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New records of tropical littoral fishes from the Canary Islands as a result of two driving forces: natural expansion and introduction by oil platforms

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ABSTRACT

The presence of eleven non-native tropical species in the Canary Islands is reported. Seven of them (*Mycteroperca tigris, Epinephelus fasciatus, Chilomycterus spinosus mauretanicus, Muraena melanotis, Holacanthus africanus, Lutjanus griseus* and *Cirrhitus atlanticus*) are recorded for the first time from the archipelago. The other four (*Epinephelus adscensionis, Cephalopholis nigri, Chromis multilineata* and *Uraspis secunda*) had already been found at the Canaries and this is the second record. Characteristics for the identification of these species and biogeographic data are provided. Some of the species seem to have arrived the islands by their own means from nearby tropical areas, in a natural process of expansion of their original distribution areas. The rest of the cases probably have been introduced associated with oil-platforms.

Key words: new records, littoral fishes, non-native species, natural spread, introduced species, oil platforms, Canary Islands.

RESUMEN

Se estudia la presencia en Canarias de once especies de peces tropicales no nativas. Siete de ellas (*Mycteroperca tigris, Epinephelus fasciatus, Chilomycterus spinosus mauretanicus, Muraena melanotis, Holacanthus africanus, Lutjanus griseus* y *Cirrhitus atlanticus*) se registran por primera vez en el archipiélago. Las otras cuatro (*Epinephelus ads-*

censionis, Cephalopholis nigri, Chromis multilineata y *Uraspis secunda*) ya habían sido encontradas previamente y éste es el segundo registro. Se aportan datos biogeográficos y características para la identificación de cada especie. Algunas de ellas parecen haber llegado a las islas por sus propios medios, en un proceso natural de expansión de sus áreas de distribución originales. El resto probablemente han sido introducidas asociadas a plataformas petrolíferas.

Palabras clave: nuevas citas, peces litorales, especies exóticas, expansión natural, especies introducidas, plataformas petrolíferas, Islas Canarias.

1. INTRODUCTION

The littoral ichthyofauna from the Canary Islands has experienced an obvious tropicalization process, particularly since the 90s (BRITO et al., 2005), resulting in the occurrence of a great number of termophilic species of tropical origin. This process, analyzed and documented recently by FALCÓN (2015) and BRITO *et al.* (2017), has several patterns to consider. Most of the species are benthic or benthopelagic and some have been successfully settled in the area (BRITO *et al*., 2005; ESPINO *et al*., 2015 b; FALCÓN, 2015; FALCÓN *et al*., 2015; TRIAY-PORTELLA *et al.*, 2015; BRITO *et al*., 2017). The process of tropicalization is clearly linked to the increasingly warm water temperatures registered in these areas as a result of climate change. Many of the species seem to have arrived the islands by their own means from nearby tropical areas, in a natural process of expansion of their distribution areas, but introductions owing to anthropogenic activities have also been significant. In the Canary Islands, the occurrence of certain thermophilic species close to or in the surroundings of main harbours has been attributed to maritime traffic as introduction vector (ballast water transport and associated fish to oil platforms) (BRITO & FALCÓN, 1996; BRITO *et al*., 2005; BRITO *et al*., 2011; ESPINO *et al*., 2015 a; FALCÓN, 2015; FALCÓN *et al.*, 2015; TRIAY-PORTELLA *et al.*, 2015; PAJUELO *et al*., 2016; BRITO *et al*., 2017).

In the present paper, we report the presence of seven species of tropical origin for the first time in the Canaries, and also the second record of other four non-native tropical species, based mainly on photographs. Furthermore, characteristics for the identification of these species and biogeographic data are provided. We also discuss about the possible via of arrival of these species and about the process of tropicalization of the Islands.

2. MATERIAL AND METHODS

Fishes were captured and/or photographed in the field. Part of the images and information comes from photographs and direct observations made by the authors during diurnal scientific dives in the main harbours of the Canary Islands (the ports of Las Palmas de Gran Canaria and Santa Cruz de Tenerife) and their surroundings, under the framework of the project MIMAR (MAC/4.6D/066), financed under the INTERREG V-A MAC 2014-2020 Programme. The rest of the images and data examined were provided by the Red-Promar network belonging to the Regional Government of the Canary Islands (http://www.redpromar.com/) – a tool comprised by observers using the ‘citizen science’

concept to monitor the marine biodiversity –, as well as directly from their authors. Information on materials examined (e.g. number of individuals, size, location, date, depth, type of habitat, etc.) is included in the Results section, below the name of the species.

