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A NEW WESTERN ATLANTIC SIZE RECORD FOR *PTEROIS VOLITANS* (ACTINOPTERYGII: SCORPAENIFORMES: SCORPAENIDAE) WITH NEW MORPHOLOGICAL DATA ON HEAD SPINULES

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Abstract. The red lionfish, *Pterois volitans* (Linnaeus, 1758), native to the Pacific Ocean has been rapidly colonizing waters of subtropical and tropical western Atlantic. In a decade since its first sighting in the USA it has reached the south-eastern Brazil coast. There are numerous records reporting the sizes of this fish in its non-native area. Until recently the maximum reported total length was 450 mm. This study describes a specimen from Margarita Island (Venezuela) which was 457 mm (TL). In addition to its substantial size, the specimen presented and uncommon series of calcified bony spinules at the lacrimal, suborbital, and preopercle ridge-spine of unclear function.

Keywords: alien fish, invasive species, lionfish, Caribbean Sea, osteology

The colonization process of the red lionfish, *Pterois volitans* (Linnaeus, 1758), has been well documented along the Gulf of Mexico and the Caribbean Sea (Chevalier et al. 2008, González et al. 2009, Morris and Akins 2009, Schofield 2009, 2010, Aguilar-Perera and Tuz-Sulub 2010, Lasso-Alcalá and Posada 2010, Ruttenberg et al. 2012, Ferreira et al. 2015, Sandel et al. 2015). Although cytogenetic, molecular, behavioural, and ecological studies of this species have been made (Cure et al. 2012, Nirchio et al. 2014, Coronado-Carrascal et al. 2015, García-Rodríguez et al. 2015), the size ranges reported for this species have not been well documented. The maximum total length of red lionfish reported by Randall et al. (1990) was 380 mm TL. However, there is no accompanying museum voucher specimen nor data regarding the precise location and time of capture to verify this record. Because numerous aspects of the biology of fish species are related to the size of the individual, the primary purpose of the presently reported results was to determine the maximum size of this species in the western Atlantic populations where it has been reported. The additional task of this paper was to describe for the first time uncommon calcified structure and number of the spinules at the spinal/ridge of three head bones.

A mature male red lionfish (Fig. 1) with a total length of 457 mm (388 mm SL) and weighing 1442 g was captured by an artisanal fisherman in the coastal waters (11°04′10″N, 64°19′44″W) off Margarita Island, Venezuela. Using features described by Schultz (1986), this specimen was identified as *Pterois volitans* (Linnaeus, 1758). To further document this record this specimen was deposited in the Ichthyological Collection of the Museo Marino de Margarita under the catalogue number MMM 1927. Measurements of this specimen were recorded to the nearest 0.01 mm using digital callipers (Table 1) and a wet weight for the specimen was recorded to the nearest gram using a digital balance. The skin of the head was then subsequently cleaned and removed to expose the configuration of the head bones and described using the osteological terminology of Eschmeyer (1965), Cervigón (1991), Matsunuma and Motomura (2013), and Matsunuma et al. (2016).

Countries in the vicinity of the Gulf of Mexico, the Caribbean Sea, the Greater and Lesser Antilles, have been monitoring lionfish populations over the last decade, and report a size increment for *Pterois volitans/miles* in the Gulf of Mexico and Caribbean Sea (as reported by different authors over time (Table 2); where these increased sizes may represent a "major ecological trend" that may be confirmed with more intensive monitoring at individual localities. Darling et al. (2011) mentioned a maximum length for *P. volitans* in the Caribbean Sea of 490 mm based on a personal communication made by James Morris. Another similar case occurred with an unpublished data of

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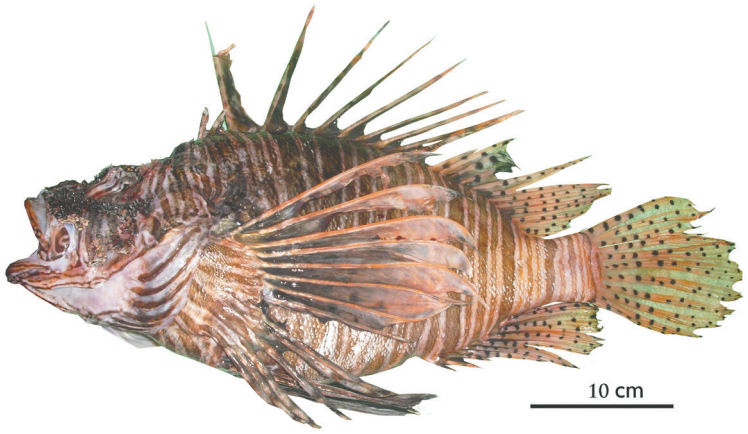

