J. Parasitol., 97(5), 2011, pp. 833–837

FIRST RECORD OF A DIGENEAN FROM INVASIVE LIONFISH, *PTEROIS* CF. *VOLITANS*, (SCORPAENIFORMES: SCORPAENIDAE) IN THE NORTHWESTERN ATLANTIC OCEAN

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ABSTRACT: Adults of *Lecithochirium floridense* (Digenea: Hemiuridae) parasitized the stomach in each of 22 necropsied lionfish, *Pterois* cf. *volitans* (Scorpaeniformes: Scorpaenidae) (prevalence = 100%, mean intensity = 11), captured in the northwestern Atlantic Ocean off Beaufort, North Carolina (34°14.83′N, 76°35.25′W). This is the first report of a digenean from the invasive lionfish and that of *L. floridense* from a species of *Pterois*. The leech specimen previously identified as *Myzobdella lugubris* from *P. volitans* in the northwestern Atlantic Ocean is re-identified as *Trachelobdella lubrica* based on a study of the original voucher specimen.

Red lionfish, *Pterois volitans* (Linnaeus, 1758), (Scorpaeniformes: Scorpaenidae) and devil firefish, *Pterois miles* (Bennett, 1828) range in the western Pacific Ocean (Poss, 1999) and throughout the Indian Ocean and Red Sea (Hamner et al., 2007), respectively. Both lionfishes remain popular in the aquarium trade and were likely introduced into the northwestern Atlantic Ocean by that association, perhaps as early as the mid-1980s (Morris and Akins, 2009). Both are now established in the northwestern Atlantic Ocean and Caribbean Sea (Morris et al., 2009; Morris and Whitfield, 2009; Sutherland et al., 2010), where they are regarded as the first non-native obligate marine fishes to establish a self-reproducing population off the Atlantic coast of the United States. Herein, we provide the first published record of a digenean from invasive lionfish captured outside of their native Indo–Pacific range.

MATERIALS AND METHODS

Lionfish were hand-netted during August 2007 at a reef area of 36-m depth in the northwest Atlantic Ocean, 39 km off Beaufort, North Carolina, USA (34°14.83′N, 76°35.25′W). The fish were brought to the sea surface alive and were killed by spinal severance immediately before necropsy. The gut of each fish was examined with the aid of a dissecting microscope and flukes were routinely processed for staining (Bullard, 2010) and scanning electron microscopy (SEM) (Bullard and Jensen, 2008). Fluke measurements are herein reported in micrometers (μm) followed by the number of specimens measured in parentheses. Scientific names, taxonomic authorities, and dates for fish taxa follow Eschmeyer (2010). Higher-level fish classification and nomenclature follows Nelson (2006) and Poss (1999). Lionfish were field-identified as per Schultz (1986), but because meristic counts for these species may overlap (Kochzius et al., 2003) and we did not have access to molecular sequence data from any host tissue, we used the designation *Pterois* cf. *volitans*. Higher-level fluke classification follows Bray (1991) and Gibson (2002a, 2002b).

RESULTS

Adults of *Lecithochirium floridense* (Manter, 1934) Crowcroft, 1946 (Digenea: Hemiuridae) parasitized the stomach in each of 22 necropsied lionfish, *Pterois* cf. *volitans* (Scorpaeniformes: Scorpaenidae) (prevalence = 100%, mean intensity = 11). No other parasitic platyhelminths were recovered from the stomach of any examined lionfish, but other parasites collected from these hosts will be reported elsewhere.

EMENDED DESCRIPTION

Lecithochirium floridense (Manter, 1934) Crowcroft, 1946

(Figs. 1–2)

