

**PARASITISM IN *PTEROIS VOLITANS*
(SCORPAENIDAE) FROM COASTAL WATERS OF
PUERTO RICO, CAYMAN ISLANDS AND BAHAMAS**

by

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ABSTRACT

Recently, *Pterois volitans*, one of the species known as lionfish, invaded the Atlantic Ocean. Individuals of *P. volitans* from Puerto Rico (N=188), Cayman Islands (N=91) and Bahamas (N=47) were examined for parasites. A total of 26 parasitic species, including the digenean *Lecithochirium floridense*, the leech, *Trachelobdella lubrica*, other digeneans, monogeneans, cestodes, nematodes, isopods a copepod and an acanthocephalan were recovered. Twenty-four new species infecting *P. volitans*, 5 new locality records from Puerto Rico, 10 from Cayman Islands, 6 from the Bahamas, 6 from the Caribbean and 4 from the subtropical western Atlantic region. Also, 2 first fish-association records are reported. Results from samples from Puerto Rico collected between 2009-2012 indicate there was no significant difference between yearly community compositions, although there was an incremental increase of parasitic species with time. Results suggest that lionfish communities were similar in composition, due to high abundances of *L. floridense* in the samples. Some of the observed species infecting lionfish are known to kill native fish species; however lower prevalences were recorded. Monitoring the development of parasite infestations in this host should continue throughout its range. Also, monitoring the impact of parasites on the fitness of this fish in its invasive range should be considered.

RESUMEN

Pterois volitans, una de las especies conocidas como “pez león”, recientemente invadió el Océano Atlántico. Individuos de *P. volitans* colectados en Puerto Rico (N= 188), Islas Cayman (N= 91) y en Las Bahamas (N= 47) fueron examinados para detectar la presencia de parásitos. En total, unas 26 especies fueron colectadas, incluyendo el digeneo *Lecithochirium floridense*, la sanguijuela *Trachelobdella lubrica*, otros digeneos, monogeneos, céstodos, nemátodos, isópodos, un copepodo y un acantocéfalo fueron recuperados. En este estudio se reportan 24 nuevas especies infectando a *P. volitans*, 5 nuevos reportes de especies de Puerto Rico, 10 de las Islas Cayman, 6 de las Bahamas y 6 de la región del Caribe y 4 de la región subtropical del oeste Atlántico. También, reportamos 2 primeras asociaciones de parásitos con un pez. Resultados de muestras de Puerto Rico colectadas entre 2009-2012 indican que no existe diferencia significativa entre la composición anual de comunidades de parásitos asociados al pez león, aunque se observó un incremento de especies parasíticas con el tiempo. Resultados sugieren que las comunidades de pez león son similares en composición debido a la gran abundancia de *L. floridense* en las muestras. Algunas de las especies que infectan al pez león son conocidas por matar especies de peces nativos, sin embargo, nuestros valores de prevalencia fueron menores. Desarrollo de infestaciones parasíticas en este huésped deberían ser monitoreadas a lo largo del rango de esta especie invasiva. Además, monitoreos del impacto de especies parasíticas sobre la aptitud de este pez deberían ser considerados.

“To my family; because you always saw the best in me.”

“To my friends; because you inspired me to keep going and never give up even when things got rough.”

“To my husband, Anton; for your patience, motivation, advice and never ending support.”

This one is for you guys!

Love,

Zu

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CHAPTER 1: INTRODUCTION

1.1 GENERAL INTRODUCTION AND LITERATURE REVIEW

Lionfish comprise two allopatric species of scorpaenid fishes, *Pterois volitans* Linnaeus, 1758 and *P. miles* Bennet, 1828; the former native from the Pacific Ocean, including the coasts of Japan, South Korea, Australia, Indonesia, Micronesia, Pitcairn Islands and French Polynesia (Shultz, 1986), and the latter occurring naturally through the Indian Ocean and the Red Sea (Hamner et al., 2007); although a distribution overlap occurs around the Indo-Mayan Archipelago (Shultz, 1986). These fishes are recognized for their similar display of long pectoral rays and venomous spines; therefore being once considered synonyms. They differ in their coloration, type of scales and fin count, *P. volitans* having one higher count in each fin, longer pectoral fin size and larger color spot size. However, meristic counts and mitochondrial DNA disagree with the identification of *P. volitans* and *P. miles*, probably due to hybridization, lineage sorting, unfixated meristic characteristics, or the classification of *P. miles* and *P. volitans* as a single species (Hamner, 2005). Based on meristic and morphometric counts, Schultz, (1986) identified *P. volitans* and *P. miles* as two separate species. Although the species have been considered synonyms, each one of them has synonyms of their own. *Gasterosterus volitans* Linnaeus, 1758, *Dendrochirus zebra* Cuvier, 1829, *P. cristatus* Swainson, 1839, and *P. volitans castus* Whitley, 1951 are considered synonyms of *P. volitans*; and *Scorpaena miles* Bennett, 1828 and *P. muricata* Cuvier, 1829 are considered synonyms of *P. miles* (Schultz, 1986).

Recently, lionfishes have invaded areas beyond their native ranges. Golani and Sonin (1992) reported invasive *P. miles* entering the Red Sea via the Suez Canal; and due to unknown events, most likely due to the aquarium trade; these species have invaded the Atlantic Ocean and

the Caribbean Sea as well. Whitfield et al., (2002); Ruiz-Carus et al., (2006); Betancour-R et al., (2010) have suggested that Florida was the initial site for the release of lionfishes. Cytochrome b data from these invasive species have identified Indonesia as the possible original habitat for the founder population; *P. volitans* population being greater than *P. miles* in the Atlantic Ocean (Hamner, 2005). Betancour-R et al., (2010) reported that *P. volitans* is all over the Atlantic and it is also more abundant than *P. miles*, which, is restricted to the US east coast and Bermuda. Genetic evidence suggests *P. volitans* is the only lionfish present in Puerto Rico (Lillystrom, pers. comm.), Bahamas (Freshwater et al., 2009) and the Caribbean (Freshwater et al., 2009; Albins and Hixon, 2011; Betancour-R et al., 2010). Unconfirmed reports of lionfishes started during the 1980's (Morris and Akins, 2009) but in 1992 documented sightings were recorded in Florida after Hurricane Andrew (Courtenay, 1995), however their establishment was officially reported in 2000, off the coasts of North Carolina, USA (Whitfield et al., 2002). Since then, sightings have been confirmed from Cuba (Chevalier et al., 2008), the Dominican Republic (Guerrero and Franco, 2008), Puerto Rico, the US Virgin Islands, the Bahamas, Colombia, Venezuela, Mexico and the northeastern coast of the US (Whitfield et al., 2002; Ruiz-Carus et al., 2006; Snyder and Burgess, 2006; Lasso-Alcalá and Posada, 2010).

P. volitans has several factors in its favor that have helped them disperse in the Atlantic Ocean quickly. First, in North Carolina and the Bahamas, they have been observed to reproduce every 4 days (Morris, 2009; Richardson, 2010) by releasing egg masses with up to 25,000 eggs (Richardson, 2010) that develop into planktonic larvae (Fishelson, 1975; Morris et al., 2009). Second, presuming that dispersal of this immature stage occurs during a period of ± 30 days (Hare and Whitfield, 2003), they can be transported for long distances due to currents (Morris et al., 2009). Long larval duration time and floating capacity of egg masses may facilitate the

dispersal by keeping the eggs in the surface where the wind currents are stronger (Freshwater et al., 2009). Third, lionfishes have been reported to go as deep as 50 m (164 ft.) in their native range (Schultz, 1986); and below scuba depths (300 m) in their invaded range (Albins and Hixon, 2011; Betancour-R et al., 2010). However, temperatures of 12°C (53.6° F) stop lionfishes from feeding and they die when temperature drops below 10°C (50° F) (Kimball et al., 2004). Geographically, these temperatures are found in Cape Hatteras, N.C. during the winter or New York during warmer seasons (Hare and Whitfield, 2003; Kimball et al., 2004). This means that the population of these invasive fishes concentrates in the tropics (Caribbean Sea, Gulf of Mexico and tropical range of the Atlantic Ocean) where the temperatures are warm enough, currents can disperse them and they can reach higher depths creating a big threat for coral-fish recruitment (Albins and Hixon, 2008; Green et al., 2012) and commercial species (Higgs, 2013).

Another factor that promotes the growth of lionfish population is the lack of natural predators. In their native range, these fishes have few documented natural predators, most likely due to their spines (Bernadsky and Goulet, 1991; Morris et al., 2009). Ecological studies observing the predation of lionfishes by other species have been performed in the Bahamas (Maljković et al., 2008; Hackerott et al., 2013), Cuba, Belize and Mexico (Hackerott et al., 2013). *P. volitans* have been found in the stomachs of a Nassau Grouper (Maljković et al., 2008), the Moray Eel, *Gymnothorax funebris* Ranzani, 1839 (Jud et al., 2011) and trained sharks (Handwerk, 2011). Mumby et al., (2011) reported that groupers, the serranids *Cephalopholis spp.*, lutjanids, carangids and aulostomids act as predators of *P. volitans*, although only groupers inflicted a significant impact on their populations. In contrast, Hackerott et al., (2013) determined that native predators do not control lionfish populations on the Caribbean reefs.

Pteroinae are known to feed off a variety of crustaceans (Fishelson, 1975, 1997) and benthic fish, sometimes using ambush strategies cornering their prey with their pectoral fins (Fishelson, 1975; Kochzius et al., 2003; Whitfield et al., 2002). Fish from the Families Haemulidae, Pomacentridae, Labridae, Opistognathidae and Gobiidae have been recorded to be part of the lionfish diet in aquaria (Albins and Hixon, 2008). In the Bahamas, juveniles have been observed feeding on shrimp, crabs and isopods (Higgs, 2013). In the same area, Morris and Akins, (2009) reported 41 species of teleost fishes (Families Labridae, Pomacentridae, Gobiidae and Serranidae) and crustaceans to be prey of lionfishes, which, are usually associated with hard bottoms, coral reefs and artificial substrates (Ray, 2005). *P. volitans* have been reported to have a great stomach expansion capacity eating over 20 fishes in a short span of time (Albins and Hixon, 2008) and expanding their stomach up to 30 times in volume, but also have the ability of fasting for over 12 weeks (Morris et al., 2009). Therefore, lionfish diet may vary depending on the availability of prey and their habitat (Morris et al., 2009). Having a great dispersal capacity, a broad distribution, a diet based on availability and possibly new predators, lionfishes interact with different species of fish associated with coral reefs that can be infected with parasites.

P. volitans from the Pacific have been only found to harbor a low number of parasites. It has been found infected by 2 monogeneans, one of them *Haliotrema pterois* (Paperna, 1972; Ogawa et al., 1995), 2 trematodes (Nagaty and Abdel-Aal, 1962; Hassanine, 2006), 1 leech (Paperna, 1976), and 1 copepod (Dojiri and Ho, 1988). In the Caribbean, records of parasites from invasive lionfishes include a trematode, nematodes, a metacercaria, 2 trypanorhynch, unidentified cysts and a brachyuran (*Argulus sp.*) from Cape Fear and Cape Lookout, North Carolina (Barse and Morris, 2006); a leech attached to the tongue of a male lionfish from Jacksonville, Florida (Ruiz-Carus et al., 2006); the trematode *Lecithochirium floridense* in

lionfishes stomachs from North Carolina (Bullard et al., 2011); some isopods, turbellaria, trematodes and nematodes in the Caribbean (Barrat, 2013); and an isopod (*Excorallana sp.*) from Bonaire (Poole, 2011) [Table 1.1]. Other localities where lionfishes have been examined for parasites include Anguilla, Bermuda, Bimini, Bonaire, Florida Straits, Jamaica, Louisiana, Mexico, Panama, St. Eustacia and Turks and Caicos (Table 1.2).

Previous research shows that *P. volitans* harbors a low number of parasites and there are no reports of parasites from either Puerto Rico, the Cayman Islands or the Bahamas. Thus the purpose of this research was to:

- Determine if lionfishes from these areas were infected by parasites and if so, by what species?
- Determine if parasitic species from the Indo-Pacific were introduced along with *P. volitans*.
- Determine if collected parasites are true parasites or incidental.
- Compare parasite fauna from the three localities (Puerto Rico, Cayman Islands and Bahamas).
- Compare the parasite species collected from Puerto Rico between 2009-2012 to determine if there was a significant difference between parasite population compositions during those years.

1.2 SUMMARY OF FOLLOWING CHAPTERS

In chapter 1, general information about lionfishes, in both their native habitat and their invaded ranges is presented. Also information on the chronologic sequence of this species

colonization in the Atlantic Ocean and the Caribbean Sea, factors promoting dispersion and population growth, natural predators, diet in the invaded range, and parasitic species found in both their native range and in the Atlantic are showed. In chapter 2, information about the first lionfish sightings in the study areas and parasites found at the collection sites, data regarding the parasitic fauna found in these fishes, their location in the host, prevalences, mean intensities and number of infected fish are presented. In the discussion section comparisons between the parasites species are performed and numbers from all collection sites are showed. We also discuss lionfishes vulnerability to parasites and other diseases. In the conclusions and future work section, main findings are stated and possible research projects related to the parasitology of this invasive fish are suggested.

*** Parasite species are organized by locality (in the order: 1. Puerto Rico, 2. the Cayman Islands or 3. the Bahamas). Parasites found in two or more localities will be discussed in the first place found.

CHAPTER 2

2.1 INTRODUCTION

Lionfish in Puerto Rico, the Cayman Islands and Bahamas waters

Schofield, (2009) offered the first report of established invasive lionfish population in the Atlantic coast of US and the Caribbean, including Bermuda Islands, the Bahamas, Turks and Caicos Islands, Cayman Islands, Cuba, Jamaica, Dominican Republic, Puerto Rico, Mexico, Honduras and Costa Rica. Although a great population *P. volitans* and a small one of *P. miles* have been reported in the Atlantic Ocean (Hamner, 2005), it is suggested that the lionfish population in Puerto Rico (Lillystrom, pers. comm.), Cayman Islands and the Bahamas (Freshwater et al., 2009; Betancour-R et al., 2010) are composed only of *P. volitans*.

In the Bahamas, invasive lionfish first appeared in 2004 at Nassau and then it had established to Abacos, Andros, Eleuthera, Exumas and San Salvador Islands in coral reef habitats, mangrove, seagrass, sandy beaches and canal habitats (Schofield, 2009). The first report of this fish in the Cayman Islands was made in February, 2008 where a single juvenile was sighted, and a second individual was captured in October, 2008 from a reef off Cayman Brac. The first documented lionfish sighting from Puerto Rico was from Vieques Island where a single individual was spotted in November, 2008 (Schofield, 2009); and in April, 2009 the Fisheries Laboratory from the Department of Natural and Environmental Resources (DNER) reported their first confirmed capture from the coast of Dorado (Lilyestrom et al., 2010). After confirming its presence in these places, mitigation responses and management plans have been developed (Sealey, et al., 2008; Bervoets, 2010; Lilyestrom et al., 2010; Meléndez et al., 2010a; Meléndez et al., 2010b), but none of them have been completely successful to control lionfish population.

Parasites species infecting Lionfishes from Puerto Rico, Cayman Islands and Bahamas

In the Caribbean, parasite species associated to lionfish have been reported from Florida (Ruiz-Carus et al. 2006; Barrat, 2013; Simmons et al., 2013); Bonaire (Poole, 2011; Simmons et al., 2013); Belize, Mexico and Panama (Barrat, 2013); Anguilla and St. Eustacia (Sarkis, 2013); Jamaica, Louisiana and Turks and Caicos (Simmons et al., 2013). From the subtropical western Atlantic, parasites have been previously reported from North Carolina (Barse and Morris, 2006; Bullard et al., 2011; Simmons et al., 2013), Bimini and Bermuda (Simmons et al., 2013).

2.2 MATERIALS AND METHODS

2.2.1 Puerto Rico

Lionfish were collected between August 2009 and April 2012, at sampling sites in 8 coastal municipalities of Puerto Rico. These sites included El Escambrón Beach, San Juan (18° 27' 55.1124"N, 66° 5' 9.6936" W), Juana Díaz (17° 58' 10.254" 'N, 66° 29' 26.0082" W) Buoy #2, Cabo Rojo (17° 55' 40.8174" N, 67° 12' 53.2758" W), Bahía de Mayagüez (18° 12' 45.0642" N, 67° 11' 0.8952" W), Tres Palmas Reserve, Rincón (18° 20' 56.223" N, 67° 15' 55.8612" W), Pico de Piedra, Aguada (18° 23' 9.9024" N, 7° 12' 43.167" W), Punta Borinquen, Aguadilla (18° 29' 43.5768" N, 67° 9' 37.5834" W) and La Parguera, Lajas (17° 57' 30.9456" N, 67° 3' 8.7192" W) [Figure 2.1].

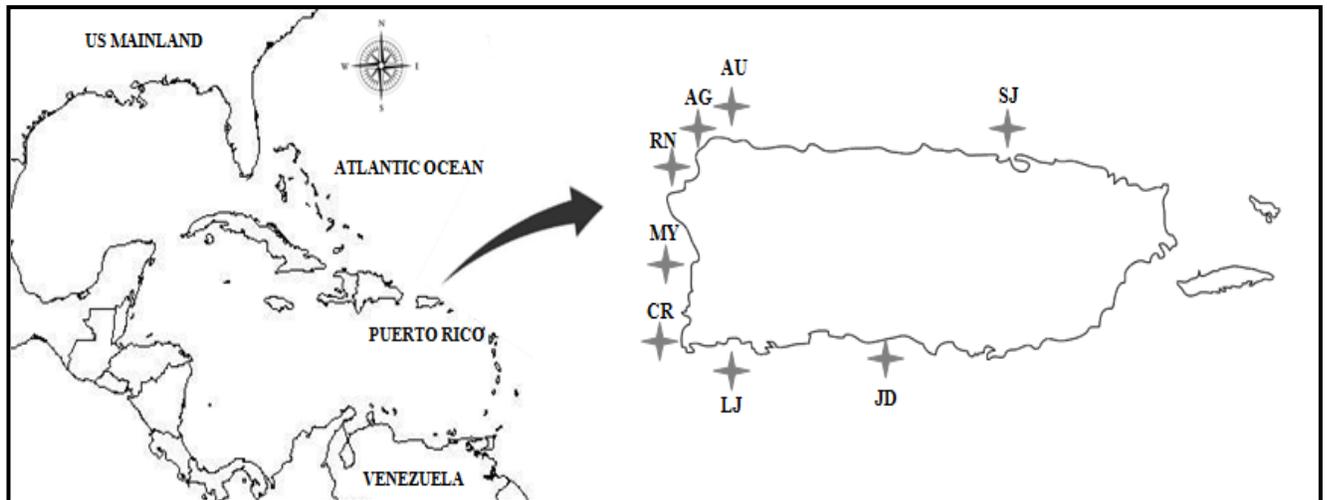


Figure 2.1. *Pterois volitans* collection sites off the coasts of Puerto Rico. San Juan (SJ), Aguadilla (AU), Aguada (AG), Rincón (RN), Mayagüez (MY), Cabo rojo (CR), Lajas (LJ) and Juana Díaz (JD).

