Check List the journal of biodiversity data

NOTES ON GEOGRAPHIC DISTRIBUTION

Check List 15 (5): 767–772
https://doi.org/10.15560/15.5.767

PENSOFT

New records and update on the geographic distribution of the Bony-eared Assfish, *Acanthonus armatus* Günther, 1878 (Ophidiidae, Neobythitinae), in the Caribbean region

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Abstract
Acanthonus armatus Günther, 1878 is reported for the first time in the southwestern Caribbean region, off Colombia. Remote Operate Vehicle videos and towed camera still photographs captured 13 images of *A. armatus* between 2215 and 2564 m. These are the first records of the species in the Caribbean continental coast of Colombia, representing a range extension to the southwestern Caribbean region, since previous records are from the northeastern Caribbean. Some photos of the specimens and the current distribution of the species in the Caribbean region are provided and reviewed.

Keywords
Acanthonus, Caribbean, range extension, ROV video survey, towed Camera, ultra-deep waters.

Academic editor: Arturo Angulo | Received 24 April 2019 | Accepted 16 July 2019 | Published 20 September 2019

Citation: Polanco F. A, Dueñas LF, Leon J, Puentes V (2019) New records and update on the geographic distribution of the Bony-eared Assfish, *Acanthonus armatus* Günther, 1878 (Ophidiidae, Neobythitinae), in the Caribbean region. Check List 15 (5): 767–772. https://doi.org/10.15560/15.5.767

Introduction

The ophidiiform family Ophidiidae includes four subfamilies with 50 genera and about 267 species (Nelson et al. 2016; Fricke et al. 2019). The subfamily Neobythitinae comprises 40 genera, including 190 species with only one species in the genus *Acanthonus* Günther, 1878 (Nelson et al. 2016; Fricke et al. 2019). Although *Acanthonus armatus* Günther, 1878 was first found and described based on a single specimen caught by the Challenger Expedition (Günther 1878) off New Guinea, it is widely distributed in tropical and subtropical latitudes (Nielsen 1965) with a known vertical range between 1171 and 4415 m (Mincarone et al. 2008). In the Caribbean region, knowledge of this species is based only on scarce and time-spaced records. The records include one specimen collected by the R/V Pillsbury cruise in 1968 off the coast of Venezuela (sta. 748, UF 230388, 1783–1865 m), one specimen caught on the 14th cruise of the R/V Akademik Kurchatov in 1973 (sta. 1232, 4090–4150 m), and recently recorded remote operated vehicle (ROV) videos from the expeditions of the R/V Nautilus (2014) and R/V Okeanos (2015) in the northeastern Caribbean between 1772 and 2760 m depth in four different localities (Mona Rift, Noroit Seamount, Guayanilla

Canyon, and Exocet Bank). In Colombia, the species was collected in the Pacific oceanic waters as the holotype of *Acanthonus spinifer* Garman, 1899, junior synonym of *A. armatus* (Nielsen 1965), by the USFC Steamer Albatross (sta. 3381, 3240 m, catalog number MCZ 28629), and in the Caribbean at the northeastern limit of the territorial waters, corresponding to the specimen caught by the R/V Akademik Kurchatov mentioned above.

The Bony-eared assfish *Acanthonus armatus*, is a deep-water benthopelagic fish, known to have the smallest brain, for its size, of any known teleost and probably any vertebrate (Fine et al. 1987). It reaches a maximum standard length of 37.5 cm (Nielsen et al. 1999). Additionally, it has large semicircular canals, brainstems and cerebella, and heavy saccular otoliths, conditions suggesting acute senses and sensibility to low-frequency sounds (Fine et al. 1987). *Acanthonus. armatus* is also one of the few deep-sea fishes that has lost its swimbladder (Suetsugu and Ohta 2004, Fine et al. 2018) and apparently forgone sound production due to this absence (Howes 1992). It has also developed a slightly negative buoyancy, but this appears to be offset by the presence of a low-density fluid in the cranium (specific gravity 1.008) (Horn et al. 1978; Fine et al. 1987). Both specializations [i.e. the reduction of certain morphological components (heavy tissues, brain and others) and improved senses] are consistent with the deep-sea pattern of low energy requirement, slow movement, and consumption of benthic preys in an unlighted environment (Fine et al. 1987). *Acanthonus armatus* has strong dentition and well-developed pharyngeal teeth indicating that it might be able to feed on large prey (Nielsen 1965). This deep-sea fish is presented as one of the discriminating benthivore species in the Lower North Atlantic Deep Water/ Labrador Sea Water mass (Quattrini et al. 2017).

