

The lionfish *Pterois volitans* (Scorpaeniformes: Scorpaenidae) invades soft-bottoms: evidence from survey data

CAMILO B. GARCÍA^{1*} & MARIO RUEDA²

¹ Departamento de Biología, Universidad Nacional de Colombia, Carrera 30 # 45-03, Bogotá D.C., Colombia.

² Instituto de Investigaciones Marinas y Costera, INVEMAR, Calle 25 No. 2-55, Playa Salguero Santa Marta, Colombia.

*Corresponding author: cbgarciar@unal.edu.co

Abstract. The presence of the invasive fish *Pterois volitans* in soft-bottoms in the Colombian Caribbean Sea is documented for the first time. Records obtained from demersal surveys and shrimp trawling by-catch monitoring are given and the potential biological and ecological consequences for soft-bottoms assemblages discussed.

Key words: invasive fish, *Pterois volitans*, soft-bottoms

Resumen. El pez león *Pterois volitans* (Scorpaeniformes: Scorpaenidae) invade los fondos blandos: evidencia a partir de campañas. Se documenta por vez primera la presencia del pez invasor *Pterois volitans* en fondos blandos del Caribe Colombiano. Se aportan registros provenientes de campañas demersales y de monitoreo de pesca acompañante de arrastres camaroneros en el Caribe Colombiano. Se discuten las implicaciones biológicas y ecológicas potenciales para los ensamblajes de fondos blandos.

Palabras clave: pez invasor, *Pterois volitans*, fondos blandos

The lionfish (*Pterois volitans*, Linnaeus, 1758), native to the Indo-Pacific, has invaded the subtropical and tropical western Atlantic (Betancurt *et al.* 2011), reaching as far south as to the southeastern coast of Brazil (Ferreira *et al.* 2015). In Colombian Caribbean waters, the lionfish has been reported both from San Andres Islands archipelago (González *et al.* 2009) and from the mainland coast in a variety of shallow water habitats including mangrove (Arbeláez & Acero 2011), coralline (González *et al.* 2009) and estuarine areas (Viloria & Acero 2015). Due to its broad diet, rapid growth, high fecundity and lack of local predators it has been postulated as a new important factor of disturbance to Caribbean ecosystems (Hixon *et al.* 2016 but see Hackerott *et al.* 2017).

The perception of the lionfish as being a shallow-water inhabitant in mostly collarine environments is probably a consequence of the fact that in the area invaded most records and research come from depths reachable by divers as noticed by

Switzer *et al.* (2015). The lionfish, however, is capable of occupying soft-bottoms at considerable depths, both in its native range (Kulbicki *et al.* 2012) and in the invaded range (Switzer *et al.* 2015). In this work, the presence of lionfish in soft-bottoms in the Colombian Caribbean continental shelf is documented and the potential impact on the ecology of demersal communities discussed.

Georeferenced records come from on board monitoring of the shrimp trawl fleet in 2013 and 2014 and from fishery independent demersal surveys in 2015 and 2016 performed along the continental shelf of the Colombian Caribbean. Further details in Rueda *et al.* (2016). Records and associated environmental data are listed in Table I and occurrences shown in Figure 1. Its distribution encompasses the complete shelf. The lack of occurrences in the central area are the consequence of no hauls conducted there during the surveys. General characteristics of the hauls where lionfish were found, include: Mean depth is 59 m (range 14

TABLE I. Soft-bottom localities and associated environmental variables of the invasive fish *Pterois volitans* (the lionfish) in the Colombian Caribbean continental shelf. Temperature, salinity and oxygen refer to the bottom (Rueda *et al.* 2016)