Fish were caught during the day by local fishermen by spearing and were individually placed in plastic bags at the surface. In the lab, fish were refrigerated until processing. Entire fishes were placed in a plastic tray where they were measured and examined externally under the dissecting microscope. Then gills and gastrointestinal tract were removed and placed in individual Petri dishes in a mixture of tap water (90%) and saline water (10%). Gill arches were separated from the branchial chamber and each gill arch was placed in another container containing the same water solution. Gills were mechanically processed by brushing each gill with small forceps. Guts were cut open in a Petri dish with the water solution and scraped with an angular probe to remove all stomach contents from the tissue. Contents of gills and guts were analyzed by taking 1ml of the fluids at a time and placing them in another Petri dish with water solution to clearly observe parasites present. Parasites were categorized by Class, counted and fixed for further identification. Monogeneans, acanthocephalans, cestodes and leeches were fixed in 10 % buffered formalin. Copepods, nematodes and isopods were preserved in 70 % ethanol

and digeneans were fixed in either steaming 10 % formalin or AFA (85ml of ethanol 85 %, 25ml of 100 % formalin and 5ml glacial acetic acid). Trematodes were stained with Semichon's acetic-carmin and prepared as whole mounts.

Parasite identification was based on Siddiqi and Cable, (1960), Dyer et al., (1985), Dyer et al., (1991), Williams et al., (1994), Williams and Bunkley-Williams, (1996) Dyer et al., (1998), Rodríguez-Ibarra and Pulido-Flores, (2011) and other manuscripts. Fish identification and common names were based on Fishbase.org. Parasite population composition in Puerto Rico samples between 2009-2012 were made by using the software PRIMER 6 where a multidimensional scaling (MDS) was performed to create a graphical representation based on a similarity matrix between samples, that allows to see aspects of the community structure (Clarke, 1993), in this case how different is each year sample to the other. Also, an analysis of similarity (ANOSIM) was performed to compare the composition and the variation in species abundance, and similarity percent test (SIMPER) was made to observe the dissimilarity between samples and determine which species distinguish one year from one another. Data was 4th root transformed, which allowed to see patterns in rare species (Clarke and Green, 1988).

2.2.2 Cayman Islands and the Bahamas

Lionfishes were collected off Lee Stocking Island (LSI), Bahamas (23°46'00"N, 76°06'00"W) in summer 2009, and Little Cayman (LC), Cayman Islands (19°41'56"N, 80°3'38"W), during the summer of 2010 (Figure 2.2). All Lionfish (N = 48 from LSI and N= 91 from LC) were collected during the day by scuba divers using hand nets. Once at the lab, fishes were placed in tanks with running seawater until processing. All fishes were processed for parasites within 24 h of capture.

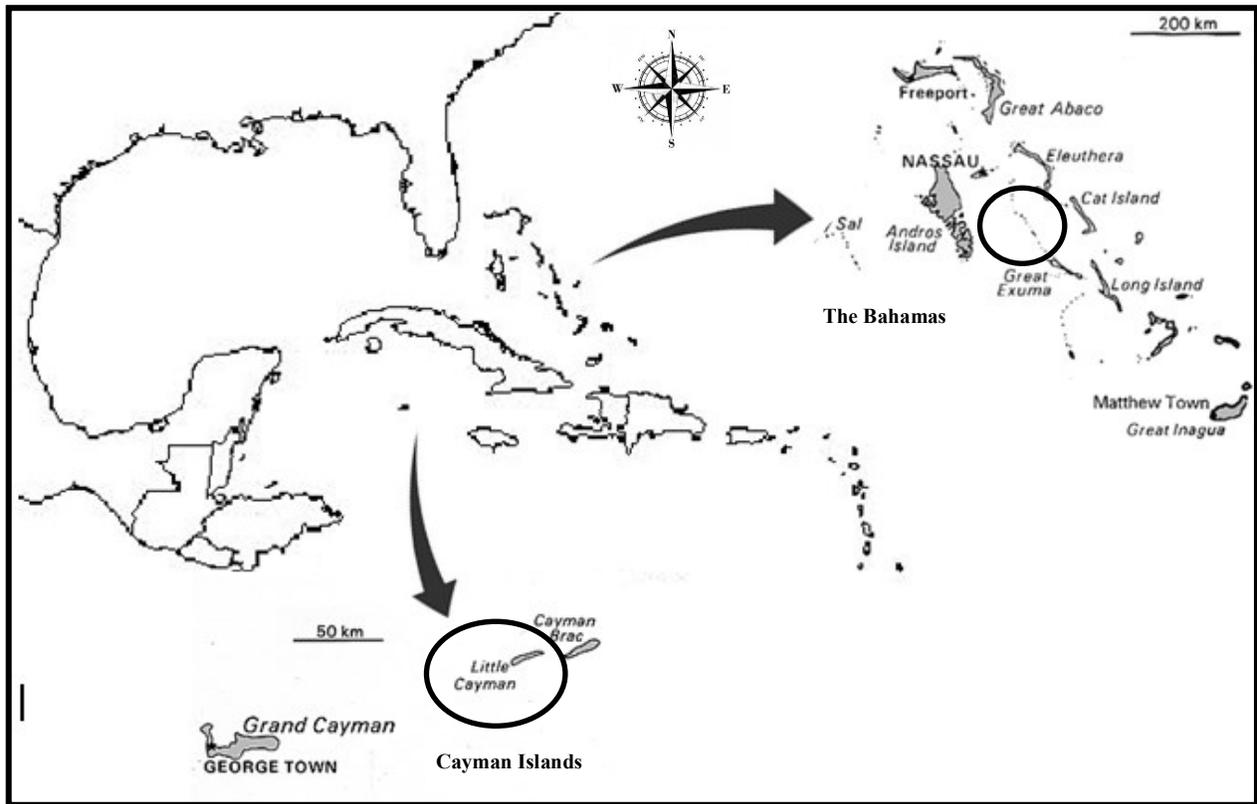


Figure 2.2 *Pterois volitans* collection sites off the coasts of Lee Stocking Island, Bahamas and Little Cayman, Cayman Islands.

Each fish was sacrificed by severing the spinal cord. The entire fish was then placed in a small tub of seawater where it was measured, and the entire gut and gills were removed. The “gut wash” technique (Cribb and Bray, 2010) was used to process guts and gills. Guts were cut longitudinally to expose the inner surface and placed in a 250 ml glass container filled with a 150 ml solution consisting of 70 % tap water and 30 % seawater. Gill arches were cut from the branchial chamber and each gill arch removed and placed in another container with the same solution. Both containers were shaken vigorously for 60 sec., and the contents were allowed to settle. The bottom sediment was then siphoned off into a Petri dish, and the remainder of the

liquid was filtered through 53 μ m plankton mesh, and the contents rinsed into a separate Petri dish.

After removal of the gut and gills, the remainder of the fish was placed in a shallow tub of tap water and allowed to soak for 15 min to dislodge any ectoparasites and parasites living in the body cavity. The body was rinsed thoroughly with a squirt bottle. A rectangular patch of scales 3 cm wide X 6 cm long was removed from each side of the fish to sample any parasites living under the scales, and the body cavity was scraped using a scalpel. The entire contents of the seawater and freshwater baths were filtered through 53 μ m plankton mesh and rinsed into separate Petri dishes. The contents of all dishes were examined under dissecting (stereo) scopes for parasites. Parasites were sorted by Class and counted, with samples of soft-bodied parasites being placed in 10 % buffered formalin and hard-bodied parasites being placed in 70% ethanol solution. Parasites were deposited in the U.S. National Parasite Collection (USNPC). All reported species are introduced in phylogenetic order according to García-Varela et al. (2000).

2.3 RESULTS

2.3.1 Puerto Rico

2.3.1.1 Parasite descriptions

One hundred and eighty-eight individuals, with total lengths between 4.4 cm and 35.6 cm were examined. Seventeen parasitic species were collected from the skin, gills and gastrointestinal tract of 145 out of 188 (77.1%) of the fishes. Of these, 20 of 25 lionfishes were from Rincón, 3 of 12 from Mayagüez, 7 of 10 from Lajas, 93 of 104 from Cabo Rojo and 22 of 28 from San Juan. Most of the organisms collected were digenetic trematodes with *Lecithochirium floridense* being the most abundant (occurring in 74.5 % of the fishes with a mean intensity of 13.5 individuals/fish) followed by *Anisakis simplex* (occurring in 11.7 % of the fishes with a mean intensity of 1.4 ind/fish). Other parasites recovered include 2 digeneans, 5 nematodes, 2 isopods, 1 leech, 2 cestodes, 2 monogeneans and 1 acanthocephalan species. Also an unknown copepod species was found although it is not reported as a parasite of lionfish. Parasite species found are described below. Prevalences, mean intensities, localities and infection sites (locations) of Puerto Rico municipalities are detailed in Table 2.1.

Phylum Acanthocephala

Family Cavisomidae

Cavisoma chromitidis Cable and Quick, 1954 (Figure 2.3)

Synonyms: none

C. chromitidis has a club-shaped proboscis, with 14 longitudinal rows of 8 hooks each, which, become smaller gradually; conical neck; brain at the mid-level of proboscis receptacle; and lemnisci elongate and unequal. Males have slightly overlapping elliptical testis occupying the middle third of the trunk length; and 4 elongated cement glands. Females have a uterine bell, a long and narrow uterus, short vagina with a prominent sphincter, spherical or oval ovarian balls; and elongated shelled embryos (Cable and Quick, 1954).

This acanthocephalan infects *Chromis marginata* Castelnau, 1855 [*Chromis multilineata* Guichenot, 1853] (brown chromis) from Puerto Rico (Cable and Quick, 1954), and other fish from the same locality (Williams and Bunkley-Williams, unpublished data). Brown chromis has been confirmed to be a prey of lionfish (Morris and Akins, 2009). This acanthocephalan resembles the genus *Fessisentis* Van Cleve, 1931, but the position of the brain near the middle of the proboscis and the elliptical testes are characteristics of the genus *Cavisoma* Van Cleve, 1931 (Cable and Quick, 1954). Only 1 specimen of *C. chromitidis* was found infecting the stomach of a lionfish, occurring in 3.6% of the fishes from San Juan (Table 2.1). This species is not a new report for Puerto Rico; however lionfish is a new host record for this acanthocephalan.

Phylum Nematoda

Order Ascaridida

Family Anisakidae

Anisakis simplex Rudolphi, 1809 (Figure 2.4)

Synonyms: none

Anisakis simplex is characterized by 3 small lips surrounding the mouth, a boring tooth and a rounded tail with a mucron at the end (Al-Zubaidy, 2010). This anisakid nematode has a worldwide distribution, infecting teleost fish as larvae, and mammals as adults, and is considered to have little or no host specificity (Williams and Bunkley-Williams, 1996). In Puerto Rico, *A. simplex* infects *Lutjanus analis* Cuvier, 1828 (mutton snapper), *L. griseus* Linnaeus, 1758 (grey snapper), *L. mahogoni* Cuvier, 1828 (mahogany snapper), *L. vivanus* Cuvier, 1828 (silk snapper), *Etelis oculatus* Valenciennes, 1828 (queen snapper) and *Ocyurus chrysurus* Bloch, 1791 (yellowtail snapper) (Bosques-Rodriguez, 2004). Williams and Bunkley-Williams, (1996) mention *Xiphias gladius* Linnaeus, 1758 (swordfish), *Sarda sarda* Bloch, 1793 (Atlantic bonito), *Scomber scombrus* Linnaeus, 1758 (Atlantic mackerel), *Katsuwonus pelamis* Linnaeus, 1758 (skipjack tuna) and *T. albacares* Bonnaterre, 1788 (yellowfin tuna) from the northeast coast of USA, but suggested it can occur in almost any fish.

Other reports include *Merluccius hubbsi* Marini, 1933 (argentine hake) from South Atlantic Ocean (Incorvaia, 2001); *Conger conger* Linnaeus, 1758 (european conger) from Madeira Island, Atlantic Ocean (Costa et al., 2009); *Theragra chalcogramma* Pallas, 1814

(Alaska pollock) from northern Japan (Quiazon, 2009); *Trichiurus lepturus* Linnaeus, 1758 (largehead hairtail) from Taiwan (Shih, 2004); *Anguilla bicolor* McClelland, 1844 (indonesian shortfin eel) from Thailand (Moravec et al., 2006); *Paralichthys isosceles* Jordan, 1891 from Rio de Janeiro, Brazil (Nunes-Felizardo et al., 2009); *Lethrinus nebulosus* Forsskål, 1775 (spangled emperor), *Carangoides bajad* Forsskål, 1775 (orangespotted trevally), *Rastrelliger kanagurta* Cuvier, 1816 (indian mackerel) and *Variota louti* Forsskål, 1775 (yellow-edged lyretail) from Hodeidah City, Yemen (Al-Zubaidy, 2010); and *Sardina pilchardus* Walbaum, 1792 (european pilchard) from the western Mediterranean (Marzoug et al., 2012). Thirty third-stage larvae (L3) of *A. simplex* were found in the stomachs of lionfishes; 14 nematodes from Rincón, 1 from Lajas, 14 from Cabo Rojo and 1 from San Juan; occurring in 28.0 %, 10.0 %, 12.5 % and 3.6 % of the fishes, respectively (Table 2.1). Lionfish is a new host record for *A. simplex*.

***Raphidascaris spp.* Railliet and Henry, 1915 (Figure 2.5)**

Synonyms: *Sprentascaris sp.* Petter and Cassone, 1984

Raphidascaris spp. nematodes are characterized by having lips without denticles, an esophagus with a small ventriculus and a short appendix; the male has equal spicules, and the female has a pre-equatorial vulva (Thatcher, 1991). Yamaguti, (1959) listed *R. anchoviellae* Chandler, 1935 as a parasite of *Sphyraena* Klein, 1778, but it may be an error. *Raphidascaris spp.* also infects *Ictalurus punctatus* Rafinesque, 1818 (channel catfish) from Mexico (Jiménez-Guzmán et al., 1986); *Selene setapinnis* Mitchill, 1815 (atlantic moonfish) from Copacabana and Barra de Guaratiba, State of Rio de Janeiro, Brazil (Cordeiro and Luque, 2004); *Auxis thazard*

Lacépede, 1800 (frigate tuna) from Rio de Janeiro Brazil (Dias-Mogrovejo et al., 2004); *Prionotus punctatus* Bloch, 1793 (bluewing searobin) from Agra dos Reis, Rio de Janeiro, Brazil (Bicudo et al., 2005); *Kajikia albida* Poey, 1860 (atlantic white marlin) and swordfish from Venezuela (Bashirullah et al., 2005); *Lutjanus synagris* Linnaeus, 1758 (lane snapper) and mutton snapper from Santa Marta and Naguanje, Colombia (Cortés et al., 2009a); *Paralichthys isosceles* from State of Rio de Janeiro, Brazil (Nunes-Felizardo et al., 2009); and *Ctenosciaena gracilicirrhus* Metzelaar, 1919 (barbel drum) from State of Rio de Janeiro, Brazil (Cárdenas et al., 2012). Four *Raphidascaaris spp.* were found in the stomach of lionfishes; 1 from Rincón and 3 from Cabo Rojo, occurring in 4.2 and 2.9 % of the fishes, respectively (Table 2.1). This nematode is a new report for Puerto Rico and possibly the Caribbean region, and lionfish is a new host record for this nematode.

Family Camallanidae

***Spirocamallanus partitus* (Bashirullah and Williams, 1980) (Figure 2.6)**

Synonyms: *Procamallanus partitus* Bashirullah and Williams, 1980

This nematode was described by Bashirullah and Williams (1980). It has a buccal capsule with 12 spiral thickenings; 4 buccal sinuses, 2 ventral and 2 dorsal; and 4 cephalic papillae. Males have 2 unequal spicules; tail is attenuated; 15 pairs of caudal papillae arranged in 3 pairs of preanal, 2 pairs of adanal and 10 pairs of postanal papillae. Females have a wide uterus, filling the whole body cavity; its vagina is located close to the cephalic end; and the tail ends with a mucron with 2 papilla-like structures at the end. *S. partitus* differs from *S. spinicaudatus*

(Bashirullah and Williams, 1980) in the number of spiral thickenings, the number and arrangement of the caudal papillae, and the presence of spines in the anal opening; and from *S. papillicaudatus* (Bashirullah and Williams, 1980) by the arrangement of the caudal papillae, the number of spiral thickenings in the buccal capsule, the shape of the tail and the absence of papillae on the female tail (Bashirullah and Williams, 1980).

The only report of this nematode was in *Stegastes partitus* Poey, 1868 (bicolor damselfish) (type host) from Puerto Rico (Bashirullah and Williams, 1980). Only 1 specimen of *S. partitus* was found in the intestines of a lionfish, occurring in 1.0 % of the fishes from Cabo Rojo (Table 2.1). Lionfish is a new host record for *S. partitus*.

***Spirocamallanus spinicaudatus* (Bashirullah and Williams, 1980) (Figure 2.7)**

Synonyms: *Procamallanus spinicaudatus* Bashirullah and Williams, 1980

This parasitic nematode, reported as a new species by Bashirullah and Williams, (1980), has only been reported from Puerto Rico infecting *Holocentrus marianus* Cuvier, 1829 (longjaw squirrelfish) (type host). It has a buccal capsule with 10 spiral thickenings; 4 buccal sinuses, 2 dorsal and 2 ventral; cervical papillae are present; 2 amphids. Males have 2 unequal spicules; tail has 13 pairs of caudal papillae, arranged in 5 pairs of preanal, 2 pairs of adanal and 6 pairs of postanal papillae; tail is slightly curved with 2 papilla-like structures at the end. *S. spinicaudatus* differs from its congeners mainly in the number of spiral thickenings in the buccal capsule, and the number and arrangement of caudal papillae. Only 2 specimens of this nematode were found in the stomach and intestines of lionfishes, 1 from Rincón and 1 from Cabo Rojo, occurring in

4.0 % and 1.0 % of the fishes, respectively (Table 2.1). Lionfish is a new host record for this nematode.

Family Trichuridae

***Capillaria sp.* Zeder, 1800 (Figure 2.8)**

Synonyms: *Procapillaria spp.*, Moravec, 1987

Members of this genus parasitize intestines of fish, amphibians, reptiles, birds and mammals (Gibbons, 2010) and are recognized by having unsegmented eggs with a plug at the poles (Rocka, 2004). Previous reports of *Capillaria sp.* mention gonads (Cortés et al., 2009a), pyloric caeca and intestines (Rocka, 2004) as sites of infection; however it was found parasitizing the stomach of a lionfish. *Capillaria sp.* has been reported from *Mugil cephalus* Linnaeus, 1758 (flathead grey mullet) from Georgia and Biscayne Bay, Florida (Skinner, 1975); and lane snapper and mutton snapper from Santa Marta and Neguaje from Colombia (Cortés et al., 2009a). Only 1 *Capillaria sp.* worm was found in the stomach of a lionfish, occurring in 3.6 % of the fishes from San Juan (Table 2.1). Lionfish is a new record for this nematode and Puerto Rico and the Caribbean are new localities records for it.

Phylum Arthropoda

Subclass Copepoda

Unknown species – Family Pandaridae (Figure 2.9)

Synonyms:

Only 1 copepod was found in the stomach of a lionfish, occurring in 10.0 % of the fish from Lajas. Copepods from the Family Pandaridae are ectoparasites of sharks and rays with a cosmopolitan distribution (Cressey, 1967). This organism was not in its usual infection location. This parasite may have been acquired during consumption of an infected prey or the parasite may have been swallowed by the fish when killed (Table 2.1).