Despite an overall scarcity of knowledge of marine deep-sea fishes in the Caribbean region, there has been much progress in the last two decades (Páramo et al. 2012; Polanco and Fernholm 2014; Polanco 2015; Polanco et al. 2017). However, fishes occurring below 1000 m depth are still poorly known and our knowledge of their distribution is restricted to few, largely historic records (Anderson et al. 1985). Here we report 13 new localities for *A. armatus* in the southwestern Colombian Caribbean from video sightings and photographs, expanding its distribution range for the whole Caribbean region.

Methods

During hydrocarbon exploratory activities in the Colombian Southern Caribbean, fish from the genus *Acanthonus* were sighted. These exploratory activities included ROV video surveys employing 80–100 m long transects in cross fashion, north, south, east, and west, from the exploratory well. Additionally, towed camera transects were employed taking still images every 2–3 seconds for a maximum of 4 hours in other exploratory sites of interest. All video footage and still images were analyzed for the presence of *Acanthonus*, and when found in the ROV videos, snapshots were taken. For every visual confirmation, the location coordinates, depth, time and date were registered (Dueñas and Puentes 2018).

Additionally, previous distribution records of *A. armatus* in the Caribbean region were searched (Fish specimen data used in this study obtained from the Florida Museum, http://www.fishnet2.net/, Rass et al. 1982, and Quattrini et al. 2017). Previous records and new reported localities were mapped to show the current distribution for the species. The map was created using ARCMAP 10.6 software (ESRI 2018).

Results

A total of 13 records of *A. armatus* were found in the search of existing records, all of them restricted to the northeastern Caribbean region and the Antilles (Table 1). These records included two samples obtained by trawling during the late 1960s and early 1970s (Rass et al. 1982; A.M. Prokofiev pers. comm.), and 11 recent sightings from ROV videos (Quattrini et al. 2017).

In this study, a total of 13 individuals of *A. armatus*, were identified from ROV videos and towed camera still images (Fig. 1). ROV video sightings (3 individuals) were registered approximately 80 km off the city of Cartagena de Indias (Bolivar) and 10 individuals were found in the towed camera images. Specimens were recorded at depths between 2215 m and 2564 m (Table 2) over soft bottoms, except for one registered swimming over authigenic carbonates, at the edge of a chemosynthetic community dominated by *Bathymodiolu*s Kenk and Wilson, 1985 mussels. The species has been reported in 25 different localities through the Caribbean region (Fig. 2), sometimes several individuals per locality as in Quattrini et al. (2017).

Table 1. Previous distribution records of *Acanthonus armatus* sightings during research expeditions using trawling nets, ROVs and drift cameras.

Method	Catalog no. / reference	Lat. (N)	Long. (W)	Depth (m)	Year	Locality	No. of individuals
41 ft otter trawl	UF 230388	11.410	067.170	1783–1865	1968	off coast of Venezuela	1
6 m Galathea trawl	Rass et al. 1982; A.M. Prokofiev pers. comm.	14.700	074.400	4090–4150	1973	Colombian Basin	1
Video recorded	Quattrini et al. 2017	18.740	067.570	1584–2903	2013	Mona Rift	1
Video recorded	Quattrini et al. 2017	18.090	064.000	964–2206	2014	Noroit Seamount	7
Video recorded	Quattrini et al. 2017	17.760	066.760	1687–2138	2015	Guayanilla Canyon	2
Video recorded	Quattrini et al. 2017	18.030	064.330	2384–2895	2015	Exocet Bank	1