We were able to examine in detail only one specimen of *Uraspis secunda*. The rest were indentified based on photographs and/or direct observations in the field. The photo-identification is perfectly applicable in the case of many littoral fishes, except for some small ones belonging to groups of difficult identification (such as gobies or cleanfishes), when the images allow to see the the distinctive species-specific features with absolute certainty, as in this case. The external well-visible morphology and/or colour pattern was compared to data from the literature (ALLEN, 1985; BÖHLKE *et al*., 1989; HEEMSTRA & RANDALL, 1993, 1999; CARPENTER, 2002; LEIS, 2006; CARPENTER & De ANGELIS, 2016; FROESE & PAULY, 2018).

During the scientific dives, the size of the fishes was estimated *in situ* to the nearest centimeter of total length (TL). The experience indicates that after a moderate amount of training, observers are able to accurately estimate size underwater especially when aided with a ruler attached to the recording slate (BORTONE *et al*., 1991), as we made. For the species identified from photographs not made by us, the size of specimens was indirectly estimated, when possible.

3. RESULTS

Family Serranidae

Mycteroperca tigris (Valenciennes, 1833) (Figure 1 A)

One adult individual (50 cm TL) caught by spearfishing at 20 m of depth at the outer part of dock Reina Sofía, (28° 8.27'N 15° 24.39'W, Port of Las Palmas de Gran Canaria) on February 2018.

The study of the two photos available allowed us to identify the species by its colour pattern as described by HEEMSTRA & RANDALL (1993) and HEEMSTRA *et al*. (2002): adults greenish brown to brownish grey with close-set, small, brown or orange-brown spots, the interspaces forming a pale green or whitish network; head and body darker dorsally, with 9 to 11 alternating oblique pale stripes and broader dark bars; median fins with irregular pale spots and stripes; pectoral fins pale yellow distally.

This species occurs in coral reefs and rocky areas and is considered an ambush predator (FROESE & PAULY, 2018). It is distributed in the western Atlantic from Bermuda, south Florida, Gulf of Mexico, West Indies to southern Brazil (HEEMSTRA *et al*., 2002). This is the first record outside its natural area of distribution.

Epinephelus fasciatus (Forsskål, 1775) (Figure 1 B)

One individual (30 cm TL) caught during the day angling from a boat on 6th June 2018, close to the Oceanic Platform of the Canary Islands (PLOCAN), located close to the Port of Las Palmas (28° 2.48'N 15° 23.12' W, Gran Canaria), over a rocky bottom of 30 m of depth. The fisherman returned the specimen to the sea after photographed and filmed.

This species is easily distinguishable by its colour pattern: ground colour varying from pale greenish grey, to pale reddish yellow to scarlet; body often with 5 or 6 faint dark bars, the last on peduncle; body scales (except ventrally) with pale centre and dark rear margin, producing a faint checked pattern; fins reddish orange, pale yellowish green, or greenish brown, the outer triangular part of interspinous membranes of dorsal fin black with pale yellow or white spot behind tip of each spine (HEEMSTRA & RANDALL, 1993; HEEMSTRA & RANDALL, 1999).

Epinephelus fasciatus is a coral o rocky reef-associated species that is common in outer reef slopes at depths below 15 m to 160 m, although it may be found in protected bays and lagoons as shallow as 4 m (FROESE & PAULY, 2018). It is an Indo-Pacific species ranging from the Red Sea and western Indian Ocean (south to Port Alfred) to Fremantle, Western Australia, and in the Pacific it ranges from Japan and Korea to southern Queensland and Lord Howe Island and eastward to the Pitcairn Islands. It occurs at most (virtually all) of the tropical and subtropical islands of the Indian Ocean and the west-central Pacific (HEEMSTRA & RANDALL, 1993; HEEMSTRA & RANDALL, 1999). Despite this is one of the two most widely distributed species of grouper in the world, this is the first record outside the Indo-Pacific region.