Class Malacostraca

Order Isopoda

Family Aegidae

***Rocinela signata* Schioedte and Meinert, 1879 (Figure 2.10)**

Synonyms: none

Only 2 species of the genus *Rocinela* have been reported from Puerto Rico; *R. oculata* from grey snapper, and *R. signata* from several other species of snappers (Bosques-Rodriguez, 2004), groupers, elasmobranchs, grunts and species in the Order Perciformes (Williams and Bunkley-Williams, 1977). This species has a broadly triangular cephalon; eyes widely separated; flagellum of antenna with 10 or 11 articles; and the pleotelson with posterior margin evenly and broadly rounded, usually with inverted W-shaped band of pigment (Kensley and

Schotte, 1989). This species is considered opportunistic since it feeds on fishes then withdraws (Bosques-Rodriguez, 2004). In the Caribbean, *R. signata* infects *Acanthurus chirurgus* Bloch, 1787 (doctorfish), *Aetobatus narinari* Euphrasen, 1790 (spotted eagle ray), *Calamus calamus* Valenciennes, 1830 (saucereye porgy), *Anisotremus surinamensis* Bloch, 1791 (black margate), *Pseudopeneus maculatus* Bloch, 1793 (spotted goatfish), brown chromis, *Epinephelus itajara* Lichtenstein, 1822 (Atlantic goliath grouper), *Haemulon album* Cuvier, 1830 (white margate), *H. sciurus* Shaw, 1803 (bluestriped grunt), *Lachnolaimus maximus* Walbaum, 1792 (hogfish), *Heteropriacanthus cruentatus* Lacepède, 1801 (glasseye), *Sphyrna barracuda* Edwards, 1771 (great barracuda) and *Sphyrna mokarran* Rüppell, 1837 (great hammerhead) from Puerto Rico (Williams and Bunkley-Williams, 1977). In the Bahamas, this species was reported by (Garzón-Ferreira, 1990; USNM 101884).

Other reports include *Haemulon steindachneri* Jordan and Gilbert, 1882 (chere-chere grunt) and *Orthopristis ruber* Cuvier, 1830 (corocoro) from Venezuela (Kensley and Schotte, 1989); mutton snapper and *Micropogonias furnieri* Desmarest, 1823 (whitemouth croaker) from Venezuela (Bunkley-Williams et al., 1998); from Los Angeles to Ecuador and in tropical western Atlantic (Brusca et al., 2001); *Dasyatis americana* Hildebrand and Schroeder, 1928 (southern stingray) and *D. guttata* Bloch and Schneider, 1801 (longnose stingray) from Colombia (Williams et al., 1994). Three specimens were found on the gills of lionfishes, 1 from Rincón and 2 from Cabo Rojo, occurring in 4.0 and 1.9 % of the fishes, respectively (Table 2.1). Lionfish is a new host record for this crustacean.

Family Gnathiidae

***Gnathia* spp.** Leach, 1814 (**Figure 2.11**)

Synonyms: *Anceus* sp. Risso, 1816

These temporary parasites have a circumtropical distribution, and are not host specific. They infect multiple species of fish as larvae (Smit and Davies 2004), especially from warm and tropical areas (Farquharson et al., 2012), and like all isopods appear to be more active at dawn and dusk, and thus most collections are likely to underestimate their prevalence and abundances on their hosts. Praniza larvae feed until engorged within hours of infection and leave the host (Grutter, 2003), move to the benthos and molt to the next stage. After the third feeding, they metamorphose into non-feeding reproductive adults (Smit and Davies 2004). *Gnathia puertoricensis* Menzies and Glynn, 1968 praniza has been reported from ocean surgeon, *Alutera schoepfii* Walbaum, 1792 (orange filefish), *Echeneis naucrates* Linnaeus, 1758 (live sharksucker), atlantic goliath grouper, white margate, *Labrisomus filamentosus* Springer, 1960 (quillfin blenny), *Lutjanus cyanopterus* Cuvier, 1828 (cubera snapper), and Great Barracuda from Puerto Rico (Williams and Bunkley-Williams, 1977). *G. marleyi* Farquharson, Smit and Sikkell, 2012 has been reported from *H. flavolineatum* Desmarest, 1823 (french grunt), *H. sciurus* Shaw, 1803 (bluestripped grunt), schoolmaster snapper, lane snapper, *Epinephelus guttatus* Linnaeus, 1758 (red hind), *Stegastes diencaeus* (Jordan and Rutter, 1897) (longfin damselfish), *Abudefduf saxatilis* Linnaeus, 1758 (sergeant-major), brown chromis, *Acanthurus coeruleus* Bloch and Schneider, 1801 (blue tang surgeonfish), *Acanthurus bahianus* Castelnau, 1855 (ocean surgeon), *Scarus taenipterus* Lesson, 1829 (princess parrotfish), *Sparisoma aurofrenatum* (Valenciennes, 1840) (redband parrotfish), *Chaetodon capistratus* Linnaeus, 1758 (four-eye butterflyfish), *Holocentrus rufus* Walbaum, 1792 (longspine squirrelfish), *Myripristis*

jacobus Cuvier, 1829 (blackbar soldierfish), *Lactophrys triqueter* Linnaeus, 1758 (smooth trunkfish) from Great Lameshur Bay, St. John, United States Virgin Islands (Farquharson et al., 2012; Coile and Sikkell, 2013).

Gnathia spp. infects *Decodon puellaris* Poey, 1860 (red hogfish), *Lutjanus buccannella* Cuvier, 1828 (blackfin snapper) and *Serranus phoebe* Poey, 1851 (tattler) from Puerto Rico, Mona Island, U.S. and British Virgin Islands, and the central and southern Bahamas (Williams and Bunkley-Williams, 1977); mutton snapper, schoolmaster snapper, *L. jocu* Bloch and Schneider, 1801 (dog snapper) and lane snapper, *Pristipomoides aquilonaris* Goode and Bean, 1896 (wenchman) from Puerto Rico (Bosques-Rodriguez, 2004); western atlantic seabream, *Haemulon aurolineatum* Cuvier, 1830 (tomtate grunt) and *Calamus penna* Valenciennes (sheepshead porgy) from Puerto Rico (Hernández-Vale, 2011). Other reports include *Apogon quadrisquamatus* Longley, 1934 (sawcheek cardinalfish), *Epinephelus niveatus* Valenciennes, 1828 (snowy grouper) and *Scorpaenodes tredecimspinosus* Metzelaar, 1919 (deepreef scorpionfish) from Colombia (Bunkley-Williams and Williams, 1999). Three *Gnathia* spp. were found on the gills of lionfishes, 2 from Cabo Rojo and 1 from Rincón, occurring in 1.9% and 4.0 % of the fishes, respectively (Table 2.1). *P. volitans* is a new host record for this isopod.

Phylum Platyhelminthes

Class Cestoidea

Family Otbobthriidae

***Otobothrium dipsacum* Linton, 1897 (Figure 2.12)**

Synonyms: *Otobothrium (Pseudotobothrium) dipsacum* (Linton, 1897) Dollfus, 1942; and *O.*

(P.) insigne Linton, 1905

Otobothrium dipsacum was redescribed by Cruz-Reyes (1973). This larval cestode has an elongated body; a pair of oval lateral bothridia with undulated margins; 4 tentacle bulbs, connecting to each bothridia in pairs; proboscis short and extendable covered in small hooks with different sizes and forms forming a V (armor). *O. dipsacum* shows a worldwide distribution in tropical and subtropical waters and it is usually reported encysted in the body cavity or the mesentery of their host (Palm et al., 1994). In contrast, Williams and Bunkley-Williams, (1996), first reported this parasite in the Caribbean free in the cavities and intestines of *Coryphaena hippurus* Linnaeus, 1758 (dolphinfish) and the Atlantic sailfish (*Istiophorus albicans* Latreille, 1804), and also different stages of this cestode were found free in the stomachs of lionfish.

Other reports of this cestode are from great barracuda from Miami, Florida (*Sphyræna barracuda*) (Ward, 1954); elasmobranchs (adult cestodes), and larval forms in *Sufflamen fraenatum* Latreille, 1804 (*Balistes mitis* Bannet, 1832) (masked triggerfish), *B. polylepis* Steindachner, 1876 (finescale triggerfish), *Abalistes stellatus* Anonymus, 1798, *Caracanthus shoepfi* Walbaum, *Centropristes striata* Linnaeus, 1758 (black seabass), *Plectorhinchus nigrus* Cuvier, 1830 (*Diagramma crassipinum* Day, 1875), *Lethrinus ornatus* Valenciennes (ornate emperor), *Lutjanus doce cacanthus* Blecker, *Mycteroperca interstitialis* Poey, 1860 (*M. falcata* Poey, 1860) (yellowmouth grouper), *Pomatomus saltarix* Linnaeus, 1766 (bluefish), *Epinephelus undulosus* Quoy and Gaimard, 1824 (wavy-lined grouper), *Parastromateus niger* Bloch, 1795 (black pomfret), swordfish from Mexico Cruz-Reyes (1973); *Makaira indica* Cuvier, 1832

(black marlin) from Hawaii (Iversen and Kelley, 1974); *Cynoglossus senegalensis* Kaup, 1858 (senegalese tonguesole) and the freshwater fish *Petrocephalus bane bane* Lacepède, 1803 (bane big-eye) from the western shore of the Cross River estuary (East Nigeria) (Palm et al., 1994); *Istiophorus platypterus* Shaw, 1792 (Indo-pacific sailfish) from the east coast of Australia (Speare, 1995); *Haemulon plumieri* Lacepède, 1801 (white grunt) and spotted goatfish from Itamaracá Island and in Itapissuma, Northeast Brazil (Palm, 1997); and *L. argentimaculatus* Forsskål, 1775 (mangrove red snapper), *Pomadasys argenteus* Forsskål, 1775 (silver grunt), *Thunnus tonggol* Bleeker, 1851 (longtail tuna) and Great barracuda from the Yemen Sea (Al-Zubaidy and Mhaisen, 2011).

Six individuals were found infecting the stomach of a lionfish, occurring in 1.0% of the fishes from Cabo Rojo (Table 2.1). *P. volitans* is a new host record for *O. dipsacum* and may have established in a new location in the body of the fish (Al-Zubaidy and Mhaisen, 2011).

Order Tetracanthida

Family Tetracanthida incertae sedis

Scolex pleuronectis Müller, 1788 (tetracanthid plerocercoid) (**Figure 2.13**)

Synonyms: *Scolex polymorphus* Rudolphi, 1819 and *S. delphini* Stossich, 1898

These undeveloped tetracanthid plerocercoids, with 4 characteristic bothridia with accessory suckers and a tapering tail, are designated *Scolex pleuronectis* because they cannot be identified beyond order. *S. pleuronectis* live in the intestines of most marine fishes and

usually mature in sharks and rays. Heavy infections in the stomach and intestines of the host appear to create little damage; however, considerable numbers may block the bile duct and gall bladder (Williams and Bunkley-Williams, (1996).

S. pleuronectis has been noted from a great number of Caribbean fishes (Williams and Bunkley-Williams, unpublished data) but it also infects edible mollusks of the Northeastern Gulf of Mexico (Cake, 1972); elasmobranchs from Texas, USA (Henson, 1975); flathead grey mullet from Biscayne Bay, Florida, USA (Skinner, 1975); swordfish in the northwest Atlantic (Williams and Bunkley-Williams, 1996); and *Engraulis anchoita* Hubbs and Marini, 1935 (argentine anchovy) from Argentina and Uruguay (Timi et al., 1999). Six *S. pleuronectis* were infecting the stomach of lionfishes, 2 were found in Cabo Rojo, 1 in Lajas and 1 in Rincón, occurring in 1.9, 10.0, and 4.0 % and of the fishes, respectively (Table 2.1). *P. volitans* is a new host record for lionfish for these immature worms.

Class Monogenea

Subclass Heteronchoinea (Polyopisthocotylea)

Gastrocotylinean post-oncomiracidia Kritsky, Bullard and Bakenhaster, 2011 (Figure 2.14)

Synonyms: none

This post-oncomiracidia was placed in the Suborder Gastrocotylinea by having diagnostic anterior and posterior pairs of ventral anchors, 4 pairs of hooks along the haptoral margin and another pair of hooks near the posterolateral margin of the haptor; the posterior anchor being one

of the defining characters of the Suborder Gastrocotylinea. These minute larval monogeneans are mostly overlooked due to their size or their difficulty to identify to species (Kritsky et al., 2011). Following the description made by this author of 2 different monogenoid forms each subdivided in 2 morphotypes, my specimen matches the morphotype 1a. Morphotype 1a differs from 1b by lacking an inner spine on the base of the shaft of the posterior anchor.

This immature monogenean has been reported infecting dolphinfish, *C. equiselis* Linnaeus, 1758 (pompano dolphinfish), grey snapper, *Seriola dumerili* Risso, 1810 (greater amberjack), *Cheilopogon melanurus* Valenciennes, 1847 (Atlantic flyingfish), and *Parexocoetus hillianus* Gosse, 1851 (flyingfish) off Mississippi and Florida, Gulf of Mexico (Kritsky et al., 2011). Five specimens, 2 from Cabo Rojo and 3 from San Juan, were infecting the gills of lionfishes, occurring in 1.9% and 3.6% of the fishes, respectively (Table 2.1). This monogenean has not been previously reported from the Caribbean, thus lionfish is a new host record, and it is a new locality record for Puerto Rico and the Caribbean.

Subclass Polyonchoinea (Monopisthocotylea)

Family Ancyrocephalidae

***Pseudempleurosoma carangis* Yamaguti, 1965 (Figure 2.15)**

Synonyms: *Metadiplectanotrema carangis* Gerasev, Gaevskaja and Kovaleva, 1987

Monogeneans are considered ectoparasites of skin and gills of fish. However, some members of this genus have adapted to endoparasitic living (Mendoza-Franco and Vidal-

Martínez, 2011). *Pseudempleurosoma carangis* was first described by Yamaguti, 1968 from Hawaiian fishes. It has a subcylindrical body; opishaptor constricted for boy proper and a truncate behind; 2 pairs of dissimilar anchors and 14 marginal hooklets; arc shaped ventral bar; ventral anchors small and simple articulated by an oblique bar; head is trapezoidal with head glands on the side; 2 pairs of eye-spots; pharynx globular; esophagus wide; testis round to oval; ovary turned back on itself; eggs oval without polar filament; and vitellaria forms lobes that run along the body.

P. carangis infects black jack (*Caranx lugubris*, Poey, 1860) type host, from Hawaii (Yamaguti, 1968); *Caranx sexfasciatus* Quoy and Gaimard, 1825 (bigeye trevally), *Myripristis berndti* Jordan and Evermann, 1903 (blotcheye soldierfish) from Hawaii (Yamaguti, 1968; Santos et al., 2001); *Sphoeroides testudines* Linnaeus, 1758 (checkered puffer) along the northern coast of Yucatán, Mexico (Mendoza-Franco and Vidal-Martínez, 2011); however, there are not any reports of this monogenean from the Caribbean. Two species of *Pseudempleurosoma* described by Santos et al., (2001) and Mendoza-Franco and Vidal-Martínez, (2011) bear multiple significant similarities. It was suggested by Santos et al., (2001) that types of *P. caranxis* (Gerasev, Gaevskaja and Kovaleva, 1987) Santos, Mourão and Cardenas, 2001 should be examined due to their host- group similarity to *P. carangis*. *P. carangis* appears to have larger dorsal and ventral bars, structures connecting their hooks. This monogenean differs from *P. guanabarensis* Carvalho and Luque, 2012 in having a smaller body and a twisted male copulatory organ (Reder De Carvalho and Luque, 2012) and from *P.gibsoni* Santos, Mourão and Cardenas, 2001 in the shape and presence of muscular sheath of the cirrus, the absence of filament on the eggs and its host and geographical distribution. One individual was found in the esophagus of a lionfish, occurring in 4.0 % of the fishes from Rincón (Table 2.1). Lionfish is a

new host report, and Puerto Rico and the Caribbean are new locality records for this monogenean.

Class Trematoda

Subclass Digenea

Family Acanthocolpidae

Stephanostomum spp. Looss, 1899 (metacercaria) (**Figure 2.16**)

Synonyms: *Critovitellarium* Viguera, 1955; *Echinostephanus* Yamaguti, 1934; *Lechradena* Linton, 1910; *Monorchistephanostomum* Viguera, 1942; *Neostephanostomum* Viguera, 1955 and *Stephanochasmus* Looss, 1900

Williams and Bunkley-Williams, (1996) characterized species of the genus *Stephanostomum* Looss, 1899 based on variable numbers of rows of spines and different configurations of spines, making identification of these species complicated. Adult *S. casum* Linton, 1910 and *S. microstephanum* Manter, 1934 have been reported from the Bahamas (Sparks, 1957); and adult *S. sentum* Linton, 1910 has been reported from big game jacks from Puerto Rico and Jamaica (Williams and Bunkley-Williams, (1996). However, it was impossible to identify this metacercaria to species level based on adult characters. *Stephanostomum spp.* infect *Epinephelus morio* Valenciennes, 1828 (red grouper) from southeastern Mexico (Moravec et al., 1997); *Cichlasoma urophthalmus* Günther, 1862 (mexican mojarra) from Mexico (Salgado-Maldonado et al., 1997); and grey snapper (Argáez-García et al., 2010). Three

metacercaria were found encysted in the stomachs of lionfishes, occurring in 2.9% of the fishes from Cabo Rojo (Table 2.1). In contrast, metacercaria infecting red groupers have been reported encysted in head tissue and near the swimbladder (Moravec et al., 1997). *Stephanostomum spp.* is not a new report for Puerto Rico but lionfish is a new host record for this trematode.

Family Didimozoidae

Neotorticaecum spp. Kurochkin and Nikolaeva, 1978 (metacercaria) (**Figure 2.17**)

Synonyms: None

Neotorticaecum spp. are larval stages of members of the Family Didymozoidae characterized by having an oral sucker, pharynx and not having a Drüsenmagen; intestinal branching anterior to acetabulum, esophagus short and slender; cellular glands surrounding distal part of esophagus and anterior part of caeca; caeca chambers increase in size posteriorly. Larvae of this family have been found in fish intestines (Rodríguez-Ibarra and Pulido-Flores, 2011) and in chaetognaths (Gómez del Prado-Rosas et al., 1999; Karlsbakk, 2001) among other species. Adults have been reported from the tissues of bony fishes from the Scombridae, Exocoetidae, Serranidae and Sphyreanidae (Yamaguti, 1970; Justo et al., 2008). Based on Gómez del Prado-Rosas et al., (1999); Vidal-Martínez et al., (2002) and Cortés et al., (2009b), these parasites should have been identified as *Torticeacum sp.*, but due to a lack in identifying characters in these trematodes, we decided to agree with the description provided by Rodríguez-Ibarra and Pulido-Flores, (2011), where they state that only four characters in these parasites are not sufficient for identification.

Neotorticaecum spp. infect *Caranx hippos* Linnaeus, 1766 (crevalle jack), *Centropomus ensiferus* Poey, 1860 (swordspine snook) and *Oligoplites saurus* Bloch and Schneider, 1801 (leatherjacket) from Santa Marta, Colombia (Galeano and Romero, 1979); *Thunnus atlanticus* Lesson, 1831 (blackfin tuna), *T. albacares* Bonnaterre, 1788 (yellowfin tuna) and *T. obesus* Lowe, 1839 (bigeye tuna) from Rio de Janeiro, Brazil (Justo et al., 2008); lane snapper from Santa Marta, Colombia (Cortés et al. (2009b). Seventeen individuals were infecting the stomachs of lionfishes; occurring in 25.0% of the fishes from San Juan (Table 2.1). This fluke represents a new host report for *P. volitans* and a new locality record for Puerto Rico.