Diagnosis of adult (based on 12 heat-killed, stained, and whole-mounted specimens [USNPC Nos. 104635 and 104636] plus 2 sputter-coated adults examined by SEM): Soma 547–1,124 (12) long, 167–427 (11) wide, 2.5–3.4 times longer than wide (Figs. 1–2), with numerous sensory papillae on ventral surface (Fig. 2). Ecsoma withdrawn or extending to 162 (1) or 15% total body length in specimen 1,023 long; partially extruded length 11–84 (5); invaginated into posterior end of body in 6 measured specimens. Forebody 138–314 (12) long or 26–30% soma length. Preoral lobe present, not prominent. Oral sucker subterminal, 57–99 (12) long, 48–102 (12) wide, 0.9–1.2 times longer than wide, bearing minute sensory papillae around rim (Fig. 2). Ventral sucker 108–230 (12) long, 111–241 (12) wide, 0.9–1.2 times longer than wide, bearing minute sensory papillae around rim (Fig. 2). Pit-like depression anterior to ventral sucker present in 1 SEM specimen, likely an artifact (Fig. 2), absent in whole-mounted specimens. Ratio of oral sucker length to ventral sucker length 1:1.9–2.6. Ratio of oral sucker width to ventral sucker width 1:2.0–2.4. Prepharynx absent. Pharynx 31–54 (11) long, 31–52 (11) wide, 0.9–1.2 times longer than wide. Esophagus short. Drüsenmagen present. Ceca bifurcating at midline posterior to level of pharynx; each cecum ending blindly in extreme posterior body end or terminating in anterior half of ecsomal space (Fig. 1).

Testes 2, opposite, subequal, subspherical, slightly overlapping posterior margin of ventral sucker, 31–111 long (11), 37–128 (11) wide, 0.9–1.5 times longer than wide. Seminal vesicle bipartite, overlapping anterior half of ventral sucker, connecting with base of sinus sac via male duct being surrounded by free prostatic cells. Sinus sac clavate, 85 (1) long in a laterally-mounted specimen, having muscular luminal wall and base, containing spherical prostate vesicle at proximal end (Fig. 1).

Ovary dextral, subspherical, amphitypic in middle third of hindbody, 43–140 (11) long, 51–195 (11) wide, often contiguous with or overlapping with testes. Mehlis' gland and Laurer's canal not observed. Seminal receptacle absent. Vitellarium primarily overlapping posterior margin of ovary, distributing in 2 groups;

Received 8 January 2011; revised 3 March 2011, 11 March 2011; accepted 18 March 2011.

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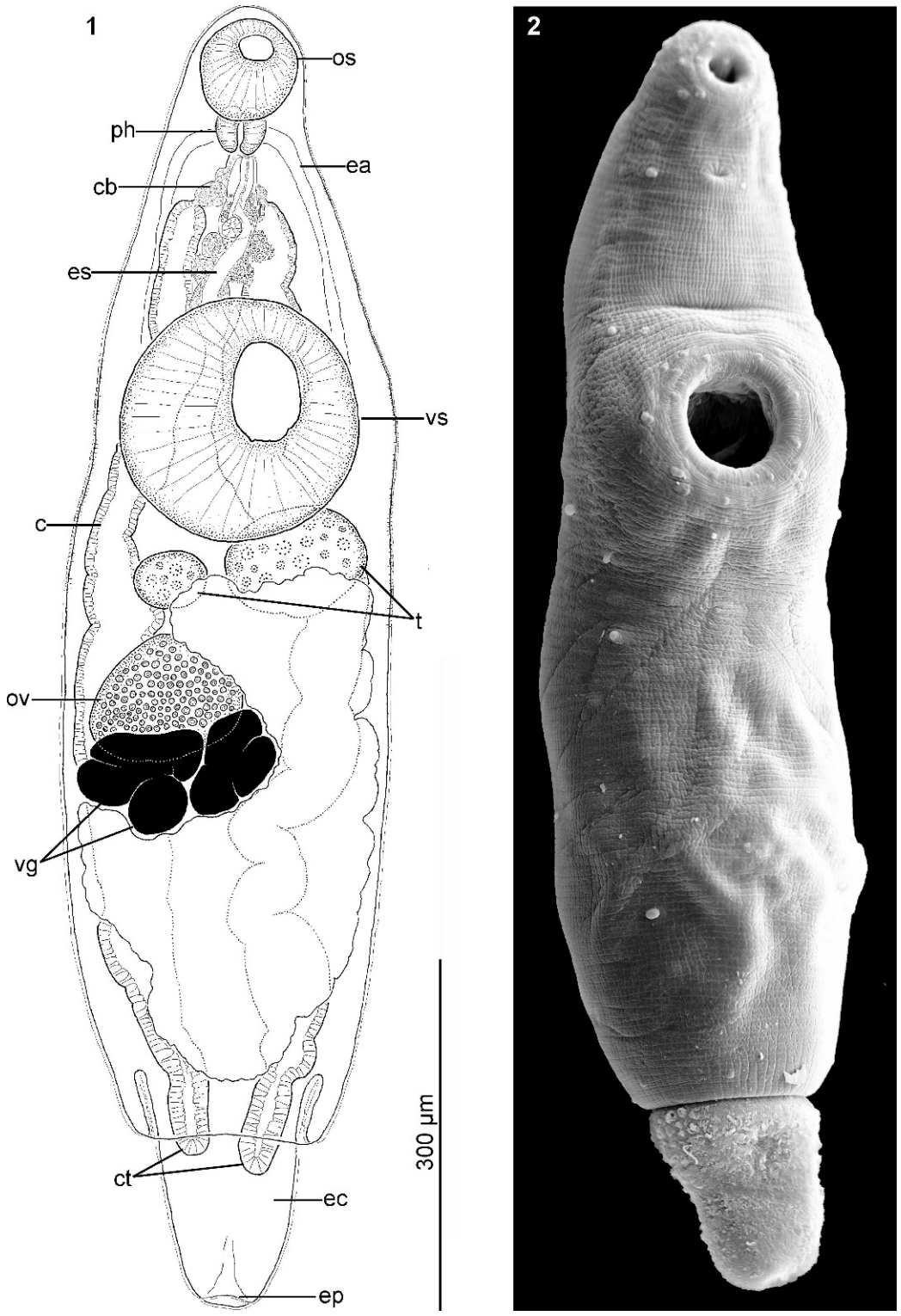
DOI: 10.1645/GE-2746.1