Epinephelus adscensionis (Osbeck, 1765) (Figure 1 C)

One adult individual (45 cm TL, 2.5 kg of total weight) caught at Baja de las Monjas (28° 9.99'N 15° 26.63'W, La Isleta, Gran Canaria), located very close to the Port of las Palmas, on 18th April 2018, using a fish trap, over a rocky bottom at 15 m of depth. The fish was consumed and there is only one photo available, in which it can be identify other local fish species (*Diplodus sargus, Epinephelus marginatus, Pagrus auriga* and *Pagellus erythrinus*).

The exam of the image confirmed the identity of this species by its colour pattern: head, body and fins yellowish or pale greenish, covered with reddish brown spots and scattered pale blotches, and some (usually 3 to 5) dark brown blotches (groups of dark spots) at base of dorsal fin and a blackish brown saddle blotch on caudal peduncle (HEEMSTRA & RANDALL, 1993; HEEMSTRA *et al.*, 2002; HEEMSTRA & ANDERSON, 2016).

This is a demersal, solitary fish that inhabits rocky reefs from shore-line to about 100 m, being essentially a coastal species (HEEMSTRA & ANDERSON, 2016). Juveniles can be found in rocky intertidal pools (LUBBOCK, 1980). *E. adscensionis* is a wide-ranging species known from both sides of the Atlantic Ocean. In the western Atlantic, it has beens reported from Bermuda, Massachusetts (1 record), North Carolina to Florida, Gulf of Mexico, and the Caribbean to southern Brazil; very common at Ascension Island and St. Helena, where it is of major importance in the fisheries; it is also known from São Tomé and Príncipe, Gulf of Guinea, in the tropical Eastern Atlantic (HEEMSTRA & RANDALL, 1993; HEEMSTRA *et al.*, 2002; HEEMSTRA & ANDERSON, 2016).

This species was previously reported from the Canary Islands by FALCÓN *et al.* (2015), tentatively identified as *Cephalopholis* cf. *cruentata* (Lacepède, 1802), based on a photograph of a specimen caught by a spear fisherman in the southern area of Gran Canaria (between Tauro and Taurito) in 2012. Up to date, records from the Canaries are the northernmost ones for the species in the Eastern Atlantic.

Cephalopholis nigri (Günther, 1859) (Figure 1 D)

One individual of (25 cm TL) photographed and sighted by two of the authors at the end of dock Reina Sofía (28° 7.27'N 15° 24.28'W, Port of Las Palmas de Gran Canaria) on 23th June 2018, during a scientific dive of the MIMAR project. Oil platforms and drilling ships are docked very close to the site where the individual was found. The specimen was observed at 25 m of depth, hidden among cement blocks without any erect macroalgae, as a result of overgrazing by the sea urchin *Diadema africanum*. It showed a timid and elusive behaviour towards the divers. Very close to the site where the specimen was found, many species are concentrated in the surroundings, including some typical species of the hard substratum of the Canary Islands (e.g. *Thalassoma pavo, Chromis limbata, Similiparma lurida, Canthigaster capistrata, Sparisoma cretense, Diplodus spp., Pagrus auriga, Mycteroperca fusca, Bodianus scrofa, Sarpa salpa, Ophioblennius atlanticus*), some pelagic or semi-pelagic species (e.g. *Boops boops, Oblada melanura, Campogramma glaycos*) and several tropical non-native species, such us the acanthurids *Acanthurus monroviae, A. coeruleus* and *A. chirurgus*, the serranid *Cephalopholis taeniops* and the pomacentrids *Abudefduf saxatilis* and *Chromis multilineata*.

According to HEEMSTRA & ANDERSON (2016), the specimen has a colour pattern with some characteristics attributed to adults, such us body dark brownish with 3 or 4 indistinct dark bars extending onto dorsal fin and 2 more on caudal peduncle, belly reddish (more visible *in situ* than in the photo), tail fin with pale margin and interspinous dorsal fin membranes with tiny black spot behind tip of each spine, but it do not show the sides of head with a reticulated pattern of hexagonal reddish spots separated by dark lines, as indicated by the mentioned authors; however, it has red spots all over head and body, attributed to juveniles.