Family Hemiuridae

***Lecithochirium floridense* (Manter, 1934) Crowcroft, 1946 (Figure 2.18)**

Synonyms: *Sterrhurus floridense* Manter, 1934, *S. microcercus* Manter, 1947, *S. musculus* Looss, 1907, *S. zeloticus* (Travassos, Teixeira de Freitas and Buhrnheim, 1966) Yamaguti, 1971 and *Separogermiductus zeloticus* Travassos, Teixeira de Freitas and Buhrnheim, 1966.

L. floridense has a subterminal oral sucker; pharynx present; esophagus short; Drüsenmagen present; caeca bifurcating at middle posterior to level of pharynx; testes 2, subequal; seminal vesicle bipartite; ovary dextral, subspherical; vitellarium overlapping posterior margin of ovary, distributed in 2 groups; uterus extensive, may extend to ecsoma; and ecsoma extruded or contracted (Bullard et al., 2011). It has been reported from lionfish from North Carolina (Barse and Morris, 2006; Bullard et al., 2011); from the Atlantic side of the Isthmus of Panama (Barrat, 2011) and from Puerto Rico (Ramos et al., (2012).

L. floridense is not a new record for Puerto Rico; Siddiqui and Cable (1960) reported it as *Sterrhurus floridensis* Manter, 1934 from flounders (*Paralichthys* sp. Girard, 1858) and *L. microcercus* Manter, 1947 from trumpetfish (*Fistularia* sp. Linnaeus, 1758), and Williams and Bunkley-Williams, (1996) reported it as *S. musculus* Looss, 1907 from crevalle jack, suggesting other names as synonyms as well. This fluke was also reported by Sparks, (1957) as *S. floridensis* from the Bahamas. This trematode infects *Holocentrus ascensionis* Osbeck, 1765 (squirrelfish), *Malacanthus plumieri* Bloch, 1786 (sand tilefish), *Scorpaena plumieri* Bloch, 1789 (spotted scorpionfish) from Nassau and Eleuthera, Bahamas (Sparks, 1957); *Abudefduf saxatilis* Linnaeus, 1758 (sergent major), Caribbean Sea (Yeo and Spieler, 1980); crevalle jack from Puerto Rico (Williams and Bunkley-Williams, 1996); and Bullard et al., 2011 listed hosts from other regions. Other reports of this trematode include mexican mojarra from Mexico (Salgado-Maldonado et al., 1997); *Epinephelus guttatus* Linnaeus, 1758 (red hind), *E. striatus* Bloch, 1792 (nassau grouper), *Mycteroperca microlepis* Goode and Bean, 1879 (gag), and *M. venenosa* Linnaeus, 1758 (yellowfin grouper) and red grouper from southeastern Mexico (Moravec et al., 1997; Cribb et al., 2002); grey snapper from Yucatán, Mexico (Argáez-García et al., 2010).

A total of 1891 *L. floridense* were infecting the stomach and the intestines of *P. volitans*; 311 specimens from Rincón (occurring in 80.0 % of the fishes), 19 from Mayagüez (occurring in 25.0 % of the fishes), 24 from Lajas (occurring in 70.0% of the fishes); 1488 from Cabo Rojo (occurring in 88.5 % of the fishes); and 49 from San Juan (occurring in 64.3 % of the fishes). *L. floridense* was found in 5 of the 8 municipalities, fishes from Juana Díaz, Aguada and Aguadilla were not infected (Table 2.1). *L. floridense* is not a new record for either Puerto Rico or *P. volitans*.

Phylum Annelida

Order Hirudinea

Family Piscicolidae

Trachelobdella lubrica Grube, 1840 (Figure 2.19)

Syn. *Pontobdella lubrica* Grube, 1840 and *Trachelobdella muelleri* Diesing, 1850

This leech is found worldwide (Williams et al., 1996) parasitizing the gills and skin of several species of fishes. In Puerto Rico, *T. lubrica* has been reported from ocean surgeon, western Atlantic seabream, *Cantherhines macrocerus* Hollard, 1853 (american whitespotted filefish), red hind, nassau grouper, white margate, *H. flavolineatum* Desmarest, 1823 (french grunt), bluestriped grunt, hogfish, cubera snapper, spotted scorpionfish (Williams, 1982); bicolor damselfish and *Elops saurus* Linnaeus, 1766 (ladyfish) (Williams et al., 1994), grey snapper and dog snapper (Bosques-Rodriguez, 2004); and whitemouth croaker from Puerto Rico (Hernández-Vale, 2011). Other reports include lionfish from the Red Sea (Paperna, 1976); *Oplegnathus punctatus* Temminck and Schlegel, 1844 (spotted knifejaw) from Iriomote Island, Japan (Williams et al., 1994); and snappers (Lutjanidae) and groupers (Serranidae) from the Gulf of Mexico (Bullard et al., (2011). In Florida, Ruiz-Carus et al. (2006) found a specimen identified as *Myzobdella lugubris* Leidy, 1851 parasitizing the middle portion of the tongue of a lionfish. However, this organism was misidentified. Bullard et al., (2011) revised the description of this leech and determined that the parasite collected was *T. lubrica*. Williams, (1982) reported this leech infecting erratically several species of fishes in the southwestern Puerto Rico but it commonly occurs on the gills of hogfish. Only 1 specimen of this leech was found infecting the

gills of a lionfish, occurring in 4.2% of the fishes from Rincón (Table 2.1). *T. lubrica* is not a new report for either Puerto Rico or lionfish.

2.3.1.2 Statistical analysis

The first multidimensional scaling tests (MDS) results show most of the year samples were clustered on one, and 2 samples, 1 from 2009 and 1 from 2012 were outliers (Figure 2.20). On the second MDS, a slight difference in the communities was observed, being 2012 samples farther away from the rest with 3 samples being outliers (Figure 2.21). Results from the ANOSIM (analysis of similarity) showed that most years were not significantly different, whereas pairwise year comparisons between 2010-2012 and 2011-2012 significantly different (Table 2.4). To determine which species contributed most to year differences similarity percent test (SIMPER) was performed. Results showed that dissimilarity percentages ranged from (29.93% - 50.96 %), indicating that the highest differences between samples are mostly due to the high abundances of *L. floridense* (Table 2.4). This hemiurid contributed with dissimilarity percentages ranging from 36.63% (comparing 2009 and 2012) to 48.33% (comparing 2011 and 2012). *Neotorticaecum spp.* was only observed during 2012, contributing with a 22.53%, a 20.35% and 23.20% of dissimilarity when compared to 2009, 2010 and 2011, respectively.

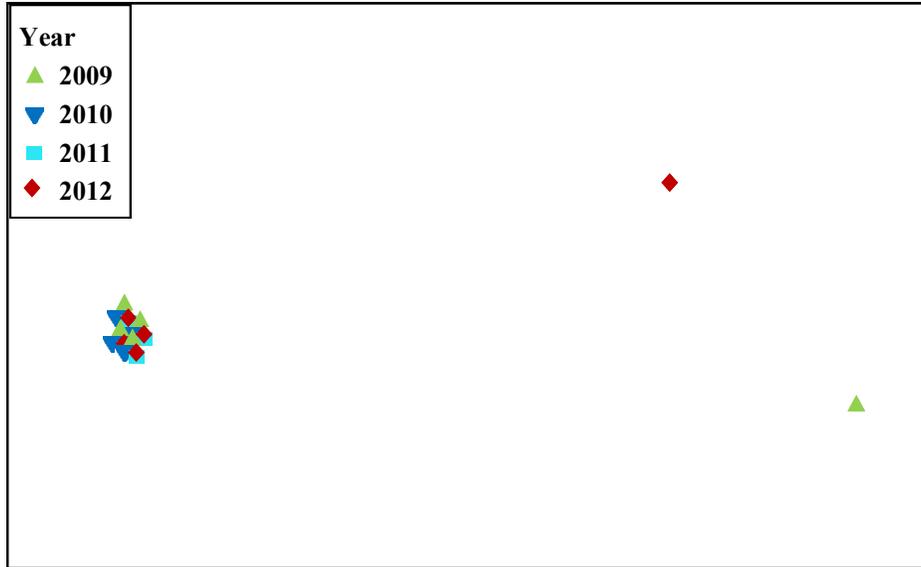


Figure 2.20. Initial multidimensional scaling (DMS) representation of parasite communities from Puerto Rico between 2009-2012. Notice outliers from 2009 and 2012.

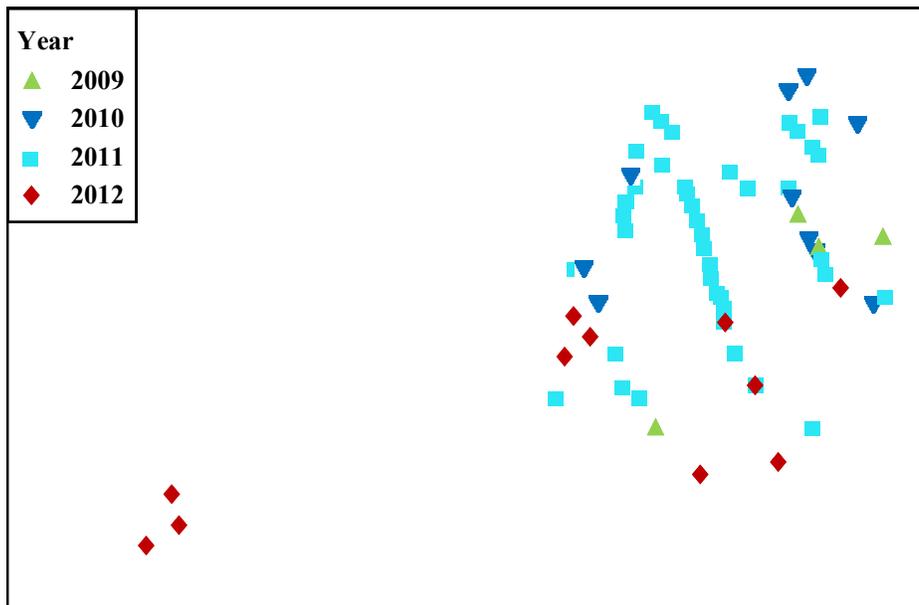


Figure 2.21. Expansion of multidimensional scaling (DMS) of parasite communities from Puerto Rico between 2009-2012. Notice slight differences between years and 3 outliers from 2012.

2.3.2 Cayman Island

Ninety-one infected *P. volitans* (total lengths = 6.8 - 34.7) collected from Little Cayman, Cayman Islands were examined and one or more parasites of 10 species were infecting 29 out of 91 (31.9 %) of the fishes. Most of the organisms collected were the digenean *L. floridense* (occurring in 17.6 % of the fishes with a mean intensity of 2.1 ind/fish) followed by *Scolex pleuronectis* and *Udonella caligorum* (Table 2.2). Other parasites recovered include 3 digeneans, 2 nematodes and 2 isopods species.

Phylum Nematoda

Order Ascaridida

Family Anisakidae

Raphidascaris spp. Railliet and Henry, 1915 (Figure 2.5)

Three *Raphidascaris spp.* were found infecting the stomachs of lionfishes, occurring in 2.2% of the fishes (Table 2.2). This nematode is a new report for Cayman Islands and lionfish.

Family Camallanidae

Spirocamallanus sp. Olsen, 1952 (Figure 2.22)

Two nematode larvae were found infecting the stomach of lionfishes, but due to the lack of adult characteristics it was not identified to species. *Spirocamallanus spp.* occurred in 2.2 % of the fish (Table 2.2) and it is a new report for Cayman Islands and for this fish.

Phylum Artropoda

Order Isopoda

Family Aegidae

***Aegiochus tenuipes* (Schioedte and Meinert, 1879) (Figure 2.23)**

Synonyms: *Aega tenuipes* Schioedte and Meinert, 1879

Isopods from the family Aegidae are opportunistic feeders that only attach to the host long enough to feed, and show low or no host specificity. *Aegiochus tenuipes* differs from *A. dentata* (Schioedte and Meinert, 1879) in their pleotelson margin form, the former having a crenulate margin and the latter a distinctive dentation (Kensley and Schotte, 1989). Monod, (1969) reported this isopod from a warsaw grouper and a northern red snapper from French Guiana, however there is some disagreement about the distribution of the snapper, but it probably does not occur in French Guiana. Thus, Monod probably examined a similar appearing *Lutjanus sp.* He also redescribed and refigured this isopod. Bruce (2009) apparently transferred this isopod species to *Aegiochus* Bovallius, 1885, although this is not stated in his paper. He suggested that it needed redescription, apparently unaware of Monod's redescription, since he did not cite Monod, (1969). Only 1 specimen of this isopod was found on the skin of a lionfish,

occurring in 1.1% of the fishes (Table 2.2). This isopod is a new record for the Cayman Islands and *P. volitans* is a new host record for this species.

Family Janiridae

Carpias serricaudus (Menzies and Glynn, 1968) Bowman and Morris, 1979 (**Figure 2.24**)

Synonyms: *Bagatus serricaudus* Menzies and Glynn, 1968

This isopod is distinguishable by their serrated pleotelson, 3 toothed carpus and short uropoda (Menzies and Glynn, 1968). It has been reported from coral rubble from Boca Cangrejos, San Juan, Puerto Rico (Menzies and Glynn, 1968), at Cahuita Reef, Costa Rica (Breedy and Murillo, 1995) and from Andros Island Bahamas (Boyko and Williams, 2004) from reef areas; however it has not been previously reported associated with a fish or at the Cayman Islands. Monod, (1961) described *Carpias ichthyoxenos* from a *Fowlerichthys senegalensis* Cadenat, 1959 (senegalese frogfish) off Senegal. One individual ectoparasite was found on a single lionfish, occurring in 1.1% of the fishes (Table 2.2). *P. volitans* is a new host record and the Cayman Island a new locality report for this isopod.

Phylum Platyhelminthes

Class Cestoidea

Family Tetraphyllidea incertae sedis

***Scolex pleuronectis* Müller, 1788 (tetraphyllid plerocercoid) (Figure 2.13)**

Forty-one tapeworm plerocercoids were found in the stomachs of infected lionfishes, occurring in 4.4 % of the fishes (Table 2.10). *P. volitans* is a new host record; and the Bahamas and the subtropical western Atlantic are new locality records for these immature larvae.

Class Monogenea

Order Gyrodactylidae

Family Udonellidae

***Udonella caligorum* Johnston, 1835 (Figure 2.25)**

Synonyms: *Nitzchia papillosa* Linton, 1898; *Lintonia papillosa* (Linton, 1898) Monticelli, 1904; *Calinella myliobati* Guberlet, 1936; and *Udonella sociales* Linton, 1910.

This ecto-hyperparasitic monogenean attaches to crustacean parasites, usually copepods, which, are attached in the gills or on the bodies of fish. *Udonella caligorum* has been reported from caligid copepods as summarized by Williams and Bunkley-Williams, (1996); argulids copepods (Rohde, 2005), and rarely, from gill tissue of the fish host (Hendrix, 1994). This monogenean has a wide distribution, including the Atlantic and Pacific coasts of North and South America, Australia, New Zealand and Europe (Hendrix, 1994).

In the Caribbean, this monogenean has been reported the copepod *Brachiella thynni* Cuvier, 1830 in an *Acanthocybium solandri* Cuvier, 1832 (wahoo); and the caligids *Euryphorus*

brachypterus Gerstaecker, 1853 in Yellowfin Tuna; and *Caligus bonito* Wilson B. C., 1905 in a snapper from La Parguera, Lajas, Puerto Rico (Williams and Bunkley-Williams, 1996). Other reports include *Gadus morhua* Linton, 1758 (Atlantic cod) from Woods Hole, USA; *Cyclopterus lumpus* Linnaeus, 1758 (lumpfish) and *Euthynnus alleteratus* Rafinesque, 1810 (little tunny) from Chesapeake Bay (Zwerner and Lawler, 1972, in Hendrix, 1994); the caligid *Caligus praetextus* Bere, 1936 in mouth and skin of *Sciaenops ocellatus* Linnaeus, 1766 (red drum) in the Mississippi Sound, Texas, USA (Overstreet, 1983); and little tunny from Chesapeake Bay, USA (Williams and Bunkley-Williams, 1996).

There were 8 other lionfish in the Cayman Islands that were infected by this worm, but infection was most likely incidental as these fish were sharing a holding tank with an individual *Holocentrus rufus* (longspine squirrelfish) that was heavily infected with the same worm (the squirrelfish host had over 3800 *U. caligorum*). A total of 36 individuals were found in the skin of lionfishes. Only 22 *U. caligorum* (occurring in 3.3% of the fishes) are taken in consideration since these were examined without any contact with other infected fishes (Table 2.2). This is a new host report for lionfish and a new locality report for the Cayman Islands.

Class Trematoda

Subclass Digenea

Family Bivesiculidae

***Bivesicula caribbensis* Cable and Nahhas, 1962 (Figure 2.26)**

Synonym: none

Although, *Bivesicula caribbensis* has only been reported from species of squirrelfish in the Caribbean Sea, their cercariae have only been found in Curacao and their definitive host can be found in Puerto Rico and Jamaica (Cable, 1963), there are no reports of this worm from Puerto Rico. Specimens follow the description offered by Cable and Nahhas, (1962): body oval; suckers absent; cirrus sac ovoid; testis single, entire and ovoid; vitelline follicles in lateral groups from esophageal level to end of caeca. *B. caribbensis* infects blackbar soldierfish from Curacao and Jamaica (Cable and Nahhas, 1962; Cable, 1963) and squirrelfish from Drowned Cays, Belize (Fischthal, 1977). Only 1 *B. caribbensis* was found in a lionfish, occurring in 1.1 % of the fishes (Table 2.2), and becoming a new report for Cayman Islands. Lionfish is a new host record for this fluke.

Family Didimozoidae

Neotorticaecum spp. Kurochkin and Nikolaeva, 1978 (metacercaria) (Figure 2.18)

Larvae from Cayman Islands and the Bahamas were either found in the stomach or the skin; however specimens found in Puerto Rico were found in the stomach. Two metacercaria were found on the skin of a Lionfish, occurring in 2.2 % of the fishes (Table 2.2).

Neotorticaecum spp. is a new report for both Cayman Islands and lionfish.

Family Hemiuridae

Lecithochirium floridense (Manter, 1934) Crowcroft, 1946 (**Figure 2.18**)

Thirty-four individuals were found in the stomachs and intestines of lionfishes, occurring in 17.6 % of the fishes with a mean intensity of 1.9 ind/fish (Table 2.2). *L. floridense* is a new report for Cayman Islands.

***Helicometrina nimia* Linton, 1910 (Figure 2.27)**

Synonyms: *Helicometrina hexorchis* Gupta and Sehgal, 1970; *H. orientalis* Srivastava, 1936; and

H. septorchis Srivastava, 1936

This trematode has been reported from 14 different fish hosts in Florida (Manter, 1940); from Bahamas from 5 fish species (Sparks, 1957) and from Puerto Rico from the striped drum (*Umbrina broussoneti* Cuvier, 1830) (Williams and Bunkley-Williams, 1996); however it has not been previously reported from the Cayman Islands. *Helicometrina nimia* has an oval body with a subterminal oral sucker; ventral sucker bigger than oral sucker; globular pharynx; esophagus slender but long; 9 -13 circular testes arranged symmetrically in two rows; small ovary; and eggs small and oval with a long filament (Vidal-Martínez et al., 2002). This worm differs from *H. parva* Manter, 1933 by having 9 testes rather than 5 (Sparks, 1957).