Acanthonus armatus Günther, 1878

Figure 1

New records. Colombia ● Oceanic Caribbean (10.493° N, 076.210°W; 2344 m), Anadarko Colombia Company, 29/9/2015 (1 specimen, Image number 2264_L01). Oceanic Caribbean (10.467°N, 076.231°W; 2257 m), Anadarko Colombia Company, 10/1/2015 (1 specimen, Image number 3129_L06). Oceanic Caribbean (10.384°N, 076.322°W; 2377 m), Anadarko Colombia Company, 10/2/2015 (1 specimen, Image number 2718_L10). Oceanic Caribbean (10.388°N, 076.317°W; 2357 m), Anadarko Colombia Company, 10/2/2015 (1 specimen, Image number 2857_L10). Oceanic Caribbean (10.382°N, 076.306°W; 2235 m), Anadarko Colombia Company, 10/2/2015 (1 specimen, Image number 2948_L12). Oceanic Caribbean (10.453°N, 076.257°W; 2215 m), Anadarko Colombia Company, 24/2/2015 (2 specimens, ROV Video numbers VTS 01 1.VOB 000454718, VTS 01 1.VOB 000464389). Oceanic Caribbean (10.287°N, 076.441°W; 2564 m), Anadarko Colombia Company, 10/3/2015 (1 specimen, Image number 2673_L14). Oceanic Caribbean (10.291°N, 076.439°W; 2563 m), Anadarko Colombia Company, 10/3/2015 (1 specimen, Image number 2761_L14). Oceanic Caribbean (10.3°N, 076.446°W; 2524 m), Anadarko Colombia Company, 10/3/2015 (1 specimen, Image number 2827_L15). Oceanic Caribbean (10.494°N, 076.217°W; 2385 m), Anadarko Colombia Company, 29/9/2015 (1 specimen, Image number 2408_L04). Oceanic Caribbean (10.482°N, 076.223°W; 2372 m), Anadarko Colombia Company, 30/9/2015 (1 specimen, Image number 2688_L04). Oceanic Caribbean (10.483°N, 076.223°W; 2374 m), Anadarko Colombia Company, 30/9/2015 (1 specimen, Image number 2693_L04).

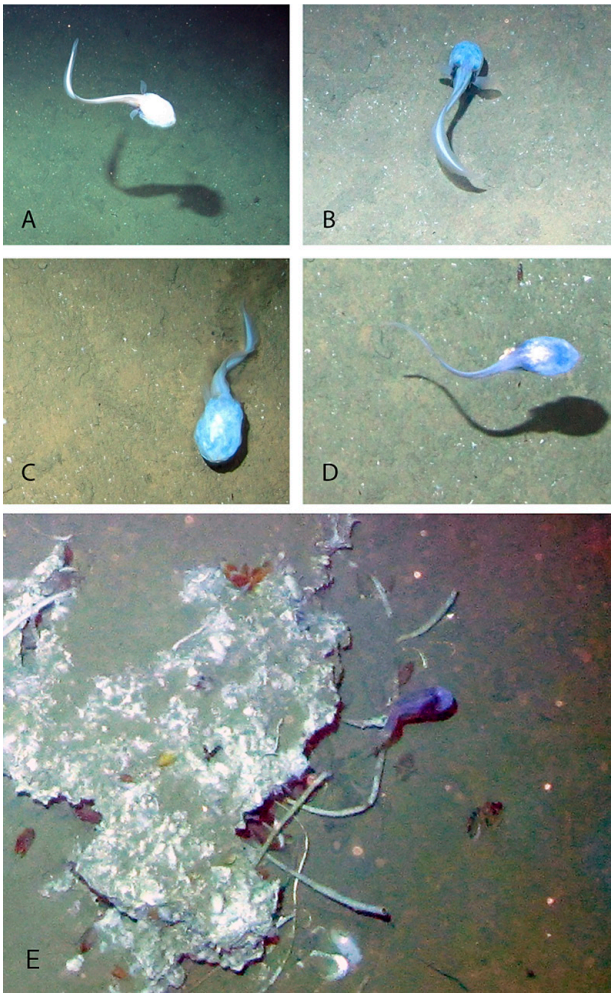

Figure 1. Example of images obtained for *Acanthonus armatus* during deep-sea hydrocarbon exploration activities in the southern Colombian Caribbean. **A.** Sighting at 2235 m deep. **B.** Sighting at 2377 m deep. **C.** Sighting at 2563 m deep. **D.** Sighting at 2357 m deep. **E.** Sighting at 2344 m associated to a chemosynthetic community.