FIGURES 1, 2. *Lecithochirium floridense* (Manter, 1934) Crowcroft, 1946 (Platyhelminthes: Digenea: Hemiuridae) from the stomach of lionfish, *Pterois* cf. *volitans* (Linnaeus, 1758), (Scorpaeniformes: Scorpaenidae) from the northwestern Atlantic Ocean (USNPC No. 104635), (1) ventral view of stained, whole-mounted specimen; oral sucker (os) excretory arm (ea), ventral sucker (vs), ecsoma (ec), excretory pore (ep), pharynx (ph), Drüsenmagen (dr), metraterm (m), dextral cecum (c), ovary (ov), dextral vitelline group (vg), cecal tips (ct). Scale value next to bar. (2) Scanning electron micrograph showing same view as in Figure 1 (same scale base value as Fig. 1).

dextral and sinistral group each having 4 and 3 posteriorly directing lobes, respectively (Fig. 1). Uterus extensive, having coils extending both anterior and posterior to ovary; coils may extend into ecsoma. Metraterm thin-walled, entering sinus sac ventrally, communicating with male duct immediately anterior to prostate vesicle forming hermaphroditic duct; hermaphroditic duct occupying anterior 2/3 of sinus sac. Genital pore median, opening at level of pharynx. Eggs oblong, 14–17 (12) long, 7–10 (12) wide, or approximately 2 times longer than wide.

Excretory vesicle nearly indistinct, with excretory bladder arms uniting dorsal to pharynx immediately posterior to level of oral sucker.

Taxonomic summary

Type host: Manter (1934) listed various marine fish hosts but did not specify a type host.

Site: Adults in stomach.

Type locality: Gulf of Mexico, off the Tortugas, Florida.

Other hosts and localities: Red hind, *Epinephelus guttatus* (Linnaeus, 1758) (Perciformes: Serranidae) (see Cribb et al., 2002); red grouper, *Epinephelus morio* (Valenciennes, 1828) (see Moravec et al., 1997); Nassau grouper, *Epinephelus striatus* (Bloch, 1792); yellowfin grouper, *Mycteroperca venenosa* (Linnaeus, 1758); gag, *Mycteroperca microlepis* (Goode and Bean, 1879); sergeant major, *Abudefduf saxatilis* (Linnaeus, 1758), (Perciformes: Pomacentridae) in the Caribbean Sea (Yeo and Spieler, 1980); little tunny, *Euthynnus alleteratus* (Rafinesque, 1810) (Perciformes: Scombridae) in the northwestern Atlantic Ocean (Pozdnyakov, 1990); pink frogmouth, *Chaunax nuttingi* Lowe, 1846 (Lophiiformes: Chaunacidae) in the Gulf of Mexico (GoM) (Klimpel et al., 2001); angler, *Lophius piscatorius* Linnaeus, 1758, (Lophiiformes: Lophiidae) in GoM; *Peristedion imberbe* Poey, 1861 (Scorpaeniformes: Peristediidae) in GoM; beardfish, *Polymixia lowei* Günther, 1859 (Polymixiiformes: Polymixiidae) in GoM; Gulf hake, *Urophycis cirrata* (Goode and Bean, 1896) (Gadiformes: Phycidae) in GoM; red scorpionfish, *Scorpaena natalensis* Linnaeus, 1758 (Scorpaeniformes: Scorpaenidae) in the Southwest Indian Ocean (Parukhin, 1989); false kinglip, *Hoplobrotula gnathopus* (Regan, 1921) (Ophidiiformes: Ophidiidae) in the southeast Atlantic Ocean; jaguar guapote, *Cichlasoma managuense* (Günther,1867) (Perciformes: Cichlidae) (Vidal-Martínez and Kennedy, 2000) and Mexican mojarra, *Cichlasoma urophthalmus* (Günther, 1862) in Mexico (Salgado-Maldonado and Kennedy, 1997; Salgado-Maldonado et al., 1997; Vidal-Martínez et al., 2001).