Some of the fish hosts for *H. nimia* in the Caribbean include saucereye porgy, mutton snapper, *Cephalopholis fulva* Linnaeus, 1758 (coney), spotted scorpionfish, and sand tilefish from the Bahamas (Sparks, 1957); dog snapper from Jamaica (Nahhas and Cable, 1964); lane snapper, *Conodon nobilis* Linnaeus, 1758 (barred grunt), striped drum from Puerto Rico (Bunkley-Williams et al., 1996); and *Halichoeres bivittatus* Bloch, 1791 (slippery dick) from La Parguera, Lajas, Puerto Rico (Dyer et al., 1998). Other reports include *Paralabrax nebulifer*

Girard, 1854 (barred sand bass) from Cerros Islands Mexico (Pacific) (Manter, 1940); mutton snapper, and *L. apodus* Walbaum, 1792 (schoolmaster snapper) from the Barrier Reef and Reef Lagoon, Belize (Fischthal, 1977); grey snapper from the Yucatán, Mexico; dolphinfish from the Pacific (Williams and Bunkley-Williams, 1996); mexican mojarra from Mexico (Salgado-Maldonado et al., 1997); and grey snapper from the Yucatán, Mexico (Argáez-García et al., 2010). Two individuals were found infecting the stomach and intestines of lionfishes, occurring in 2.2 % of the fishes with a mean intensity of 1.0 ind/fish (Table 2.2). This represents a new host record for lionfish and a new locality record for Cayman Islands.

2.3.2 Bahamas Islands

Infected *P. volitans* collected from Lee Stocking Island, Bahamas were examined and one or two parasites of 9 species were recovered from 21 out of 47 (44.7%) fishes. Most of the organisms collected were the digenean metacercaria *Neotroticaecum spp.*, occurring in 19.2 % of the fishes with a mean intensity of 3.2 ind/fish (Table 2.3). Other parasites recovered include 2 digeneans, 2 nematodes, 3 isopods and 1 cestode species.

Phylum Nematoda

Order Ascaridida

Family Anisakidae

***Goezia sp.* Zeder, 1800 (Figure 2.28)**

Synonyms: none

Deardorff and Overstreet, (1980) described *Goezia pelagia* Deardorff and Overstreet, 1980 from *Rachycentron canadum* Linnaeus, 1766 (cobia) and *Chaetodipterus faber* Broussonet, 1782 (Atlantic spadefish) from the Gulf of Mexico; and Williams and Bunkley-Williams, (1996) isolated *G. pelagia* from cobia from Alabama, Mississippi and Louisiana, USA; however this genus has been found in brackish water (Moravec et al., 1995; Arthur and Ahmed, 2002) and freshwater (Martins and Yoshitoshi, 2003). Other reports of this nematode include frigate tuna off Rio de Janeiro, Brazil (Dias-Mogrovejo et al., 2004); and *Ariopsis assimilis* Günther, 1864 (mayan sea catfish) and leatherjacket from Chetumal Bay, Mexico (Aguirre-Macedo et. al, 2007). This species is characterized by the spines covering most of the body, conspicuous lips, and a conical tail with a finger-like projection at the end (Williams and Bunkley-Williams, 1996). Details of the caudal papillae of specimens of this genus are used to identify to species, *G. pelagia* having 12 to 19 pre-anal, 2 para-anal and 4 post-anal pairs of papillae (Deardorff and Overstreet, 1980).

G. pelagia is extremely damaging to fish hosts, and has a limited geographical range, probably has little host preference, and it may be used as a biological tag (Williams and Bunkley-Williams, 1996). One *Goezia sp.* was found infecting a lionfish, occurring in 2.1% of the fishes with a mean intensity of 1.0 id/fish (Table 2.3). This is the first report of this nematode in the Bahamas and in the subtropical western Atlantic region, and *P. volitans* is a new host record for this worm.

***Raphidascaris spp.* Railliet and Henry, 1915 (Figure 2.5)**

Only 1 nematode was found infecting the stomach of a lionfish, occurring in 2.1% of the fishes with a mean intensity of 1.0 ind/fish (Table 2.3). This nematode is a new report for the Bahamas and the subtropical western Atlantic, and lionfish is a new host record for this nematode.

Phylum Artropoda

Order Isopoda

Family Cirolanidae

***Eurydice convexa* Richardson, 1900 (Figure 2.29)**

Synonyms: none

This isopod was first collected from Florida (Schotte et al., 1995). Ocaña et al., 2009 reported it from Cuba noting that it is an abundant species in the wave breaking areas. This author reported this species preying on the bivalve *Donax striatus* Linnaeus, 1767 and on a species of polychaete that share the same habitat. *E. personata* Kensley, 1987 is very similar and often mistaken by *E. convexa*; however they differ in the lanceolate frontal, the form of the pleotelson apex and the size of the pleotelson spines (Kensley and Schotte, 1987). Although this isopod has been reported from Puerto Rico (Moreira, 1972), it was not found in the samples. Other reports from the Caribbean place *E. convexa* in Puerto Rico (Moore, 1902 in Moreira,

1972); Bahamas and the Caribbean (Kensley and Schotte, 1989). Outside the Caribbean range, this isopod has been found in Georgia, Florida and Brazil (Moreira, 1972); South Carolina to Florida Keys, and Gulf of Mexico (Kensley and Schotte, 1989). One individual was found infecting a lionfish from the Bahamas, occurring in 2.1 % of the fishes with a mean intensity of 1.0 ind/fish. This not a new report for the Bahamas, but it is a new host report for lionfish (Table 2.3). This is also the first report of this organism associated with a fish.

Family Corallanidae

***Excorallana quadricornis* (Hansen, 1890) (Figure 2.30)**

Synonyms: *Corallana quadricornis* Hansen, 1890

Excorallana quadricornis is easily recognizable for having well separated eyes and 2 pairs of tubercles protruding from the cephalon, the anterior pair close together connected by a rounded ridge and the posterior pair is situated between the eyes (Richardson, 1905; Kensley and Schotte, 1989). Menzies and Glynn, (1968) reported this isopod from the West Indies and suggested it might be expected to occur in Puerto Rico as well. Eckert, (1988) reported *E. antillensis* Hansen, 1890 on *Dermochelys coriacea* Vandelli, 1761 (leatherback sea turtles) at Sandy Point, St. Croix. Recently, Poole, (2011) reported *Excorallana sp.* Stebbing, 1904 from Bonaire, Dutch Caribbean; and Anonymous, (2013) reported *E. antillensis* on nassau grouper in the Cayman Islands. Other reports from the Caribbean include intertidal in grass flats and between mangrove roots, Jamaica; Martinique; Belize; Venezuela (Kensley and Schotte, 1989); *Schizoporella errata* Waters, 1878 (bryozoan) from Bermuda; St. Thomas, U.S Virgin Islands

(Richardson, 1905; Kensley and Schotte, 1989); and Cuba (Barro et al., 2013). Outside the Caribbean range, this species have been found in Crystal River, Florida (Anonymous, 1985); *Chelonia mydas* Linnaeus, 1758 (green turtle) from Aves Island, Venezuela (Delaney, 1989); *S. errata* from Ubatuba and São Sebastião, southwestern Brazil (Morgado and Tanaka, 2001); and Turpialito from Venezuela (USNM 205743). Geographical distribution of *E. quadricornis* includes the Western Atlantic, Caribbean Sea and Brazil (Richardson, 1905; Menzies and Glynn, 1968; Delaney, 1984; Kensley and Schotte, 1989; Morgado and Tanaka, 2001; Barro et al., 2013). One *E. quadricornis* was found infecting a lionfish, occurring in 2.1% of the fishes from the Bahamas with a mean intensity of 1.0 id/fish (Table 2.3). This is the first record of this isopod associated with a fish. *P. volitans* is a new host record and the Bahamas a new locality report for this isopod.

Family Gnathiidae

***Gnathia* spp. (Figure 2.11)**

Only 1 praniza larva was found infecting a lionfish, occurring in 2.1% of the fishes with a mean intensity of 1.0 id/ fish (Table 2.3). Lionfish is a new host record for this isopod.

Phylum Platyhelminthes

Class Cestoidea

Order Tetraphyllidea

Family Tetrphyllidea incertae sedis

Scolex pleuronectis Müller, 1788 (tetrphyllid plerocercoid) (Figure 2.13)

Eight individuals were found in the stomachs of lionfishes, occurring in 6.4 % of the fishes with a 2.7 ind/fish (Table 2.3). This plerocercoid is a new report for lionfish.

Subclass Digenea

Family Didimozoidae

Neotorticaecum spp. (metacercaria) León-Régagnon, Pérez-Ponce de León and Lamothe-Argumedo, 1997 (Figure 2.17)

Thirty-one metacercarias were infecting the skin of lionfishes, occurring in 19.2% of the fishes with a mean intensity of 3.4 ind/fish (Table 2.3). This digenean was the most abundant parasite infecting lionfishes from the Bahamas. *Neotorticaecum spp.* is a new report for the Bahamas and *P. volitans* is a new host record for these metacercarias.

Family Hemiuridae

Lecithochirium floridense (Manter, 1934) Crowcroft, 1946 (Figure 2.18)

This fluke was reported by Sparks, (1957) as *Sterrhurus floridensis* Manter, 1934 from the Bahamas. *L. floridense* was the second most abundant parasite infecting lionfishes in this

location. Six worms were found in the stomach of lionfishes, occurring in 10.4% of the fishes with a mean intensity of 1.2 ind/fish (Table 3.2). Lionfish is not a new host for this digenean.

Family Opecoelidae

Pachycreadium crassigulum (Linton, 1910) Manter, 1954 (Figure 2.31)

Synonyms: *Lebouria crassigula* Linton, 1910; and *Plagiopurus crassigulus* (Linton, 1910) Price, 1934

Pachycreadium Manter, 1954 species have similarities with the digeneans *Pycnadenoides pagrosomi* Yamaguti, 1938 and *P. calami* Manter, 1947; and only differs from the genus *Pycnadena* Linton, 1910 in the arrangement of their testes. Siddiqi and Cable, (1960) disagree with the description made by Linton (1910) regarding the distribution of the vitelline follicles, the presence of an oral ring and the position of the genital pore. The specimen found agrees with Siddiqi and Cable, (1960) having vitelline follicles distributed from the posterior part of the body to pharynx level, noticeable muscles across the ventral sucker, genital pore next to pharynx, 2 symmetrical testes and a round ovary posterior to the acetabulum.

P. crassigulum has only been reported from the Caribbean, in saucereye porgy from Cabo Rojo, Puerto Rico (Siddiqi and Cable, 1960); and *Calamus bajonado* Bloch and Schneider, 1801 (jolthead porgy) from Belize (Fischthal, 1977). One individual infected a lionfish, occurring in 2.1% of the fishes with a mean intensity of 1.0 id/fish (Table 2.3). This trematode is a new report for the Bahamas and *P. volitans* is a new host report for this species.

2.4 DISCUSSION

Pterois volitans is a highly popular aquarium fish because of the display of colors and long fins. Their introduction into the Atlantic Ocean remains unknown; however there are speculations about how this event occurred. In 1992, a private aquarium in Biscayne Bay, Florida was destroyed during hurricane Andrew and several lionfishes were released (Courtenay, 1995). Other speculation is various events of lionfish introductions; however mitochondrial data shows no evidence of multiple introductions and also shows that these expanded from the epicenter (Florida). This is also consistent with the reported sightings of this fish (Betancour-R et al., 2010). There is general agreement that lionfish in the Atlantic are unlikely to be extirpated and represent a significant source of perturbation of western tropical and subtropical reef communities (e.g., Albins and Hixon, 2008, Barbour et al., 2011). There is also general agreement that neither predation by Atlantic piscivorous fishes (Hackerott et al., 2013) nor removal by humans is likely to represent significant sources of population control in the immediate future. The latter is due in part to the fact that *P. volitans* occurs well below scuba depths (300 m; e.g., Albins and Hixon, 2011; Barbour et al., 2011). Although the lionfish invasion is regrettable, it provides an exceptional opportunity to understand the ecology of host-parasite interactions in general, and the role of parasites in species invasions in particular, and infections by parasitic organisms remain a possible source of biotic resistance to the lionfish invasion (Tables 2.1 - 2.3).

In terms of parasitological significance, we report the second species of an *Asollota* isopod (Monod, 1961) to associate with a fish. This further supports their ability to associate with these, possibly temporary hosts. We also note 2 organisms that have not previously been reported to associate with fishes, 24 new host records for *P. volitans*, 6 new locality records for

the Caribbean, 4 new locality records for the subtropical western Atlantic region, 6 for the Bahamas, 10 for the Cayman Islands, and 5 for Puerto Rico. Before our paper, only 5 species of parasites were known for *P. volitans* in the Atlantic. We report 26 parasites infecting lionfish and an unknown parasitic species from Puerto Rico, the Cayman Islands and the Bahamas.

The parasite fauna of *P. volitans* in our 3 localities were quite different, most of the species infecting lionfish being generalists and/or species that infect carnivorous fishes. When comparing the number of species found in common among the three island localities; lionfish from the Cayman Islands only had 4 species in common with those of Puerto Rico; and lionfish from the Bahamas had 5 species in common with Puerto Rican lionfish (Tables II, III). This suggests that a variety of opportunistic parasites are infecting lionfish. This also means that many localities must be studied in the future to adequately assess the development of the parasitic fauna in *P. volitans* in the Atlantic.

Kennedy and Bush, (1994) observed a change in spatial and temporal differences in the parasitic population composition of the introduced species *Oncorhynchus mykiss* (rainbow trout) around the world. Evolving in a restricted and known geographical area, the rainbow trout has been introduced to eastern North America, South America, New Zealand, Europe and different parts of Asia either via eggs and/or fry, free of parasites. These authors found that the proportion of specialist parasites in rainbow trout decline with increasing distance from the native range and these specialists are in turn replaced by generalists. Generalist parasites infecting this fish were acquired by neighboring species, usually not phylogenetically related. In our case, lionfish was first reported from Florida, North and South Carolina and Georgia (Hare and Whitfield, 2003; Whitfield et al., 2002). Although *Lecithochirium floridense* is not a specialist species, Bullard et al. (2011) observed a prevalence of 100% of this hemiurid in the 22 lionfish they sampled from

North Carolina, USA. However, we found prevalences of *L. floridense* to be 74.5% in Puerto Rico (N= #), 17.6 % in the Cayman Islands (N= 91) and 8.5 % in the Bahamas (N= 47). Our lower prevalences could be due to differences in sampling effort, differences in local abundance of the parasite, and/or competition among a more diverse community of intestinal parasites in Puerto Rico, the Cayman Islands, and the Bahamas, as compared to those of North Carolina. *L. floridense* infects both scorpaenid fishes as well as unrelated fish in the Caribbean (Williams and Bunkley-Williams, 1996; Bullard et al., 2011), and it was found in all 3 study localities mostly with the higher intensities. However, we also found other generalist species (e.g. *Gnathia sp.*) infecting *P. volitans*.

To make more ecologically relevant comparisons of parasite communities infecting lionfish across their invasion gradient, we must also investigate the parasite communities of ecologically similar, native fishes. This will give us insight into the availability of parasites at different localities and how the intensity of parasite infestation might compare between lionfish and native reef carnivores. Furthermore, we know very little about the parasites infecting lionfish in their native Indo-Pacific region: only 2 digeneans (Nagaty and Aal, 1962; Hassanine, 2006), 2 monogenoids (Paperna, 1972; Ogawa et al., 1995), 1 leech (Paperna, 1976), and 1 copepod (Dojiri and Ho, 1988) have been documented. A more comprehensive study of lionfish parasites in the Indo-Pacific will not only reveal to what degree lionfish are susceptible to parasitism, but also whether lionfish have introduced any parasites to the Atlantic region.

We report 2 species of parasites with high prevalence among lionfish at all sites: *L. floridense* and *Neotorticaecum spp.* The cestode *Scolex pleuronectis* was also common, occurring in 6.4% of individuals from the Bahamas, 4.4 % from the Cayman Islands, and at an average of 2.1 % from Puerto Rico. In great quantities, this cestode blocks the bile duct or the

gall bladder of its host (Williams and Bunkley-Williams, 1996). This parasite has been associated with the death of *Epinephalus guttatus* (red hinds) held in cages in Puerto Rico, where the fish were fed a diet of raw fish scraps. A similar problem was reported in cage-cultured fishes in the northern Gulf of Mexico, this cestode having intensities ranging from 1-9000 individuals (Williams and Bunkley-Williams, 1996). The voracious appetite of *P. volitans* may similarly result in high accumulation of this parasite. However, we have only seen intensities ranging from 1-38, thus far (Tables II, III), much lower than the intensities reported by Williams and Bunkley-Williams (1996). *Udonella caligorum* also had a fairly high prevalence of 3.3 % in the Cayman Islands and an intensity ranging from 1-19 (Table III). Several other lionfish were highly contaminated with this monogenean, but this was a result of sharing a holding tank with a native squirrelfish superinfected with *U. caligorum* (>3800 parasites on the squirrelfish). This suggests that this worm has the capacity to switch hosts and adapt to a new environment in a short period of time. This worm is a commensal of crustacean parasites of fishes and a parasite of fishes. It is known to damage cultured fishes and facilitates *Trichodina spp.* (Protozoa) infections (e.g., Freeman and Ogawa, 2010). The other parasites we report occurred rarely and thus would appear to have limited potential to regulate *P. volitans* populations at our study localities at this time. However, some of these may become more influential in the future and/or may be influential at other sites in the invaded range. High parasite infections can regulate fish populations by delaying growth and affecting reproductive performance (Barber et al., 2000; Schultz et al., 2006; Ravichandran et al., 2009). In their native range, lionfish have an average length of $15.5\text{cm} \pm 6.2\text{cm}$ (Darling et al., 2011); however, in their invaded range, lionfish have reached $\pm 45\text{cm}$ long (Whitfield, et al., 2007). High population densities and bigger body size are responsible for damage by introduced species (Torchin et al., 2003), body size being favored

by the lack of overfishing or low predation in the invaded range (Guichón et al., 2003). Possibly in the future these parasites may impact lionfish fitness.

Puerto Rico sample analysis of similarity (ANOSIM) indicated that only comparisons between 2010-2012 and 2011-2012 were significantly different (Table IV). Similarity percent (SIMPER) results indicated that the highest differences between samples are due to the high abundances of *L. floridense*. One weakness of this test is that it is based on the species with the highest abundances (Clarke, 1993), in this case, *L. floridense*. Thus, the difference in years is mostly due to the fluctuations in abundances of this hemiurid. We can suggest that excluding 2012, our communities from 2009-2011 are similar in composition, *L. floridense*, consistently being in the samples every year. Significant values from 2012 are possibly due to a small sample size (20 fish).

Although our study only showed intensities of parasites of lionfish and new reports for these species and their localities, it did not assess the impact of parasites on the fitness of invasive lionfish. Even though, it provides an important early step. Monitoring the development of parasite infestations in this host should continue throughout its range and over time.

2.5 CONCLUSIONS AND FUTURE WORK

1. A total of 26 parasitic species from Puerto Rico, Cayman Islands and the Bahamas are reported. Of these, 17/26 species were found in Puerto Rico, 10/26 in the Cayman Islands and 9/26 in the Bahamas.
2. Lionfish mostly harbored local parasite species in each of the localities. Most species were opportunistic.