Cephalopholis nigri is a demersal species that inhabits sandy, muddy and rocky bottoms to a maximun deph of 100 m, ussually above 50 m, and that can be occassionally found in stuaries (HEEMSTRA *et al.*, 2002; HEEMSTRA & ANDERSON, 2016; FROESE & PAULY, 2018). It is known from the tropical Eastern Atlantic, from Senegal to Angola, including São Tomé and Príncipe (not recorded from Cabo Verde Islands) (HEEMSTRA *et al.*, 2002; HEEMSTRA & ANDERSON, 2016), and it had also been recorded from the Canary Islands, based on a specimen caugth in 1988 at the port of Santa Cruz de Tenerife (BRITO, 1991).

Family Diodontidae

Chilomycterus spinosus mauretanicus (Le Danois, 1954) (Figure 1 E)

One individual (25 cm TL) sighted and photographed at La Caleta de Adeje (28° 5.98'N 16° 45.39'W, southwest of Tenerife) on 14th May 2018, hidden among rocks at 7-8 m of depth.

The exam of the photo available permited us to observe some of the characteristics that identify the genus and species, such us the relatively small spines of back and sides fixed in an erect position, fleshy tentacles laterally on head and trunk and tentacles above eyes absent or small, and also the color pattern of the subspecies: dorsal background dark

olive brown with diffuse lighter spots and three characteristic large dark blotches on back and sides (above and behind pectoral and under dorsal fin base), but no small black spots interspersed, with irregular, wavy, diagonal lines on sides of head and trunk, and no spots on fins (LEIS, 2006; LEIS, 2016). In the Western-Central Atlantic, there is a sister species, *C. s. spinosus*, which is distinguished by no having black line on sides of head and trunk (LEIS, 2006).

The genus *Chilomycterus* is represented in the Eastern Atlantic by two species: *C. reticulatus*, that presents a circumtropical distribution (LEIS, 2006; FROESE & PAULY, 2018), inluding the Canary Islands (BRITO *et al*., 2002), and *C. spinosus mauretanicus*, known from Cabo Blanco (Mauritania) to Angola. The record of the latter species from Portugal (LEIS, 2006; CARNEIRO *et al*., 2014) needs confirmation, but recently it has been recorded from the Alboran Sea, western Mediterranean (GARRIDO *et al*., 2014). It had also been cited wrongly from the Canary Islands (LEIS, 2006; LEIS, 2016) but this is the first confirmed and valid record of this subspecies in the archipelago. It is a demersal species that occurs on the shelf mainly on sandy or muddy, but also rocky, bottoms from coastal waters to about 190 m of depth (LEIS, 2016). The ability of the family Diodontidae to travel long distances under drifting floating objects is known (LUIS *et al*., 2015).

Family Muraenidae

Muraena melanotis (Kaup, 1859) (Figure 1 F)

One individual sighted and photographed during a diurnal scuba dive at Radazul (28° 24.01'N 16° 19.44'W, Tenerife) on 26th July 2018, hidden among rocks at 12 m of depth.

Despite the fact that the moray had only the anterior part of the body exposed, it was enough to confirm the identification by large posterior nostril and the colour pattern, as described by SMITH & BRITO (2016): dark brownish black with pale round spots as large as or larger than eye (smaller on head), spots very close together, giving a honeycomb appearance, belly pale with few or no spots, posterior nostril tube white and gill opening in bold black blotch.

Muraena melanotis is a demersal species that lives on rocky bottoms from 0 to 60 m of depth. Like all moray eels, it has a pelagic leptocephalus larva of long duration, which allows a great dispersion. It is widely distributed in the eastern tropical Atlantic from Mauritania to Namibia, including Cabo Verde Islands and the islands of the Bay of Biafra (SMITH & BRITO, 2016), and it has also been recorded occasionally from St. Paul's Rocks, Fernando de Noronha Archipelago and Rocas Atoll, in the southwestern tropical Atlantic (FEITOZA *et al.*, 2003; PINHEIRO *et al*., 2018). Up to date, this is the northernmost valid record for the species; previous records from the Canary Islands are erroneous (SMITH & BRITO, 2016).