Remarks

Lecithochirium floridense is distinct from congeneric and morphologically similar hemiurids primarily by the combination of having (1) extruded ecsoma 15% of total body length, (2) ceca extending far posteriad and penetrating into ecsoma region, (3) egg 16–17 μm long, (4) vitellarium dividing into 2 multi-lobed groups, (5) prostatic vesicle present, (6) genital pore medial, at level of pharynx, (7) ovarian complex in middle 1/3 of body, overlapping testes, (8) oral sucker width to ventral sucker width ratio 1:2.5, (9) seminal vesicle bipartite, (10) sinus sac clavate with muscular wall, and (11) preacetabular pit absent. *Lecithochirium monticellii* (Linton, 1898) Crowcroft, 1946 has a larger body (5.5 mm long), a posterior ovarian complex with elongated vitelline lobes, an oral sucker to ventral sucker width ratio of 1:5.4, and larger eggs 18–25 μm long (see Linton, 1898). *Lecithochirium fusiforme* Lühe, 1901 has ceca terminating anterior to the ecsoma and elongated dendritic vitelline lobes (Linton, 1910; Pérez-Vigueras, 1958). *Lecithochirium synodi* Manter, 1931 has a tripartite seminal vesicle, eggs 12–16 μm long, a "cervical pit" (=conspicuous and glandular preacetabular pit), and elongate dendritic vitelline lobes (see Manter, 1931; 1947). *Lecithochirium branchiale* (Stunkard and Nigrelli, 1934) Manter, 1943 has ceca terminating anterior to the ecsoma, elongate vitelline lobes, and eggs 19 μm long (see Stunkard and Nigrelli, 1934). *Lecithochirium microstomum* Chandler, 1935 has a larger body (2.75–4.8 mm long), a preacetabular pit (="deep sinus"), and ceca terminating anterior to ecsoma (Chandler, 1935). *Lecithochirium texanum* (Chandler, 1941) Manter, 1947 has a trilobed seminal vesicle, a pored preacetabular pit, and eggs measuring 18 μm long (Chandler, 1941; Manter, 1947). *Lecithochirium mecosaccum* Manter, 1947 has ceca terminating anterior to the ecsoma, a sucker width ratio of 1:2, a tripartite seminal vesicle, no external pars prostatica, a large sinus sac, and a preacetabular pit. *Lecithochirium microcercus* (Manter, 1947) has a sucker width ratio of 1:2, a minute ecsoma, a genital pore far anterior to oral sucker base, a tripartite seminal vesicle, a short sinus sac, and nearly indistinct vitelline lobes. *Lecithochirium parvum* Manter, 1947 has a preacetabular pit, ceca terminating anterior to the ecsoma, a tripartite seminal vesicle, a weakly muscular sinus sac lacking conspicuous prostatic vesicle, and a posteriorly located ovarian complex. *Lecithochirium havanensis* (Pérez-Vigueras, 1958) n. comb. has elongated dendritic vitelline follicles. *Lecithochirium latum* (Pérez-Vigueras, 1958) n. comb. has a sucker width ratio of 1:2 and smaller eggs measuring 13.4 μm long by 10 μm wide (Pérez-Vigueras, 1958). *Lecithochirium loossi* (Pérez-Vigueras, 1958) n. comb. has elongated dendritic vitelline lobes. *Lecithochirium ryptici* (Pérez-Vigueras, 1958) n. comb. apparently lacks a prostatic vesicle but otherwise does not differ appreciably from *L. floridense* (see Pérez-Vigueras, 1958) and, therefore, may comprise a junior subjective synonym of *L. floridense*.