3. So far, lionfishes harbor a higher number of parasites in the Atlantic than the Indo-Pacific. This is due to the lack of comprehensive studies of lionfish in its native range.
4. No parasite species were brought from the Indo-Pacific.
5. Initial MDS did not show a clear pattern of population communities of parasites from 2009-2012. Subsequent MDS showed a slight difference between yearly communities but analysis of similarity (ANOSIM) results indicates that parasitic communities are similar.
6. SIMPER results show that dissimilarities are due to fluctuations in abundances of *L. floridense*.
7. Hopefully, developing fauna and future work can show the impact of parasites on lionfish fitness.

Future works should include more intensive and extensive research on parasitic species harbored by lionfish. These should include Cuba, Dominican Republic-Haití, and other non-studied areas of the Gulf of Mexico where this destructive fish is present. Also, Indo-Pacific lionfish parasite fauna should be studied and compared to Atlantic. As a long-term research, the effects of parasite infections in lionfish behavior, reproduction and growth rates through time should also be studied.

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TABLES

Table 1.1. Parasites previously reported from lionfish in the Atlantic Ocean and Caribbean Sea.

Citation	B	C	Di	D	I	Co	L	Mc	M	N	T	U
Barse and Morris, (2006) □	+	+		+ ¹				+		+		
Ruiz-Carus, et al., (2006) □							+					
Barrat, (2011) □				+ ¹				+				
Bullard et al., (2011) □				+ ¹			+					
Poole, (2011) □							+ ²					
Ramos et al., (2012) □				+ ¹	+	+	+	+	+	+		
Barrat, (2013) □				+	+					+	+	
This Thesis		+	+	+ ¹	+	+	+	+	+	+		+

B= branchiuran (*Argulus* sp.), C= cestode, Di= didymozoan, D= digenean, I= isopod, Co = copepod, L= leech (*Trachelobdella lubrica*), Mc= metacercaria, M= monogenean, N = nematode, T= turbellarian, U= udonellid. ¹*Lecithochirium floridense*, ²*Excorallana* sp.

Table 1.2. Atlantic localities in which lionfish have been examined for parasites.

Locality	Citation(s)
Anguilla	Sarkis, 2013 □
Bahamas	This thesis
Belize	Barrat, 2013; Simmons et al., 2013 □
Bermuda	Simmons et al., 2013 □
Bimini	Simmons et al., 2013 □
Bonaire	Poole, 2011; Simmons et al., 2013 □
Cayman Islands	This thesis
Florida	Ruiz-Carus et al. 2006; Barrat, 2013; Simmons et al., 2013 □
Florida Straits	Simmons et al., 2013 □
Jamaica	Simmons et al., 2013 □
Louisiana	Simmons et al., 2013 □
Mexico	Barrat, 2013 □
North Carolina	Barse and Morris, 2006; Bullard et al., 2011; Simmons et al., 2013 □

Panama Barrat, 2013 □

Puerto Rico This thesis

St. Eustacia Sarkis, 2013 □

Turks and Caicos Simmons et al., 2013 □

Table 2.1. Locality, number of infected fish (I.F.), prevalence (P %), average intensity (A.I.) and range of parasitic species found in *Pterois volitans* from Puerto Rico with comparisons between municipalities. Rincón, N= 25; Mayaguez, N= 12; Lajas, N=10; Cabo Rojo, N=104; and San Juan, N= 28. (N= total number of hosts examined)

Parasite species	Locality	I. F.	P %	A. I.	Range
Acanthocephala					
<i>Cavisoma chromitidis</i>	SJ	1	3.6	1.0	1
Nematoda					
<i>Anisakis simplex</i>	RN	7	28.0	2.0	1-5
	LJ	1	10.0	1.0	1
	CR	13	12.5	1.1	1-2
	SJ	1	3.6	1.0	1
<i>Raphidascaris sp.</i>	RN	1	4.0	1.0	1
	CR	3	2.9	1.0	1
<i>Spirocamallanus partitus</i>	CR	1	1.0	1.0	1
<i>Spirocamallanus spinicaudatus</i>	RN	1	4.0	1.0	1
	CR	1	1.0	1.0	1
<i>Capillaria sp.</i>	SJ	1	3.6	1.0	1
Isopoda					
<i>Rocinela signata</i>	RN	1	4.0	1.0	1
	CR	2	1.9	1.0	1
<i>Gnathia spp.</i>	RN	1	4.0	1.0	1
	CR	2	1.9	1.0	1

Parasite species	Locality	I. F.	P %	A. I.	Range
Cestoda					
<i>Otobothrium dipsacum</i>	CR	1	1.0	6.0	6
<i>Scolex pleuronectis</i>	RN	1	4.0	1.5	1
	LJ	1	10.0	1.0	1
	CR	2	1.9	1.0	1
Monogenea					
Gastrocotylinean Post-oncomiracidia	CR	2	1.9	1.0	1
	SJ	1	3.6	3.0	3
<i>Pseudempleurosoma carangis</i>	RN	1	4.0	1.0	1
Digenea					
<i>Stephanostomum sp.</i>	CR	3	2.9	1.0	1
<i>Neotorticaecum sp.</i>	SJ	7	25.0	2.4	1-4
<i>Lecithochirium floridense</i>	RN	20	80.0	15.6	2-59
	MY	3	25.0	6.3	1-12
	LJ	7	70.0	3.4	1-7
	CR	92	88.5	16.2	1-78
	SJ	18	64.3	2.7	1-11
Hirudinea					
<i>Trachelobdella lubrica</i>	RN	1	4.0	1.0	1

Table 2.2. Number of infected fish (I.F.), prevalence (P %), average intensity (A.I.) and range of parasitic species found in *Pterois volitans* from Cayman Islands (n= 91). (n= total number of hosts examined).

Parasite species	I. F.	P %	A.I	Range
Nematoda				
<i>Raphidascaris spp.</i>	2	2.2	1.0	1
<i>Spirocamalanus sp.</i>	2	2.2	1.0	1
Isopoda				
<i>Aegiochus tenuipes</i>	1	1.1	1.0	1
<i>Carpias serricaudus</i>	1	1.1	1.0	1
Cestoda				
<i>Scolex pleuronectis</i>	4	4.4	10.3	1-38
Monogenea				
<i>Udonella caligorum</i>	3	3.3	7.3	1-19
Digenea				
<i>Bivesicula caribbensis</i>	1	1.1	1.0	1
<i>Neotorticaecum spp.</i>	2	2.2	1.0	1
<i>Lecithochirium floridense</i>	16	17.6	2.1	1-7
<i>Helicometrina nimia</i>	2	2.2	1.0	1

Table 2.3. Number of infected fish (I.F.), prevalence (P %), average intensity (A.I.) and range of parasitic species found in *Pterois volitans* from the Bahamas (n= 47). (n= total number of hosts examined).

Parasite species	Locality	I. F.	P %	A. I.
Nematoda				
<i>Goezia spp.</i>	1	2.1	1.0	1
<i>Raphidascaris spp.</i>	1	2.1	1.0	1
Isopoda				
<i>Eurydice convexa</i>	1	2.1	1.0	1
<i>Excorallana quadricornis</i>	1	2.1	1.0	1
<i>Gnathia spp.</i>	1	2.1	1.0	1
Cestoda				
<i>Scolex pleuronectis</i>	3	6.4	2.7	2-4
Digenea				
<i>Neotorticaecum spp.</i>	9	19.2	3.44	1-21
<i>Lecithochirium floridense</i>	4	8.5	1.0	1
<i>Pachycreadium crassigulum</i>	1	2.1	1.0	1

Table 2.4. Analysis of similarity (ANOSIM) of Puerto Rico samples between 2009-2012. To perform this test data was 4th root transformed to have a more homogeneous data.

Groups	R significance level (= p)
2009, 2010	0.537
2009, 2011	0.203
2009, 2012	0.346
2010, 2011	0.179
2010, 2012	0.002
2011, 2012	0.001

FIGURE PLATES

Plate I

Figure 2.3. *Cavisoma chromitidis* Cable and Quick, 1954. Ventral view of the worm. Notice the club shaped proboscis.



Plate II

Figure 2.4. *Anisakis simplex* Rudolphi, 1809. (A) Anterior view of the worm, notice the lips and the tooth; (B) Ventral view of worm; (C) View of the whole worm.

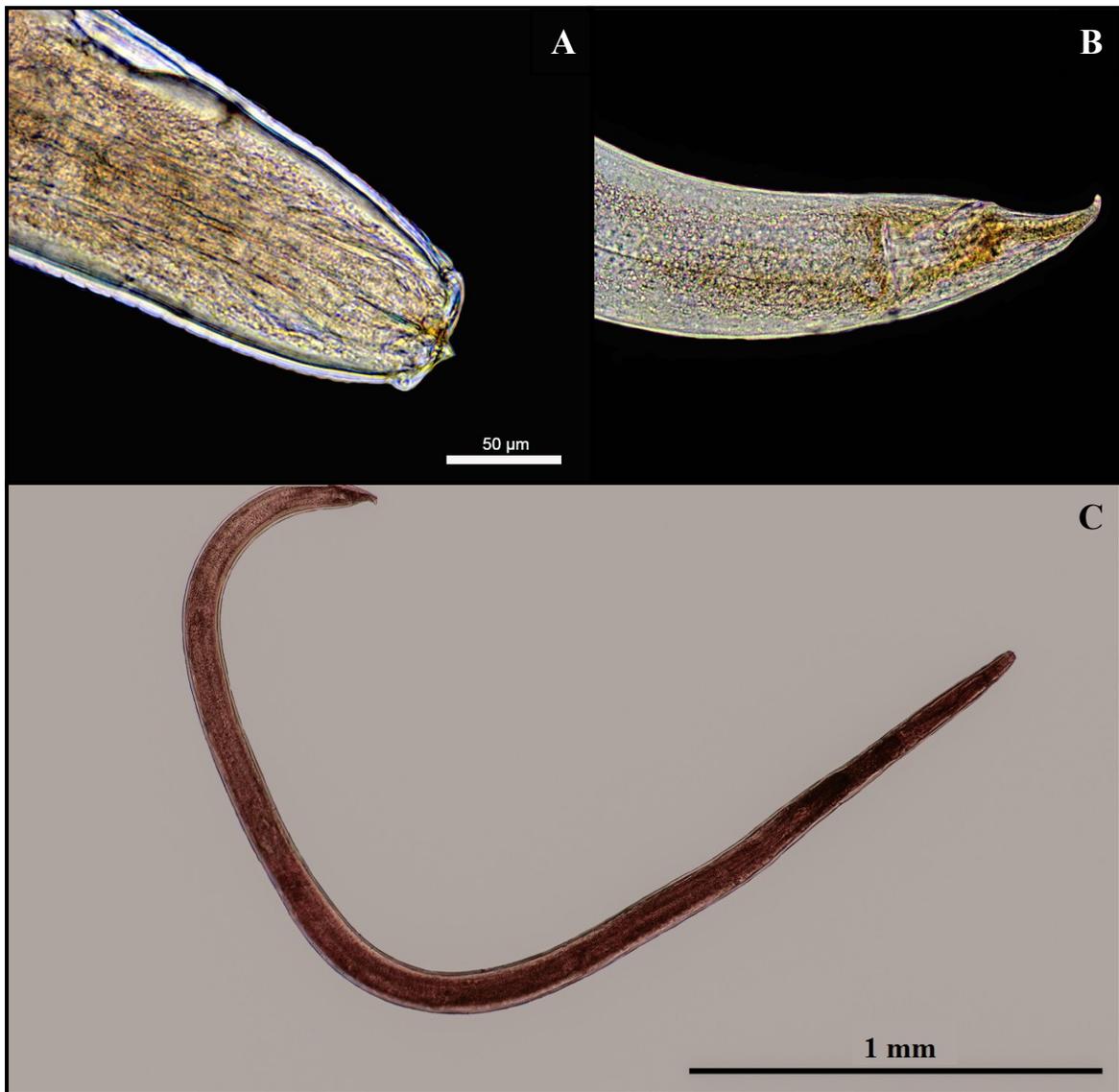


Plate III

Figure 2.5. *Raphidascaris spp.* Railliet and Henry, 1915. View of whole worm.

Figure 2.6. *Spirocamallanus partitus* Bashirullah and Williams, 1980. (A) View of posterior part of the worm; notice mucron (O) and finger-like projection at the end of the tail. (B) View of whole worm; (C)

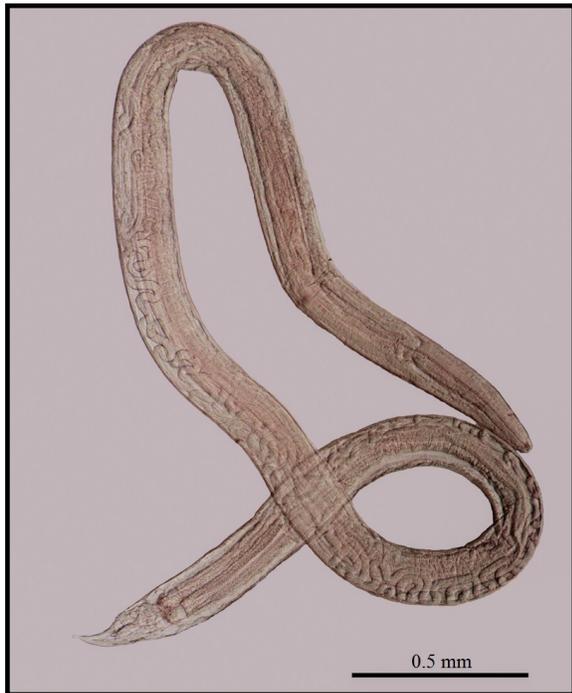


Figure 2.5

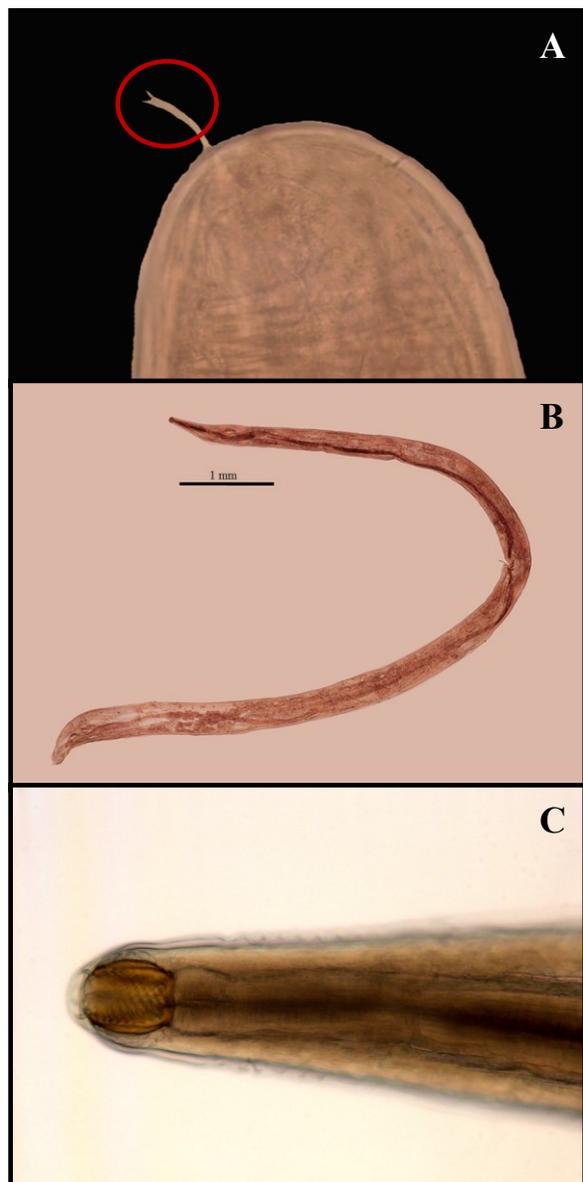


Figure 2.6 (A – C)

Plate IV

Figure 2.7. *Spirocamallanus spinicaudatus* Bashirullah and Williams, 1980. (A) Bucal capsule of the worm, notice 10 spiral thickenings (st). (B) Posterior end of female, notice finger-like projection at the end of the tail.



Plate V

Figure 2.8. *Capillaria sp.* Zeder, 1800. (A) Anterior end of the worm. (B) *Capillaria sp.* eggs. Notice plugs (pl) at both ends, characteristic of this species. (C) Posterior end of nematode. (D) Another view of nematode eggs (eg) with plugs (pl).

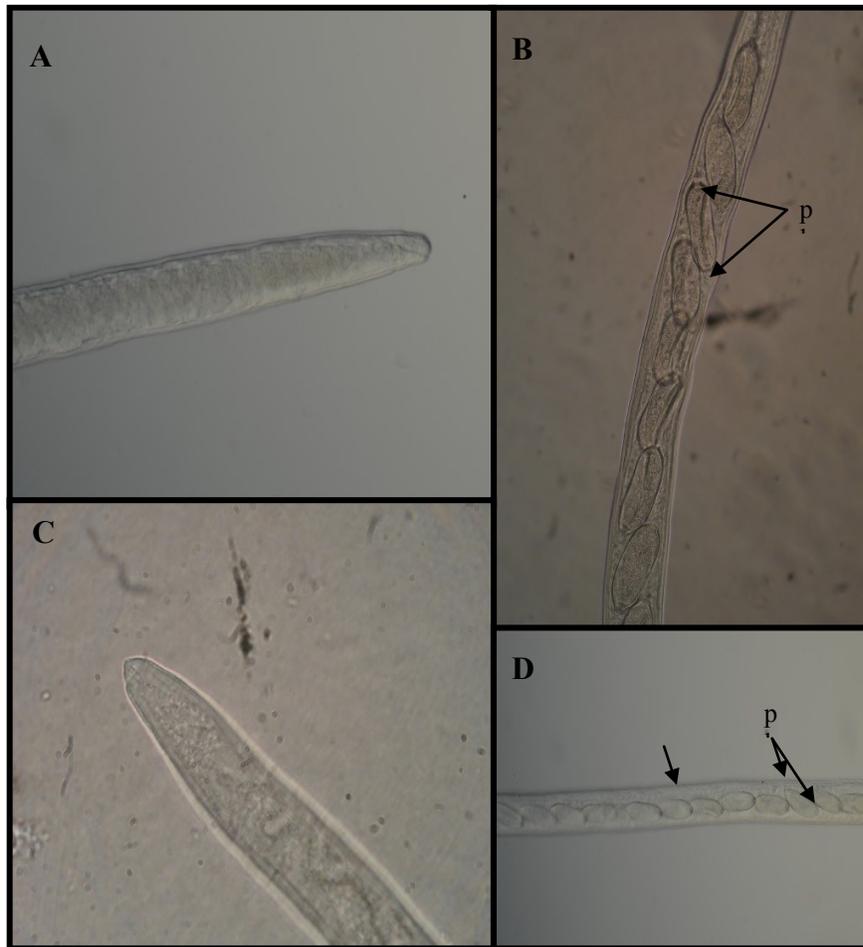


Plate VI

Figure 2.9. Unknown copepod. Dorsal view of whole specimen.

Figure 2.10. *Rocinela signata* Schioedte and Meinert, 1879. (A) Dorsal view of isopod; (B) Ventral view of isopod.

Figure 2.11. *Gnathia spp.* praniza larva from the gills of Lionfish. Dorsal view of whole specimen.