Identification. The organisms found in the images (videos and still photographs) match the diagnostic features for *Acanthonus armatus*, as clearly observed in most specimens in the photos and videos available (Fig. 3). These diagnostic features include: (1) a tadpole body shape characterized by a large head and a long isocercal tail; (2) a snout with a prominent bifid spine and two long and slender conspicuous spines, one extending well beyond rear margin of head, and the other at lower angle of preopercle; (3) pelvic fin-rays reduced to a pair of simple filaments, which are placed close together on

Table 2. Information on *Acanthonus armatus* sightings during deep-sea hydrocarbon exploration activities using ROVs and drift cameras (Dueñas and Puentes 2018).

Method	Image	Lat. (N)	Long. (W)	Depth (m)	Time	Date (dd/mm/yyyy)
Towed camera	2264_L01	10.493	076.210	2344	17:03	29/9/2015
Towed camera	3129_L06	10.467	076.231	2257	7:46	10/1/2015
Towed camera	2718_L10	10.384	076.322	2377	2:16	10/2/2015
Towed camera	2857_L10	10.388	076.317	2357	3:52	10/2/2015
Towed camera	2498_L12	10.382	076.306	2235	14:28	10/2/2015
ROV	VTS 01 1.VOB 000454718	10.453	076.257	2215	9:30	24/2/2015
ROV	VTS 01 1.VOB 000464389	10.453	076.257	2215	9:30	24/2/2015
Towed camera	2673_L14	10.287	076.441	2564	1:37	10/3/2015
Towed camera	2761_L14	10.291	076.439	2563	2:24	10/3/2015
Towed camera	2827_L15	10.3	076.446	2524	5:25	10/3/2015
Towed camera	2408_L01	10.494	076.217	2385	19:35	29/9/2015
Towed camera	2688_L04	10.482	076.223	2372	20:33	30/9/2015
Towed camera	2693_L04	10.483	076.223	2374	20:35	30/9/2015