DISCUSSION

The lionfish hosts we studied likely were infected on site, in the northwestern Atlantic Ocean, rather than introduced as infected individuals because: (1) the prevalence of *L. floridense* infection among the wild-caught lionfish we sampled was 100%, (2) adult *L. floridense* may live for only a few months in the gut of the definitive fish host (Margolis and Boyce, 1969; Scott, 1969), (3) *L. floridense* infects other fishes in the region (e.g., Pozdnyakov, 1990), and (4) lionfish have established a self-reproducing population at the collecting site (Morris et al., 2009).

Adults of *L. floridense* infect the gut of at least 16 species of piscivorous marine fishes assigned to 12 genera and 10 families including members of Scorpaeniformes (Parukhin, 1989). Thus, it is not surprising that invasive lionfish host this euryxenous fluke in the northwestern Atlantic Ocean. The lionfish is a new host record for this fluke. Parasite records comprising a total of 2 monogenoids (Paperna, 1972; Ogawa et al., 1995), 2 trematodes (Nagaty and Aal, 1962; Hassanine, 2006), 2 leeches (Paperna, 1976; Ruiz-Carus et al., 2006), and 1 copepod (Dojiri and Ho, 1988) have been published from *P. volitans*, while only 1

monogenoid (Colorni and Diamant, 2005) and 1 myxozoan (Diamant et al., 2004) have been reported from *P. miles*. These records likely represent only a fraction of the parasites that infect these lionfishes.

In the only previously published record of a parasite from invasive lionfish, Ruiz-Carus et al. (2006) collected 2 specimens of *P. volitans* (1 male and 1 female) and detailed a single leech specimen they identified as *Myzobdella lugubris* from the tongue of a male lionfish. *Trachelobdella lubrica* infects lionfish (Paperna, 1976) and it is also a well-known ectoparasite of the buccal cavity of ocean-dwelling actinopterygian fishes (Sawyer, 1986; Mizzan, 1994), including scorpaenids (Celik and Aydin, 2006), in the Mediterranean Sea, Caribbean Sea, Gulf of Mexico, and Atlantic Ocean. One of us (S.S.C.) borrowed Ruiz-Carus et al.'s (2006) voucher specimen (U. S. National Parasite Collection No. 94040, not "88999") and compared it with several specimens of *Myzobdella lugubris* from fishes of Mississippi Sound (30°23′32″N; 88°47′45″W). The voucher specimen clearly has 12 pairs of lateral pulsatile vesicles along the body margin and lacks eye pigmentation on the oral sucker. The specimen recovered from lionfish is, therefore, *T. lubrica* (see Meyer, 1965; Paperna, 1976), not *M. lugubris*, which lacks external pulsatile vesicles and has a pair of distinct eyespots on the dorsal surface of the oral sucker (Sawyer et al., 1975). *Trachobdella lubrica* is a common parasite of snappers (Lutjanidae) and groupers (Serranidae) in the Gulf of Mexico (S. Bullard and S. Curran, pers. obs.) and differs from *M. lugubris* not only by its preference for hosts that range in oceanic waters (high salinity) but also in its fidelity for infecting the buccal cavity rather than the external body surface of its fish hosts.

ACKNOWLEDGMENTS

We thank the NOAA Aquatic Invasive Species Program, the National Centers for Coastal Ocean Science, National Science Foundation (DEB1048523), Mississippi–Alabama SeaGrant, and the College of Agriculture (Auburn University) for funding support; Andrew McElwain (APL, Auburn University) for taking the scanning electron micrographs; P. Whitfield and the many NOAA divers that assisted with sample collection aboard the NOAA R/V Nancy Foster; D. Ahrenhoz, J. Govoni, M. Fonseca, and J. Smith for constructive comments on this manuscript; and Eric Hoberg and Pat Pilitt (USNPC, Beltsville, Maryland) for loaning the leech specimen. Views expressed are those of the authors and do not necessarily represent policy of any government agency. A portion of this work was supported by National Science Foundation grants DEB-1051106 and DEB-1048523 to S.A.B.

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