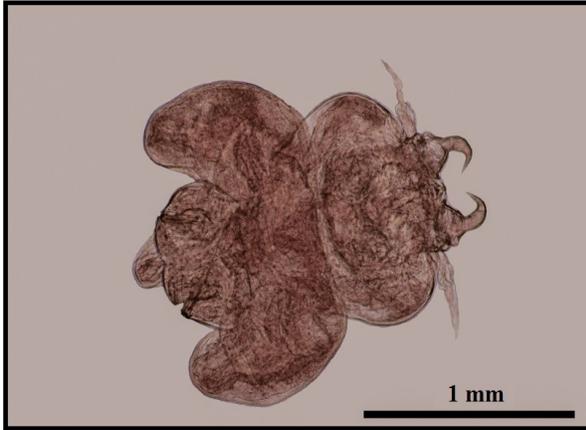


Figure 2.9

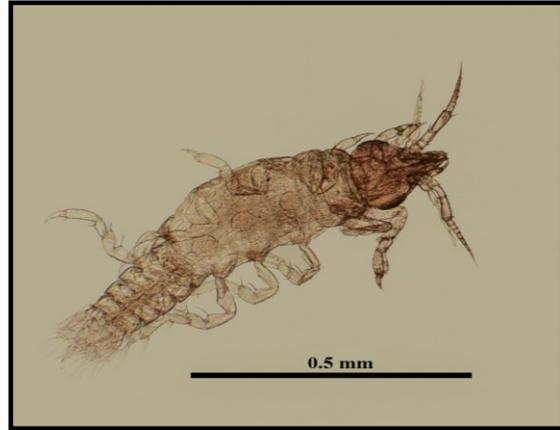


Figure 2.11

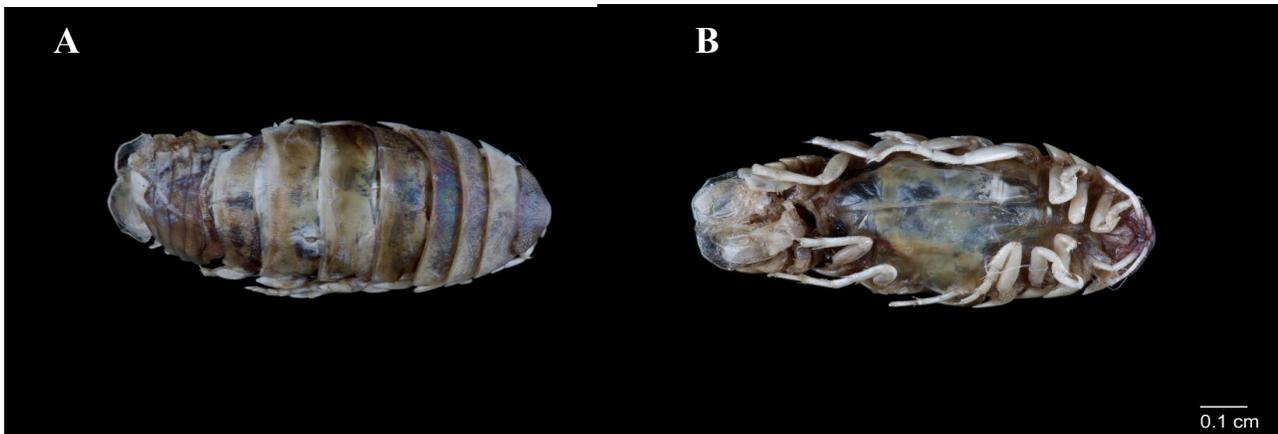


Figure 2.10 (A - B)

Plate VII

Figure 2.12. *Otobothrium dipsacum* Linton, 1897. Different stages of *Otobothrium dipsacum* found in the stomach of lionfish. (A and C) View of the worm with developing proglotid and characteristic bothridia (bo) [only A]; (B) View of mature worm with invaginated proboscis..

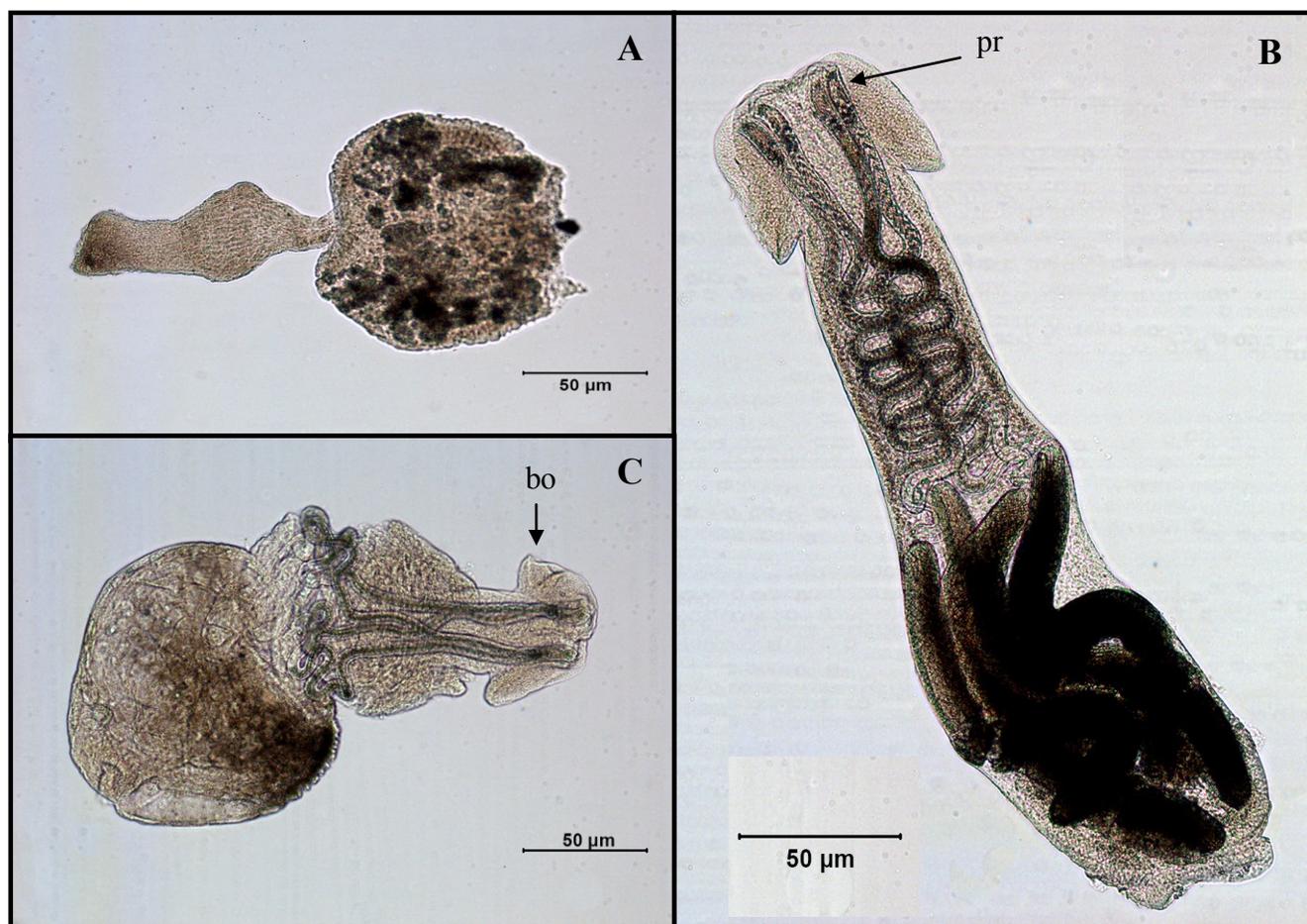


Plate VIII

Figure 2.13. *Scolex pleuronectis* Müller, 1788. (A - B) Plerocercoids with distinctive bothridia, conical body and tail; (C) Immature worm without any distinctive characteristics.

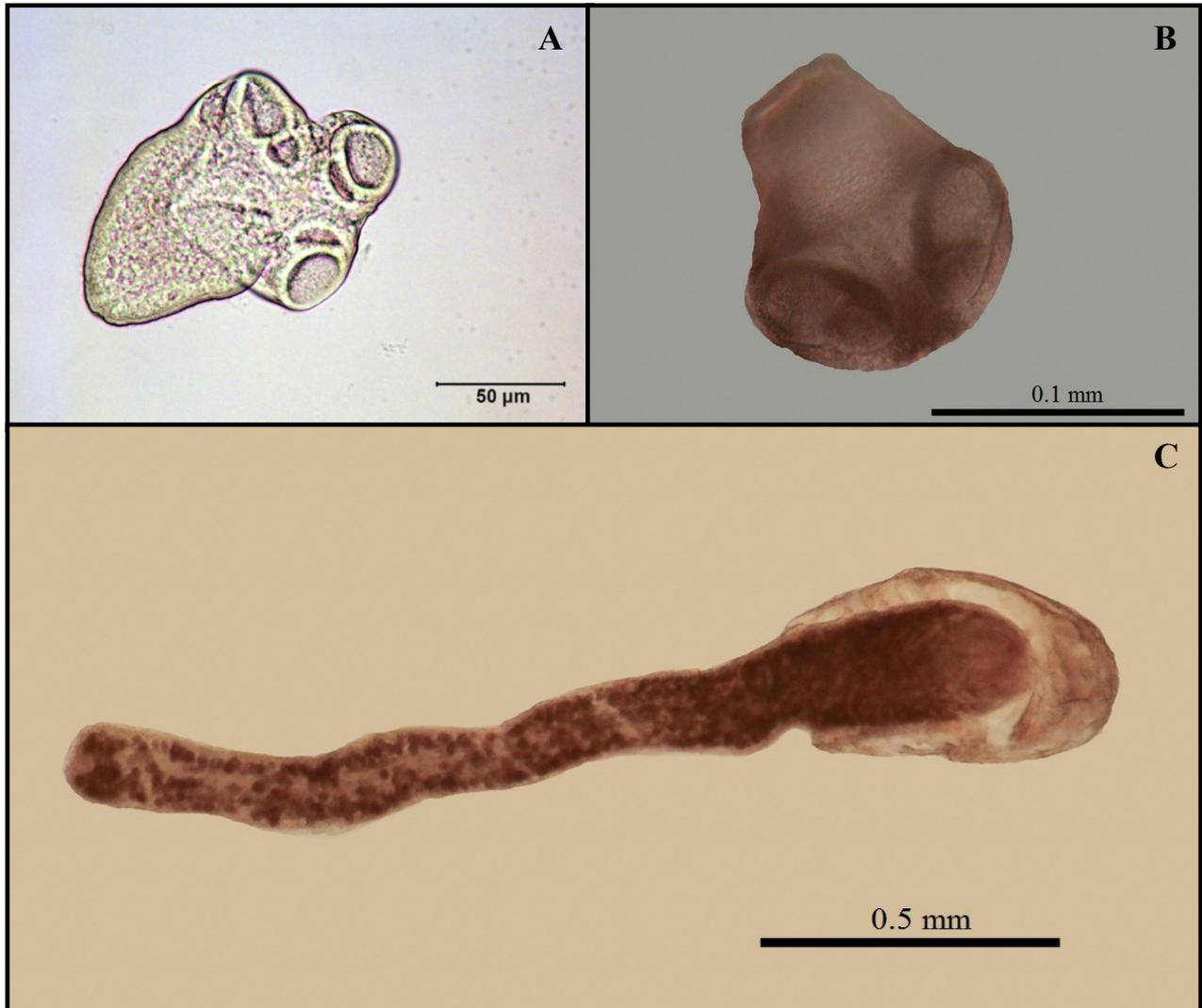


Plate IX

Figure 2.14. . **Gastrocotylinean post-oncomiracidia.** (A) Ventral view of the worm. Notice the pair of oral suckers (os), the first pair of anchor (an1) and the second pair of anchors (an2); (B) Notice marginal hooklets (mh).

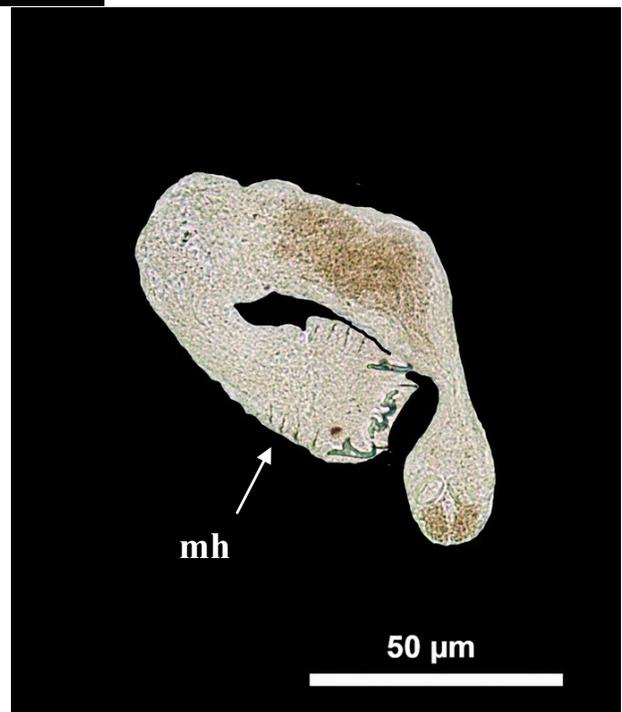
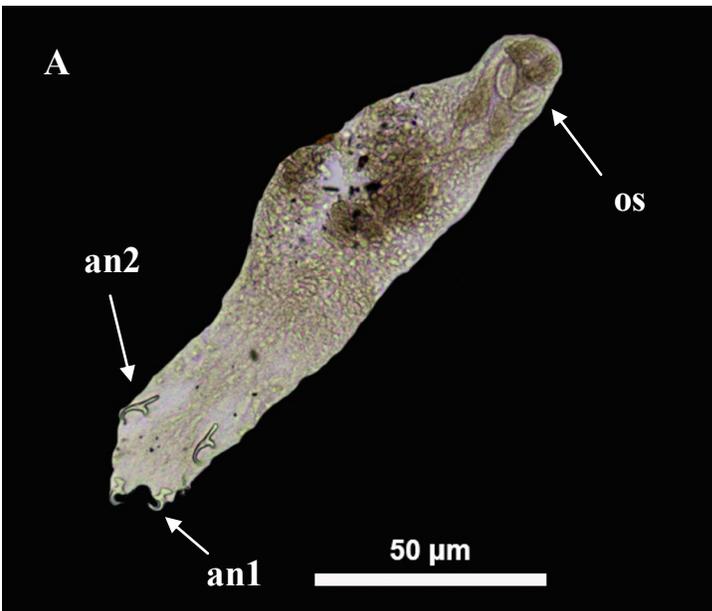


Plate IX

Figure 2.15. *Pseudempleurosoma carangis* Yamaguti, 1965. (A) ventral view of whole specimen, notice eye spots (ey). (B) Posterior end of monogenean; first pair of anchors (an1); second pair of anchors (an2); hooklets [one side] (ho), ventral bar (quadrangular shield) (ba).

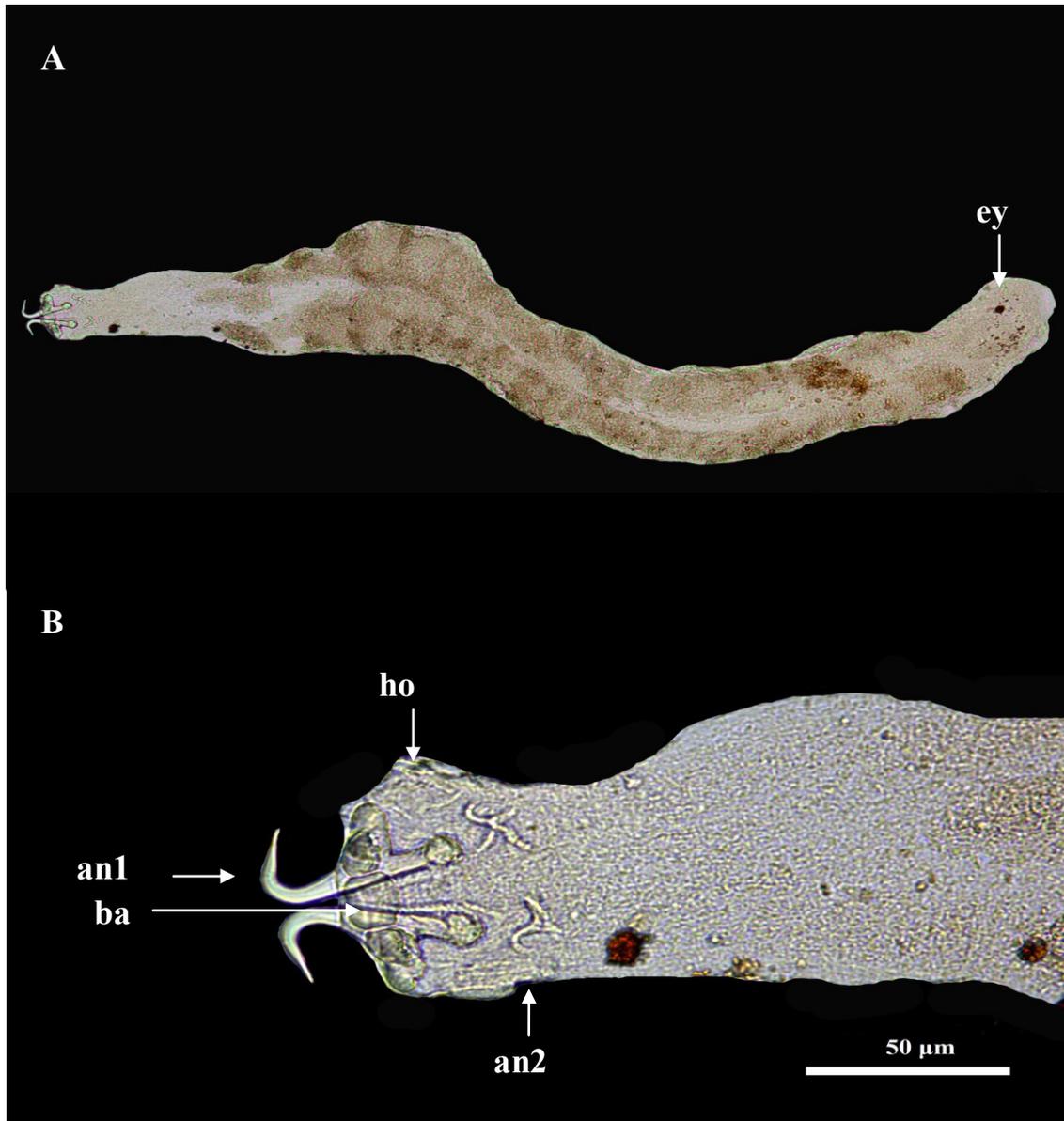


Plate X

Figure 2.16. *Stephanostomum* spp. Looss, 1899. Encysted metacercaria found in the stomach of lionfishes. (A) View of encysted worm; (B) Rows of spines encircling the mouth (r) and the spiny tegument are characteristic of this genus. Notice eye spots (e) characteristic of this immature stage.

Figure 2.17. *Neotorticaecum* spp. León-Régagnon, Pérez- Ponce de León and Lamothe-Argumedo, 1997. Ventral view of the whole worm.