Family Pomacanthidae

Holacanthus africanus Cadenat, 1951 (Figure 2 A)

An adult of 23 cm TL sighted, photographed and filmed by several of the authors at 18 m of depth at the outer central part of dock Reina Sofía, (28° 7.97'N 15° 24.41' W, Port of Las Palmas de Gran Canaria) on 20th June 2018, during a scientific dive of the MIMAR project. The individual was among rocks of the breakwater and showed a relatively curious behaviour towards the divers but without allowing an excessive approach. The rocky substratum was an urchin-grazed barren, as a result of overgrazing by the sea urchin *Diadema africanum*. Some characteristic fish species associated with this habitat in the Canary Islands were abundant here (e.g. *Chromis limbata, Similiparma lurida, Thalassoma pavo, Canthigaster capistrata, Ophioblennius atlanticus*).

In all the available images, the body colour (three large bands alternatively brownish, yellowish whitish, brownish, with a dark spot above the pectoral-fin base, and also the mouth and all fins (yellowish), are clearly observed. This colour pattern corresponds to an adult individual (BAILLY, 2016).

This is a littoral species that occurs among rocks between 1 and 40 m. Little is known about its biology. It is distributed in the tropical eastern Atlantic from Senegal to Democratic Republic of the Congo, including Cape Verde Islands and São Tomé Island (BAILLY, 2016). This record from the Canary Islands is the northernmost one known for the species.

Family Lutjanidae

Lutjanus griseus (Linnaeus, 1758) (Figure 2 B)

One individual (27 cm TL) photographed and sighted by two of the authors at 18 m depth in a dock of the inner area of the Port of Las Palmas de Gran Canaria (28° 7.70'N 15° 24.74'W, Gran Canaria) on 5th July 2018, during a scientific dive of the MIMAR project. It was over an artificial hard substratum formed by blocks, boulders and gravel, covered in part by mud and some turf-forming macroalgae. The specimen was actively swimming 0.5-1.5 m over the bottom and showed a relatively elusive behaviour towards the divers, making it difficult to take a high quality photo. In the surroundings, many fish species (but few individuals) were observed. These include some species very abundant in natural rocky bottoms of the Canary Islands (e.g. *Thalassoma pavo, Chromis limbata, Similiparma lurida, Canthigaster rostrata, Diplodus sargus, Chelon labrosus*), other less common (e.g. *Pomatomus saltatrix, Kyphosus sectatrix, Diplodus annularis, Diplodus puntazzo, Serranus scriba*), and also two non-indigenous fish species: the European seabass, *Dicentrarchus labrax*, which has small nativel populations in the eastern islands (Lanzarote and Fuerteventura) and that has been introduced to the central and western islands of the archipelago through aquaculture (BRITO *et al.,* 2002; TOLEDO-GUEDES *et al.,* 2009, 2014a, 2014b; Ramírez *et al*., 2015), and the Sergeant-major, *Abudefduf saxatilis*, presumably introduced through oil platforms (FALCÓN, 2015; TRIAY-PORTELLA *et al.,* 2015; PAJUELO *et al.,* 2016).

The only photo available and a detailed observation by the first author during several minutes permitted us to confirm the identity of the species by its colour pattern, according to ALLEN (1985) and ANDERSON (2002): body greyish with orange or reddish tinges, with no dark lateral spot below anterior part of soft dorsal fin, and fins greyish; it also showed two characteristics of young specimens, such as a broad oblique dark stripe on head running from tip of snout through eye towards base of spinous dorsal fin and a withish blue line (interrupted in our specimen) on cheek below eye. The specimen also presented two characteristics not described by the mentioned authors but that could be typical of the species, since they are observed in almost all the photos published online: margins of dorsal and caudal fin distinctly blackish and body scales on back and sides with the center darker than their edges, giving the appearance that to have dark points along the body.

Adults inhabit coastal as well as offshore waters around coral reefs, rocky areas, estuaries, mangrove areas, and sometimes in lower reaches of rivers (especially the young) (ALLEN 1985; ANDERSON 2002; FROESE & PAULY, 2018). This species is native to the tropical and subtropical western Atlantic, distributed from Massachusetts to the Caribbean, including Bermuda and the Gulf of Mexico, more common from Florida to the south. Records from Brazil are based on misidentifications (FROESE & PAULY, 2018). There are some dubious records of vagrants individuals in the Gulf of Guinea, although they are probably based on misidentifications, and the most recent work does not include it among the lutjanids present in the eastern Atlantic (CARPENTER, 2016). So, this is the first confirmed and valid record from this side of the Atlantic.