Fig. 1. Mature male specimen of Pterois volitans (457 mm TL) caught from the coastal waters of Margarita Island, Venezuela

Table 1
Absolute and relative values of basic biometric characters of the *Pterois volitans* specimen caught at the Margarita Island, Venezuela

	Character	Value	
		Absolute	% in TL
Morphometric measurements [mm]	Total length	457.1	
	Standard length	388.3	84.94
	Pre-pectoral fin length	127.2	27.78
	Pre-dorsal fin length	104.3	22.82
	Pre-anal fin length	235.4	51.50
	Post-pectoral fin length	118.5	25.92
	Total height	154.5	33.80
	Head height	109.4	23.93
Meristic counts	Dorsal fin rays	VIII + 11	
	Pectoral fin rays	14	
	Pelvic fin rays	I + 5	
	Anal fin rays	III + 7	
	Caudal fin rays	14	

TL = total length; Roman numbers denote number of (spiny) rays, while Arabic numbers denote number of soft rays.

a lionfish with a TL of 476 mm (Morris 2012). Nevertheless both specimens lack information regarding the precise location, year of capture, or museum voucher data. The previous maximum total length reported and confirmed for this species for the western Atlantic was 450 mm TL, based on a fish caught in 2004 in North Carolina, USA (Muñoz et al. 2011). In the Gulf of Mexico and Caribbean Sea waters a report of 424 mm TL from a specimen caught in 2009 from the Commonwealth of the Bahamas (Morris and Akins 2009). The Venezuelan specimen (457 mm TL) is by 7 mm longer or 1.5 percentage points (PP) larger than the USA specimen; 33 mm longer (7.22 PP larger) compared to the previous Bahamian reported specimen, and 77 mm longer (16.48 PP larger) than the 380 mm TL specimen reported by Randall et al. (1990). One biological explanation for this longer specimen could be attributed to feeding activity, where lionfish daily rations and size of prey in the Atlantic is greater than in the native range (Cure et al. 2012), furthermore owing to the lack of natural predator pressure in the Atlantic coast. Also these results are congruent with the hypothesis and results obtained previously, given that the population of this species in the Atlantic Ocean grow faster and larger compared to their native Pacific distribution, and that the males of *P. volitans* reach larger sizes than females, (Darling et al. 2011, Morris, 2012, Pusack, 2016).

Beside the fact of reported morphological changes associated with the growth rate, including the increase in numbers of almost all head spines and the number of spinules in many *Pterois* species (Matsunuma and Motomura 2013), other curious features of this specimen here described are the level of development from the bony ridge and number of spinules (Fig. 2) located at the lacrimal, suborbital and preopercle ridge/spine which is far greater than seen in the majority of other specimen of *Pterois volitans* (Fig. 3). The precise function of these structures is unknown, but may be associated with the reproduction. This adaptation may provide some competitive advantages over other males at the time of courtship and/or fertilizing the buoyant eggs masses before they ascend to the surface (Fishelson 1975, Morris 2012). Despite the scarce information available today regarding reproductive and matting process of *P. volitans*, there still exists a lack of understanding regarding the biology of this species in the western coast of the Atlantic Ocean. This can be resolved in the future with ethology studies from wild fish populations, through the use of ROV videos and/or the capture of deep-sea specimens, where SCUBA diving and hand collection is not possible.