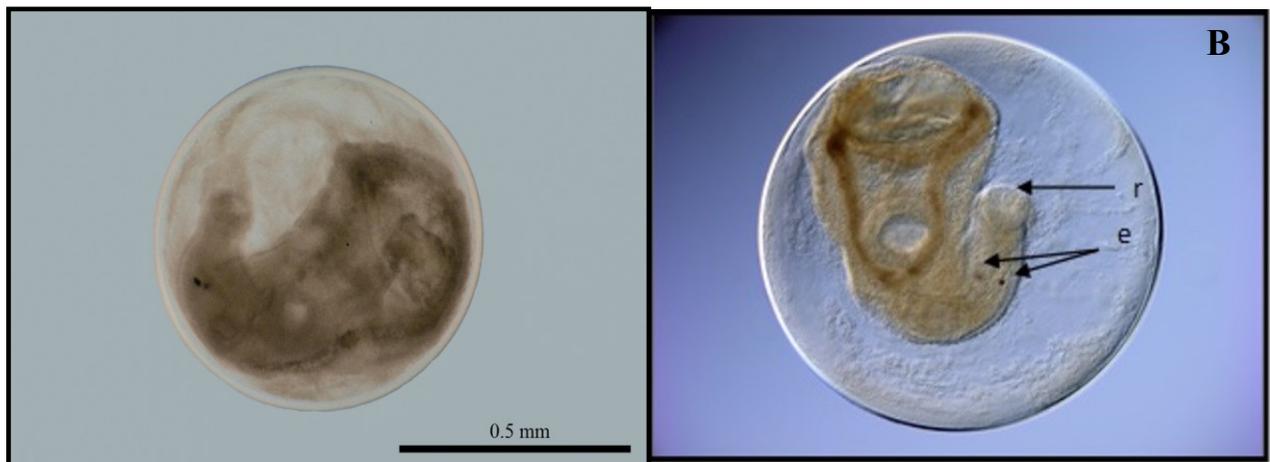


Figure 2.16 (A – B)

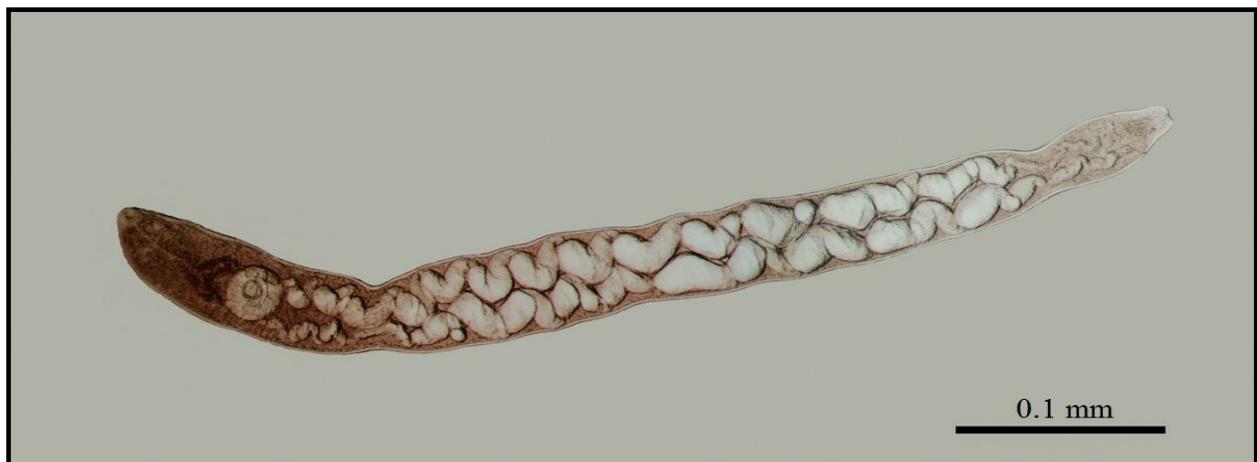


Figure 2.17

Plate XI

Figure 2.18. *Lecithochirium floridense* Manter, 1934. Ventral view of the worm. Notice the multi-lobed vitellarian group (vg), ovary (ov), overlapping testis (te) and the protruded ecsoma (ec).

Figure 2.19. *Trachelobdella lubrica* Grube, 1840 from the gills of lionfish. Ventral view of whole worm.

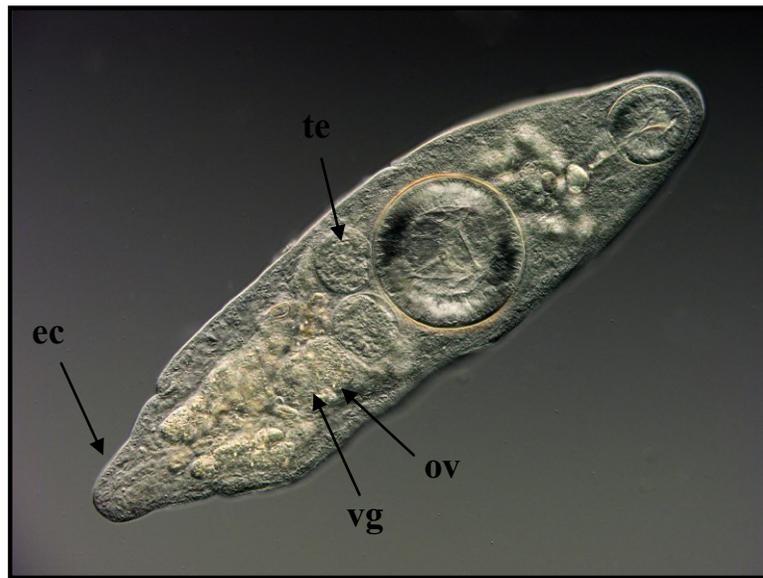


Figure 2.18



Figure 2.19

Plate XII

Figure 2.22. *Spirocamallanus sp.* Olsen, 1952. Ventral view of the worm.

Figure 2.23. *Aegiochus tenuipes* (Schioedte and Meinert, 1879). (A) Dorsal view; (B) Ventral view.

Figure 2.24 *Carpias serricaudus* Menzies and Glynn, 1968. Dorsal view of the isopod.

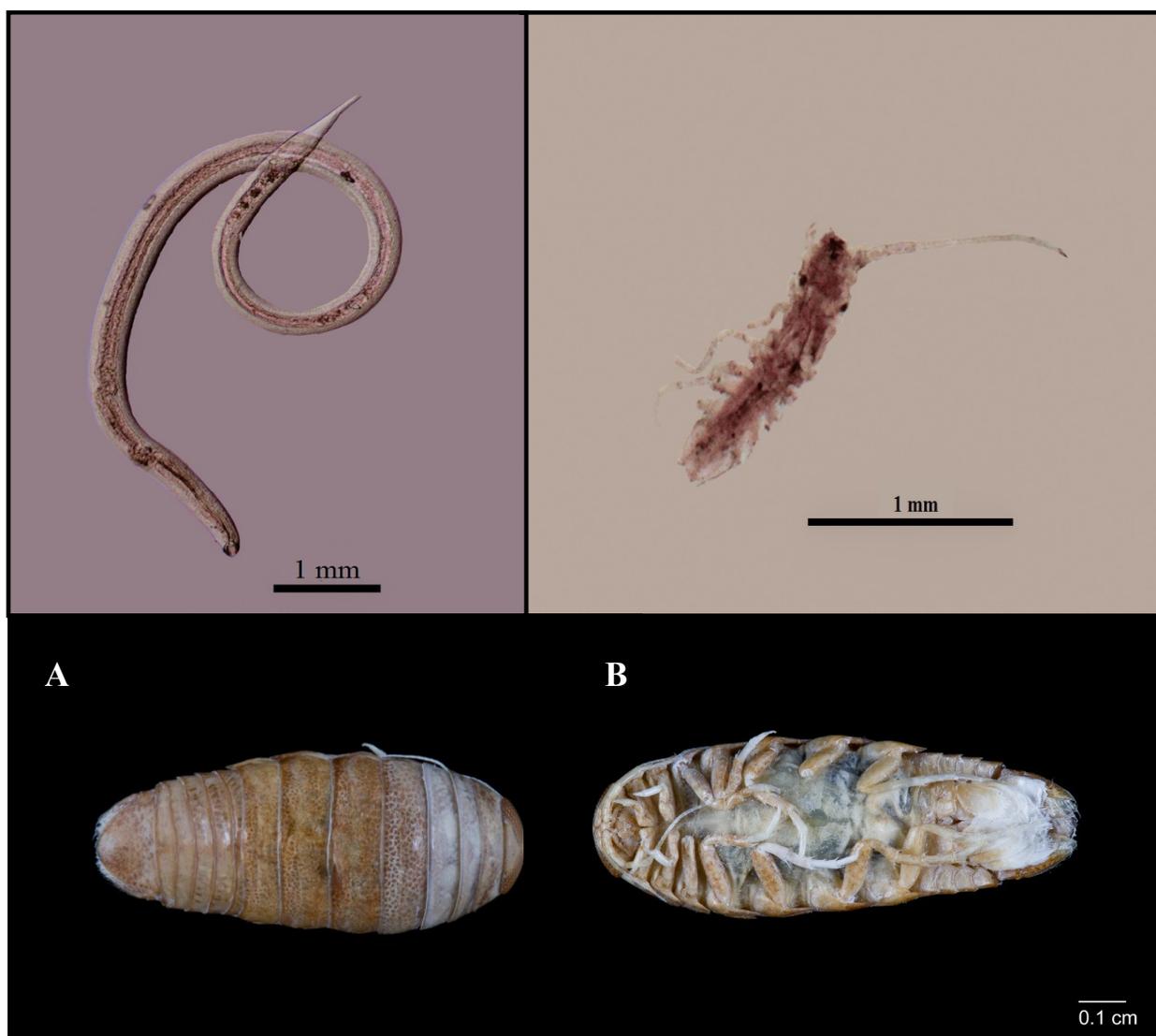


Figure 2.23 (A – B)

Plate XII

Figure 2.25. *Udonella caligorum* Johnston, 1835. Ventral view of worm.

Figure 2.26. *Bivesicula caribbensis* Cable and Nahhas, 1962. Notice characteristic vitelline follicles (vf) in lateral fields on anterior part of body and single ovoid testes (te).

Figure 2.27. *Helicometrina nimia* Linton, 1910. Ventral view of the worm. Notice the 9 testes (te), characteristic of the species

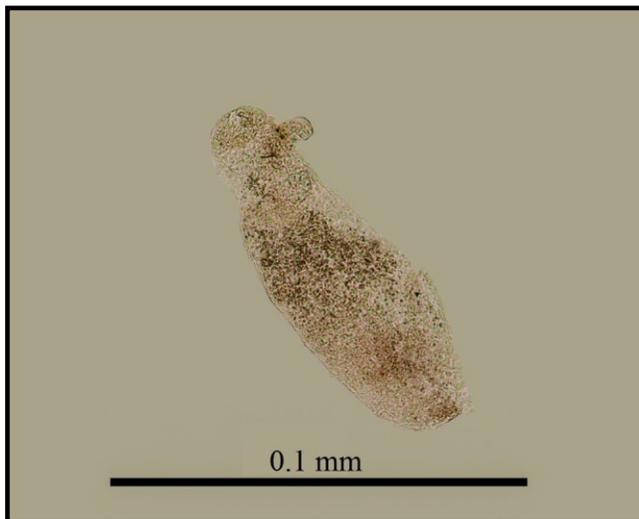


Figure 2.25

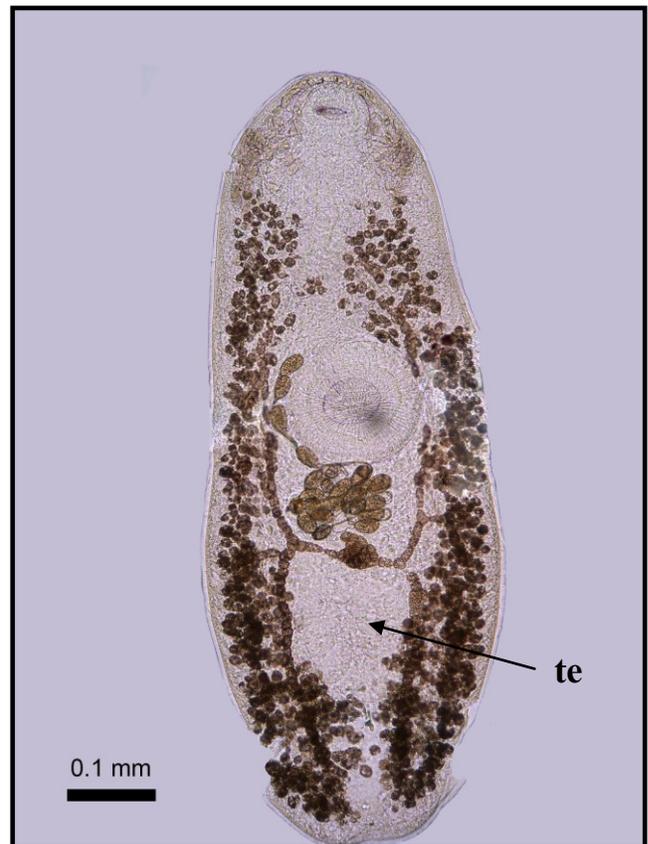
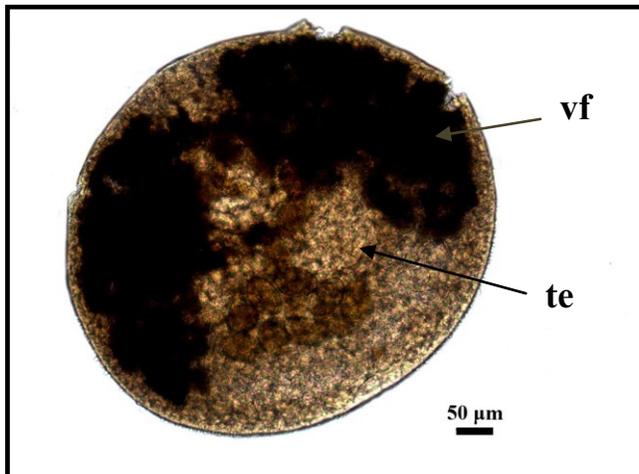


Figure 2.27

← **Figure 2.26**

Plate XIV

Figure 2.28 *Goezia sp.* Zeder, 1800. Ventral view of the worm. Notice conspicuous lips, the spines on the cuticle characteristic of this species, and the finger like projection at the end of tail characteristic of the species.

Figure 2.29. *Eurydice convexa* Richardson, 1900. Side view of isopod.

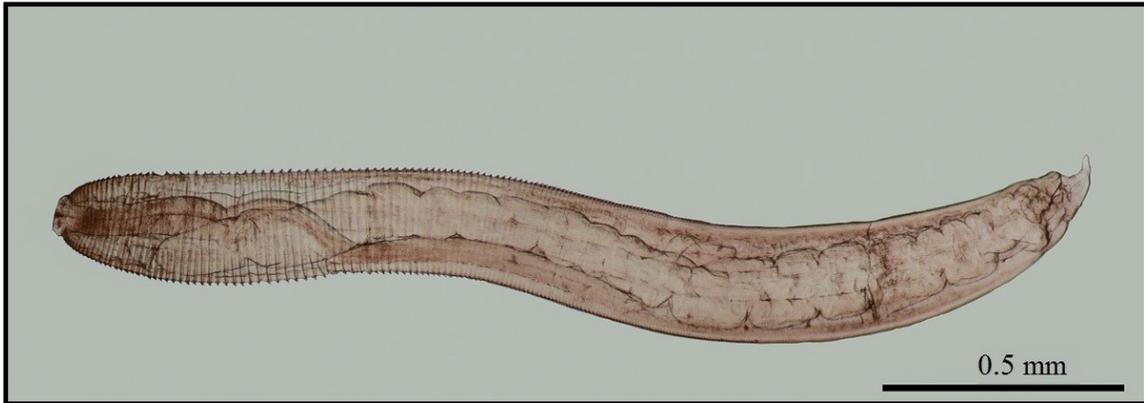


Figure 2.28



Figure 2.29

Plate XV

Figure 2.30. *Excorallana quadricornis* Hansen, 1890. (A) Dorsal view of the isopod; (B) Notice pairs of tubercles (tu) characteristic of this species

Figure 2.31. *Pachycreadium crassigulum* (Linton, 1910) Manter, 1954

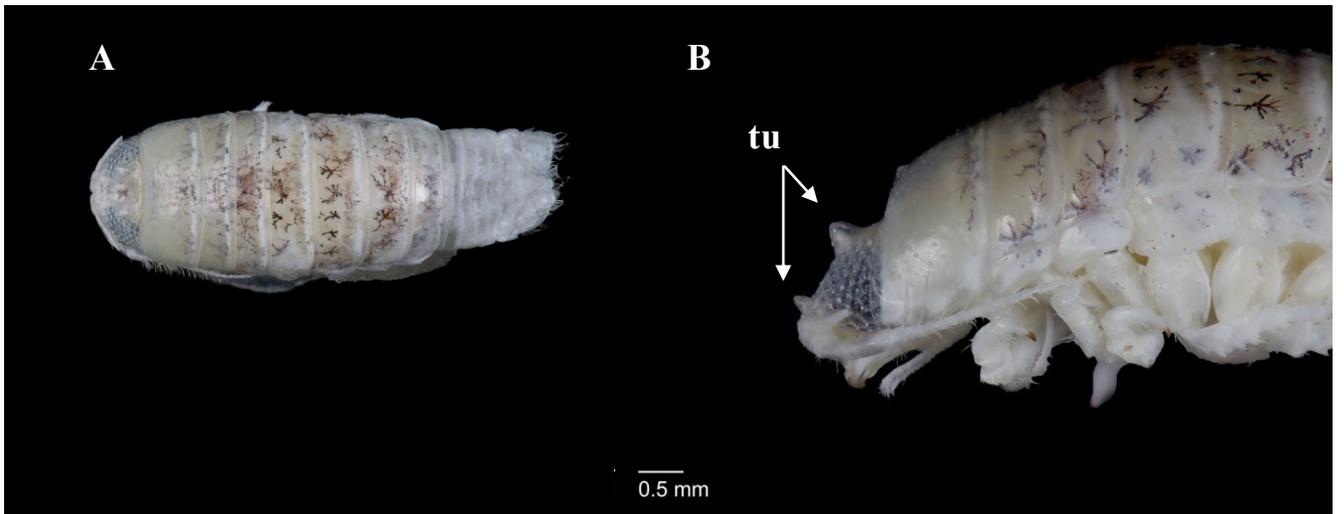


Figure 2.30

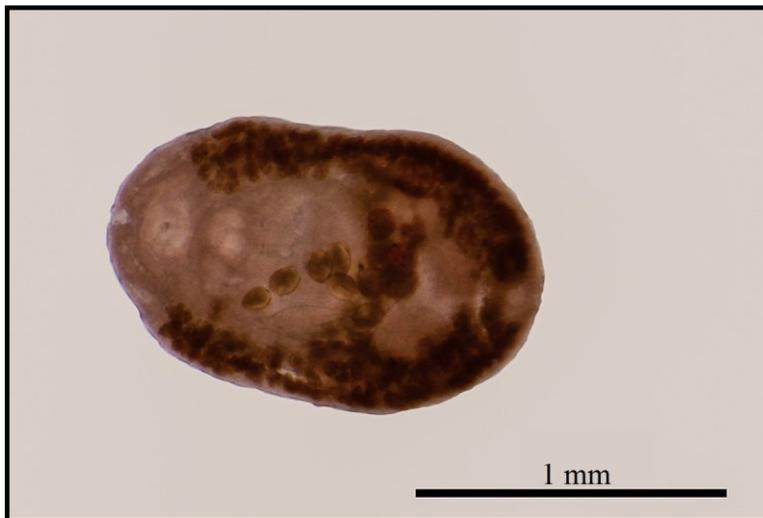


Figure 2.31