Family Cirrhitidae

Cirrhitus atlanticus Osório, 1893 (Figure 2 C)

One individual (30 cm TL) sighted, photographed and filmed by one of the authors between 6 and 9 m of depth at the outer central part of dock Reina Sofía, (28° 7.98'N 15° 24.42' W, Port of Las Palmas de Gran Canaria) on 9th October 2018, during a scientific dive of the MIMAR project. It was leaning on its pectoral fins on a block of the breakwater at 6 m, probably watching for preys, and moved deeper among the blocks when the diver approached it. During the same dive, three other non-native species (*Abudefduf saxatilis, Acanthurus monroviae* and *Acanthurus chirurgus*) were observed only a few tens of meters around. The individual was sighted very close to the point indicated for the specimen of *Holacanthus africanus* previously seen on June (see above for description of the bottom and species seen in the surroundings).

The colour pattern agrees in general quite well with the one described by ROCHA (2016) for the species: body dark brown, the upper posterior half darker; 6 white blotches at base of dorsal fin (the last 4 more conspicuous; the second very little visible in our specimen); the 2 larger white spots are the fourth (at base of first dorsal ray) and the last (at posterior half of caudal peduncle); a row of 3 or 4 (five in our specimen) white spots on upper anterior portion of body, in a line behind the eye; a third row of white spots just below lateral line, from behind the opercle to caudal peduncle; a series of pale brown stripes on head radiating from eye. It is possible that the few differences indicated in the number of

white blotches are due the size of the specimen; maximum total length known is 19.2 cm (RANDALL, 1963), but the estimated size for our specimen was about 30 cm.

C. atlanticus is found at depths between 5 to 10 m. Little is known about its biology. It is distributed in the tropical eastern Atlantic, only known from São Tomé and Príncipe, Annobon Islands and Ghana (ROCHA, 2016), and it has also been identified as inhabiting the waters off Mayumba, Gabon (CARPENTER *et al.*, 2015).

This record from the Canary Islands is the northernmost one for the species and the first known outside the Gulf of Guinea; although the size was estimated *in situ* and may have some degree of inaccuracy, it is also clearly the largest specimen known to date.

Family Pomacentridae

Chromis multilineata (Guichenot, 1853) (Figure 2 D)

Six individuals (between 10 and 12 cm TL) sighted at the end of dock Reina Sofía (28° 7.28'N 15° 24.27'W, Port of Las Palmas de Gran Canaria) on 23th June 2018; two individuals (both 10 cm TL) sighted and photographed at the inner area of the same dock (28° 8.08'N 15° 24.46'W) on 5th July 2018. All specimens were observed during two scientific dives of the MIMAR project by some of the authors of the present paper. The first six were found actively swimming between 20 and 25 of depth (1-3 m over the bottom) forming a small mixed school whith the native pomacentrid *Chromis limbata*, in the same area indicated for *Cephalopholis nigri* (see above for description of the bottom and species seen in the surroundings). The other two individuals were seen swimming in pair over an artificial hard substratum of boulders and gravel, covered in part by mud and some turf-forming macroalgae, at a depth of 5 m (usually 0.5-1 m over the bottom and sometimes among the rocks). Other fish species seen in the surroundings were *C. limbata, Thalassoma pavo, Similiparma lurida, Canthigaster rostrata, Chelon labrosus, Diplodus sargus* and *Sarpa salpa*, among others typical form this type of habitat in the Canaries, and also another non-native pomacentrid, *Abudefduf saxatilis* (a group of 6 individuals).

All the specimens sighted showed a pattern colour typical of the eastern Atlantic form of *C. mulitilineata*, characterized by a body bluish grey or greyish becoming slightely paler ventrally, with a large black spot in axil of pectoral fin, upper and lower margins of caudal fin dark, and edge of dorsal fin distintly dark, almost black; some individuals showed a bright yellow spot immediately behind last dorsal fin ray. This pattern differs from the western Atlantic form in not having margins of dorsal and anal fins, as well as central portion and tips of caudal fin, yellow or clear, as described by CARTER (2002).