Latitude	Longitude	Depth (m)	Temperature (°C)	Salinity (psu)	Oxygen (ml/l)	Year
9,27988	-76,16753	14				2013
9,02963	-76,42853	27				2014
8,66516	-77,29516	60	28,6	36,0	4,0	2015
8,77333	-77,16066	77	28,6	36,1	3,8	2015
9,24966	-76,39150	56	28,4	36,2	4,2	2015
9,02150	-76,53983	66	28,3	36,2	4,0	2015
9,83216	-76,15366	102	26,8	36,5	4,6	2015
12,30241	-72,00635	41	29,0	36,2	4,3	2016
12,25043	-72,33319	71	27,8	36,6	3,4	2016
12,18728	-72,41275	71	27,5	36,6	2,5	2016
12,08070	-72,47763	61	28,3	36,5	2,4	2016
12,15668	-72,49586	81	27,0	36,7	2,4	2016
12,01186	-72,56076	61	28,0	36,6	6,3	2016
12,02200	-72,74820	61	27,5	36,6	6,1	2016
11,89433	-72,75855	41	28,1	36,5	5,5	2016
11,84535	-72,88829	41	28,3	36,5	6,2	2016
11,78676	-73,09801	81	26,7	36,7	5,9	2016
11,68932	-73,10215	31	28,8	36,4	5,7	2016
11,49508	-73,23553	41	27,8	36,6	6,1	2016
11,44138	-73,37843	81	26,0	36,8	6,4	2016
11,38349	-73,44030	61	26,7	36,7	7,3	2016
11,34030	-73,43195	51	27,3	36,6	6,6	2016
11,34765	-73,58827	101	23,5	36,9	6,2	2016

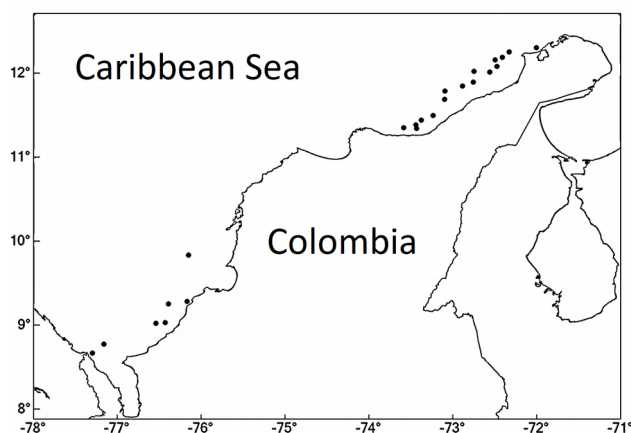


Figure 1. Colombian Caribbean georeferenced occurrences of the lionfish (*Pterois volitans*) in soft-bottoms. Data from demersal surveys and shrimp trawling monitoring in years 2013 to 2016 (Rueda *et al.* 2016).

to 102 m), mean bottom temperature is 27.6 °C (range 23.5 to 29.0 °C), mean bottom salinity is 36.5 psu (range 36.0 to 36.9 psu) and mean bottom oxygen is 4.8 ml/l (range 2.4 to 7.3 ml/l) (Table I). Notice that on the basis of 2896 occurrences in the invaded range Reyes-Bonilla *et al.* (2014) found a median depth occurrence of 21 m, a surface median temperature of 26.9 °C, a surface median salinity of 35.9 psu and a median surface oxygen of 4.6 ml/l.

Reyes-Bonilla *et al.* (2014) depth results confirm the assertion of bias in perceived depth occurrence of *P. volitans* in the invaded area. The other environmental variables are in proximity of observations in the present note.

As for when it did invade there are no records of *P. volitans* in Colombian Caribbean soft-bottoms before 2013 (García & Armenteras 2015), the year when it was first found in trawling from the shrimp fishery (Table I), whereas the first record in mainland shallow coralline areas in Colombian Caribbean dates back to 2009 (Gonzalez *et al.* 2009). Switzer *et al.* (2015) suggest that *P. volitans* invaded from the depth into shallow waters in the Eastern Gulf of Mexico. This does not seem to be the case in the Colombian Caribbean. Rather, the low incidence in 2013-2014 and the pattern of subsequent spatial expansion suggest the contrary for this area (Table II). In fact, in the course of four years its incidence has increased several orders of magnitude (Table II).

