidentifiable prey in our fish collected at 1000 and 1500 h may suggest that feeding occurs at different times in the northcentral GOM. Few of the known prey of lionfish from the Bahamas were collected in the trawls in our study; however, lionfish are known to be non—specific piscivores (Morris and Akins 2009), and are thus no doubt eating dominant fishes on the GOM reefs such as sciaenids, lutjanids and sparids.

Analysis of ovarian tissue suggests lionfish reproduction in the GOM is similar to that seen in North Carolina and the Bahamas (Morris 2009; Morris et al. 2011), with asynchronous oocyte development and the probability of continuous egg production when environmental conditions are favorable. Seasonality of the spawning season in its native range is currently unknown, but collections off North Carolina and the Bahamas suggest that invasive lionfish are able to spawn year—round, with an estimated spawning frequency of every 3—4 days (Morris 2009). Based on data collected in this study, female lionfish in the GOM are sexually mature by 188 mm TL and spawning capable by 213 mm TL; this is similar to findings in North Carolina, where female lionfish > 170 mm TL are sexually mature (Morris 2009).

TABLE 3. *Fish species captured in SEAMAP trawl collections with lionfish from the northcentral Gulf of Mexico on 30 May 2012.*

Parameter	Number at E1108	Number at E1007
Engraulidae		
Anchoa hepsetus	37	
Clupeidae		
Harengula jaguana	6	
Carangidae		
Trachurus lathami	50	
Lutjanidae		
Lutjanus campechanus	13	
Rhomboplites aurorubens		3
Gerreidae		
Eucinostomus argenteus	12	3
Haemulidae		
Haemulon aurolineatum	1	1
Sparidae		
Lagodon rhomboides	62	
Stenotomus caprinus	1054	
Sciaenidae		
Cynoscion arenarius	31	
Cynoscion nothus	6	
Equetus umbrosus		1
Leiostomus xanthurus	175	
Micropogonias undulatus	1004	
Mullidae		
Mullus auratus	6	
Paralichthyidae		
Syacium gunteri		2
Syacium papillosum		1

The data presented here provide preliminary information on the invasive lionfish in the northcentral GOM, and suggests that life history characteristics contributing to their rapid and successful invasion of and establishment in the western North Atlantic and Caribbean regions are similar in the GOM. However, life history traits of invasive fishes can change during the invasion process as new habitats are colonized (Bøhn et al. 2004, Gibbs et al. 2008, Gutowsky and Fox 2012), underscoring the need for additional, comprehensive biological data on lionfish from the GOM as their abundance increases and they become established.

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