This species can be found a wide range of habitats from a depth of 1 to 60 m, but mainly in hard substratum, where it forms moderate-sized feeding-schools over reef tops, rising above the bottom to feed on plankton (CARTER, 2002; FROESE & PAULY, 2018). It is distributed in tropical and subtropical waters of both sides of the Atlantic (FROESE & PAULY, 2018). The eastern and western Atlactic populations of *C. multilineata* are genetically distinct, but the distinction is below the species level (ROCHA *et al.*, 2008).

Chromis multilineata was recorded for the first time from the Canaries by FALCÓN *et al.* (2015), based on a photographs of three specimens seen in June 2015 in the

outer area of the same dock than the ones reported herein. At present, these are the northernmost records for the species in the Eastern Atlantic.

Family Carangidae

Uraspis secunda (Poey, 1860) (Figure 2 E-F)

One adult individual (58 cm TL) caught by spearfihing at Radazul (28° 24.00'N 16° 19.41'W; Tenerife) on 17 September 2018, at 18 m of depth over a rocky bottom.

Although the specimen had been previously eviscerated to be consumed, the fisherman finally gave it to us and we were able to examine it in detail, presenting the same characters attributed to the genus and species by SMITH-VANIZ (2016), including the colour of the interior of the mouth (tongue, roof and floor of mouth white or cream coloured, the rest blue-black.). Anyway, according to this author, adults of *U. secunda* and *U. helvola* (Forster, 1801) are virtually impossible to distinguish, although juvenile characters involving allometric growth patterns suggest that they may be distinct species. If subsequent studies indicate that these two nominal species are conspecific, the oldest available name is *Uraspis helvola*.

U. secunda is mainly a pelagic oceanic species with pantropical distribution; in the eastern Atlantic it has been recorded from the Cape Verde Islands and outer parts of continental shelf and slope from Mauritania to Angola (SMITH-VANIZ, 2016). It has been recently recorded from the Canary Islands by BRITO *et al*. (2017). These are the northernmost records for the species in the Eastern Atlantic up to now.

4. DISCUSSION

In the present paper, we report the presence of eleven non-native tropical species in the Canary Islands. Seven of them (*Mycteroperca tigris, Epinephelus fasciatus, Chilomycterus spinosus mauretanicus, Muraena melanotis, Holacanthus africanus, Lutjanus griseus* and *Cirrhitus atlanticus*) are recorded for the first time from the archipelago. The other four (*Epinephelus adscensionis, Cephalopholis nigri, Chromis multilineata* and *Uraspis secunda*) had already been found at the Canaries and this is the second record. *M. melanotis, H. africanus, C. atlanticus* and *C. spinosus mauretanicus* were previously known only from the tropical Eastern Atlantic (CARPENTER & De ANGELIS, 2016; FROESE & PAULY, 2018), being these the northernmost records for each species, except for the last one, recently recorded from western Mediterranean (GARRIDO *et al*., 2014). *C. nigri*, that was recorded from the Canaries by BRITO (1991), is another species distributed in the eastern Atlantic and with the Islands as northern limit. Up to date, the archipelago also continues been the northernmost knwon limit in the eastern Atlantic for two species of tropical Amphi-Atlantic distribution, *C. multilineata* and *E. adscensionis*, as well as one pantropical species, *U. secunda*. For *M. tigris* and *L. griseus*, two species of western tropical and subtropical Atlantic origin, this is the first time that they are found in this side of the ocean. Finally, this is the first record from the Atlantic of *E. fasciatus*, an Indo-Pacific species.

The littoral ichthyofauna of the Canary Islands has experienced a tropicalization process since the late 80s and the early 90s, that seems directly related to the increasing of sea water temperature (BRITO *et al*., 2005; FALCÓN, 2015; FALCÓN *et al*., 2015; BRITO *et al*., 2017). The sea surface temperatures of Canary Islands have increased due to the climate change, with and average value of 0.28 °C per decade for the period covering from 1982 to 2013, more markedly during the wintertime, resulting in a current sea surface temperature range of 17-25 ºC and an average value of 21 ºC (VÉLEZ *et al*., 2015). Unquestionably, this scenario has been favoured the occurrence, settlement and expansion of species with warm water affinities.