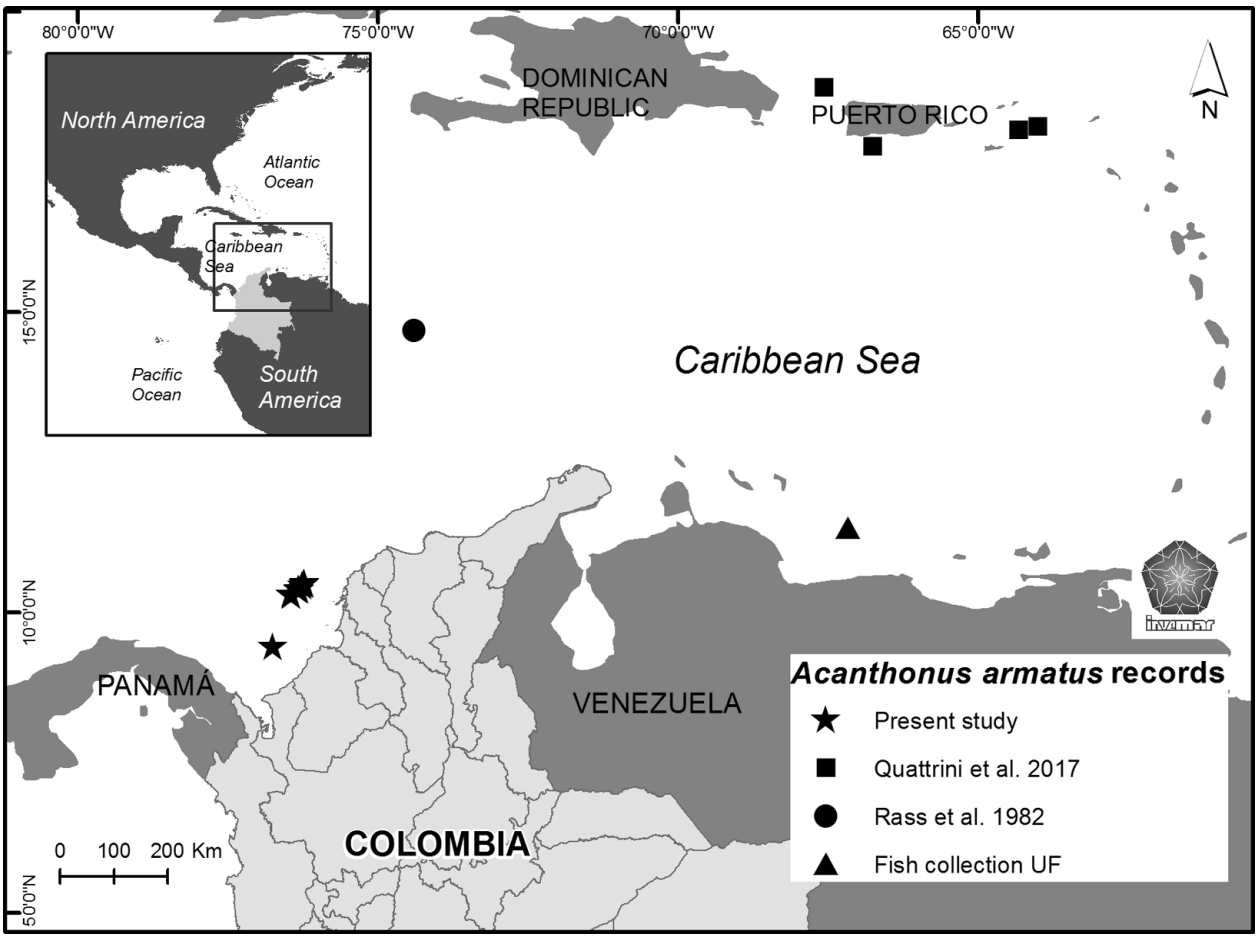

Figure 2. Distribution of *Acanthonus armatus*. The map includes the geographic location of previous records of the species (▲) R/V Pillsbury, (●) R/V Akademik Kurchatov, (■) R/V Nautilus and R/V Okeanos and (★) localities provided by this contribution.

the humeral symphysis (this last character is a diagnostic character of the species, but it was not possible to observe in all specimens given the position of the individuals in the photos and videos. Also, the tadpole swimming behavior of the individuals is typical of the species driving the large head by the undulating movements of the long tail.

Discussion

The present study expands the known distribution of *Acanthonus armatus* to the southwestern Caribbean, based on 13 sightings off the Colombian Caribbean. With this contribution, there are currently 26 records of *A. armatus* in the Caribbean region. The probability of detecting more specimens may increase if more sampling initiatives are developed in the area. As stated in the last complete review of the history of marine fish knowledge and discovery (Eschmeyer et al. 2010), the habitats that will contribute more new discoveries in this fauna group are those located in the deep sea. In the Caribbean, even with technological advances and increased deep-sea exploration during the last two decades (Polanco et al. 2017), a very small area of the deep sea has been examined. The exploration has been restricted to the upper-middle slope areas of the continental shelves of a limited number of countries. It is clear that the knowledge on deep-sea fishes in the region is still scarce (Diaz and Acero 2003; Miloslavich et al. 2010) and the extant species remain unpublished.

The use of ROVs and towed cameras can add valuable information on the distribution, behavior, live coloration and ecology of some deep-sea benthic species. Expeditions including ROVs and/or towed cameras give more information of the different types of habitats where the species can be found than traditional methods, such as data on basin walls, seamounts, canyons, ridge/banks (Quattrini et al. 2017), and, as in this study, chemosynthetic communities. The present work shows how the use of ROVs and towed cameras generates new knowledge about the deep-sea fauna of the Caribbean and highlight the need for underwater research below 1000 m depth.