Species captured together with *P. volitans* in trawls amount to 99 species of fishes plus several invertebrate species. There is an estimate of 625 demersal soft-bottom fish species in the Colombian Caribbean (García 2018) and among them, a long

TABLE II. Incidence of the invasive fish (*Pterois volitans*) in soft-bottom hauls in the Colombian Caribbean Sea. Occurrences refers to the number of times all species were captured and refers only to fishes (Rueda *et al.* 2016).

Year	Hauls	% in Hauls	Occurrences	% in Occurrences
2013	44	2.3 % (1 in 44)	1029	0.1% (1 in 1029)
2014	17	5.9 % (1 in 17)	297	0.3 % (1 in 297)
2015	32	15.6% (5 in 32)	471	1.1 % (5 in 471)
2016	52	30.8 % (16 in 52)	779	2.1 % (16 in 779)

list of sharks and rays (García 2017). Thus, the potential for interspecific interactions is very high.

It is an intriguing question whether the traits described for *P. volitans* in the invaded range that come from observations and research in shallow coralline areas are valid for *P. volitans* in rather deep soft-bottoms. Thus, Green *et al.* (2011) found that *P. volitans* is more active eating in crepuscular times (dawn and dusk) and inactive in the night (22 to 05 hours) in shallow Bahamian coral reefs. The lionfish moves short distances and display high site fidelity in rocky reefs (Bacheler *et al.* 2015). Scorpaenidae in the Caribbean are not very voracious fishes with the family consumption to biomass ratio (Q/B) ranking down in a study of Caribbean fishes Q/B's including soft-bottom fishes (García & Duarte 2002). *P. volitans* shows the caudal fin typical of the family with an aspect ratio of approximately one, indicative of the rather sedentary habits and hunting strategy by ambushing prey. Most soft-bottom fish in the dark would escape *P. volitans*, thus its impact on soft-bottom communities as predator might not be as significant as postulated for coral reefs at least for fishes.

Two L_{∞} estimates for *P. volitans* exist for the Caribbean Sea. Farquhar (2016) reports 38.7 cm total length (TL) in Bonaire and Pusack *et al.* (2016) reports 32.2 TL in Caymans/Bahamas, but again for coralline habitats. García & Duarte (2006) reports L_{∞} values for 26 soft-bottom fish species in the Colombian Caribbean. After calculating total lengths from the original standard lengths in García & Duarte (2006, Table II) with factors provided in FishBase (Froese & Pauly 2018), it turns out that all these 26 fish species are bigger than halve the size of *P. volitans* in Cayman/Bahamas and the same is true for *P. volitans* in Bonaire with the exception of *Ctenosciaena gracilicirrhus* with an estimated L_{∞} of 18.2 cm TL. Considering that *P. volitans* eats fishes of maximal around 44% of its length (Alvin & Hixon 2008), most soft-bottom demersal fishes would escape in size from *P. volitans* predation.

In terms of trophic position *P. volitans* is regarded as a top predator (trophic position 4.2, Arias-Gonzalez *et al.* 2011, supplementary material)

in a reef in Campeche Bank which is a natural consequence of eating fish and not having predators. García & Contreras (2011), reports trophic positions of 119 fish species, the bulk of them demersal soft-bottom fishes. Of these as much as 40 species show trophic positions equal or above 4.0 (García & Contreras 2011, Table I) which, again, suggests that in soft-bottoms of Colombian continental Caribbean Sea *P. volitans* is exposed to a variety of potential predators and competitors.

In balance, *P. volitans* might not be as successful in invaded soft-bottoms as it appears to be in hard shallow bottoms. The fact remains, however, that in a few years it has increased its presence substantially in demersal hauls (Table II). Might it be that shallow water *P. volitans* are the sources of these invaders and that its presence in deep soft-bottoms is sustained by a spillover effect from those shallow populations?

Acknowledgments

The authors wish to thank AUNAP (Autoridad Nacional de Acuicultura y Pesca) and INVEMAR (Instituto de Investigaciones Marinas y Costeras) from Colombia for putting at our disposal the data used in this work (Agreements No 148-2015 and 196-2016).

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Received: July 2018

Accepted: August 2018

Published: December 2018