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Table 2

Maximum length of *Pterois volitans* documented for the Gulf of Mexico and the Caribbean Sea, in a chronological order

TL [mm]	SL [mm]	Year	Country (locality)	Reference
450		2004	North Carolina (USA)	Muñoz et al. 2011
170		2007	Cuba	Chevalier et al. 2008
	295	2008	Bahamian Archipelago	Darling et al. 2011
424		2009	Bahamian Archipelago	Morris and Akins 2009
150		2009	Colombia (San Andrés Island)	González et al. 2009
215		2009	Venezuela	Lasso-Alcalá and Posada 2010
125		2010	Caymans Islands	Pusack et al. 2016
302		2010	Turks and Caicos Islands	Claydon et al. 2012
381		2010	Honduras (Roatán)	Biggs and Olden 2011
137		2010	Mexico (Yucatán)	Aguilar-Perera and Tuz-Sulub 2010
40		2010	Colombia (Bahía Chengue)	Arbeláez and Acero 2011
260		2010	Colombia (Guajira)	Martínez-Viloria et al. 2011
	185	2011	United States (Florida)	Jud et al. 2011
	226	2011	United States (Florida)	Huge et al. 2013
244		2011	Costa Rica	Sandel et al. 2015
340		2011	United States (Florida Keys)	Ruttenberg et al. 2012
385		2012	United States (Gulf of Mexico)	Fogg et al. (2013)
265		2012	Colombia (Santa Marta)	Muñoz-Escobar and Gil-Agudelo 2012
280		2012	Colombia (Santa Marta)	Coronado-Carrascal et al. 2015
377		2013	United States (Gulf of Mexico)	Dahl and Patterson 2014
250		2013	Mexico (Tabasco)	Wakida-Kusunoki and Amador del Ángel 2015
250		2014	Brasil (Rio Janeiro)	Ferreira et al. 2015
≈300		2015	Cuba	García-Rodríguez et al. 2015
375		2015	Mexico (Quintana Roo)	Sabido-Itzá et al. 2016
457		2015	Venezuela	This study

TL = total length, SL= standard length.

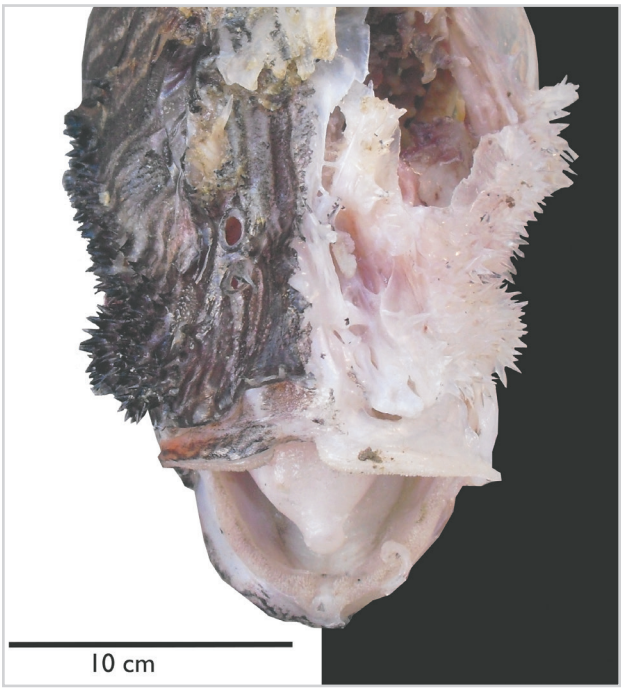

Fig. 2. Dorsal view of the head of the *Pterois volitans* specimen, showing the level of development of the bony ridge of some of the head bones on both sides

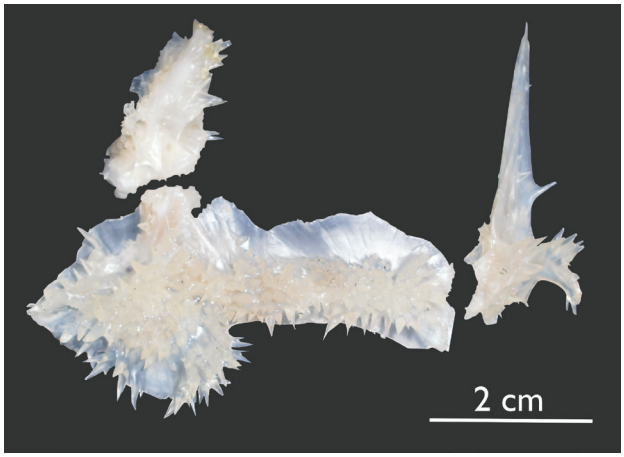

Fig. 3. Development of the bony spinules located at the lacrimal, suborbital, and preopercle ridge/spine from the head bones (the lacrimal and suborbital), may have at least three fused bones referred to in literature as first, second, and third infraorbital bones

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