Acknowledgements

Funding for the exploratory drilling project was provided by Anadarko Colombia Company (ACC), a subsidiary of Anadarko Petroleum Company (APC), and Ecopetrol. Other companies involved in the project were Dolphin Drilling which operated the Mobile Operating Drilling Unit (MODU), from which the ROV was operated by Subsea 7 (and its division I-TECH services); we thank

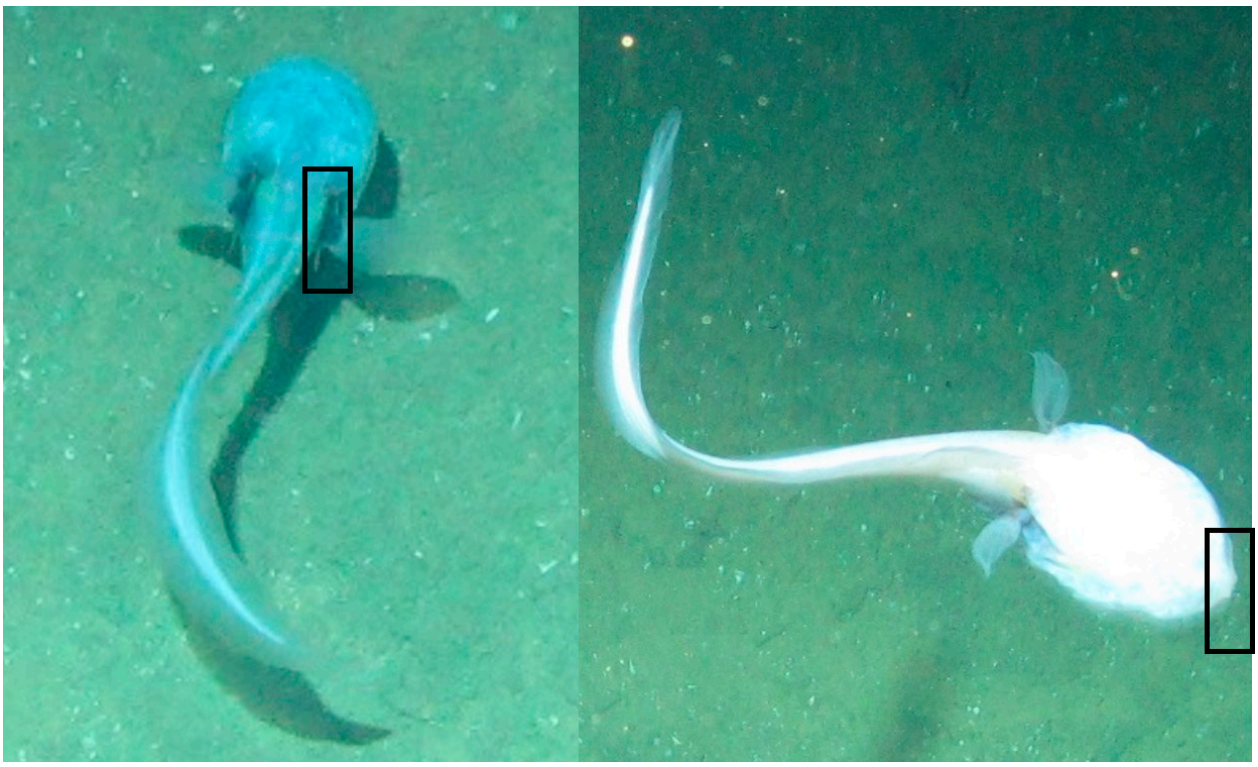

Figure 3. Diagnostic features of *Acanthonus armatus*. A tadpole body shape and the characteristic spines of the species framed in the black rectangles.

their technical staff for conducting the ROV surveys, for their willingness, time, and patience that made possible the images we worked with. Towed camera images were provided by CSA Ocean Science Inc., during additional exploratory studies. We want to thank Tim Tirlia and Bob Gregory of APC who approved sending videos for the analysis, and the COLCIENCIAS Post-Doctoral Program (Fondo Nacional de Financiamiento para la Ciencia, la Tecnología y la Innovación "Francisco José de Caldas", Convocatoria 2017, Número 784). Funds, analysis and identification of specimens was provided by Instituto de Investigaciones Marinas y Costeras-INVEMAR, Colombia. Thanks to Lina Vasquez (Information Systems Laboratory of INVEMAR) for her support in cartography and to Robert H. Robins, Collection Manager, Division of Ichthyology, Florida Museum and Eddie Borden (Anadarko) for English review. Contribution No.1227 of the Instituto de Investigaciones Marinas y Costeras – INVEMAR, Colombia.

Authors' Contributions

APF identified the specimens. APF, LFD and VP wrote the manuscript. JL provided the videos, photographs and the geographic information.

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