The tropicalization process has been detected in other subtropical and temperate regions, although its intensity is higher in border zones between tropical and subtropical biogeographic areas, such as the Canary Islands (BRITO *et al.*, 2005; FALCÓN, 2015; BRITO *et al*., 2017). In many cases, thermophilic species recorded in the Canaries seem to respond to a natural process of geographic spreading to higher latitudes, across the biogeographic border located at Cabo Blanco (Mauritania, African coast), where a thermic discontinuity causes a change between warm-temperate and tropical faunas (SPALDING *et al*., 2007; BRIGGS & BOWEN, 2013; ALMADA *et al*., 2013). The oceanographic structures of the area between the Canary Islands and the aforementioned Mauritanian border, with a complex system of currents (e.g. PEÑA-IZQUIERDO *et al.*, 2012), can generate the larval dispersal towards northernmore latitudes, and also facilitate the arrival in the Islands of species with high mobility in adult stage.

On the other hand, new tropical fish species found close to or in the surroundings of main harbours are suspected of arriving as consequence of maritime traffic as introduction vector (ballast water transport and associated fish to oil platforms) (BRITO & FALCÓN, 1996; BRITO *et al*., 2005; BRITO *et al*., 2011; FALCÓN, 2015; FALCÓN *et al.*, 2015; TRIAY-PORTELLA *et al*., 2015; PAJUELO *et al*., 2016), something that is very clear with species from very distant areas.

In the case of the oil platforms, a very important vector of introduction in the Canary Islands since 2011, their slow navigation makes it possible for fish associated (small and large specimens) to travel long distances, very far from their original areas of distribution (FALCÓN, 2015; FALCÓN *et al.*, 2015; TRIAY-PORTELLA *et al.*, 2015; PAJUELO *et al.*, 2016). These platforms come from different areas of the eastern or western tropical Atlantic, but also from the Indian Ocean, resulting in a curious mix of species; in this sense, for example, we suspect that the two Atlantic forms of *Abudefduf saxatilis* recognized by CAMPBELL *et al.* (2018) are probably together in the Canary Islands (unpublished data).

The observation of underwater images of oil platforms vessels shows that some small benthic species take refuge among the fouling embedded in the hull, while the larger ones are in the water intake spaces, closed with grids, where they seem to have entered state of larvae or juveniles. On the other hand, highly mobile species (such as acanthurids) swim freely around the platform following it during its slow navigation (FALCÓN, 2015; A. Brito, pers. obs.; R. Herrera, pers. com.).

The areas where the specimens were found in the present study, their original geographic distributions, and their biological and ecological characteristics (high mobility in juvenile or adult stage, rafting-like behaviour, and larval dispersal) allow us to hypothe-

size with relative certainty about their way of arrival. According to such criteria, in the cases of *Uraspis secunda, Chilomycterus spinosus mauretanicus* and *Muraena melanotis* it is possible to think that they have arrived the islands by their own meas, in a natural process of expansion of their original distribution areas (natural spread). But this option seems unlikely for the other species recorded herein, considering that they have found in a docking port of the platforms or their vicinity, and that some of them come from original areas of distribution as remote as the Western Atlantic (such us *Lutjanus griseus* and *Mycteroperca tigris*) and the Indian Ocean (such us *Epinephelus fasciatus*), without previous records in the eastern Atlantic, and it seems clear, therefore, that they have been introduced. For *Epinephelus adscensionis* exists a record from the tropical eastern Atlantic at São Tome (Gulf of Guinea), based on and a photograph published by WIRTZ (1992), and was recorded for the first time in the Canaries in the south of Gran Canaria in 2012 (FALCÓN *et al.*, 2015, identified as *Cephalopholis* cf. *cruentata*), far from the main port of Las Palmas, although not far from another port where the platforms are temporarily stationed (Puerto de Arinaga) (F. Espino, pers. com), when the first one is overbooked. That record of *E. adscensionis*, as well as those of *Cephalopholis nigri* and *Chromis multilineata*, two species with native populations in the eastern Atlantic, have also been explained as introductions in the Canaries (FALCÓN, 2015; FALCÓN *et al*., 2015), due it is very difficult that these species have arrived the islands by their own means (low mobility in juvenile or adult stage and low larval dispersal) and to their exclusive occurrence in port areas. This could also have occurred for *Holacanthus africanus* and *Cirrhitus atlanticus*, two species native to the eastern tropical Atlantic which are not known to travel long distances on its own.

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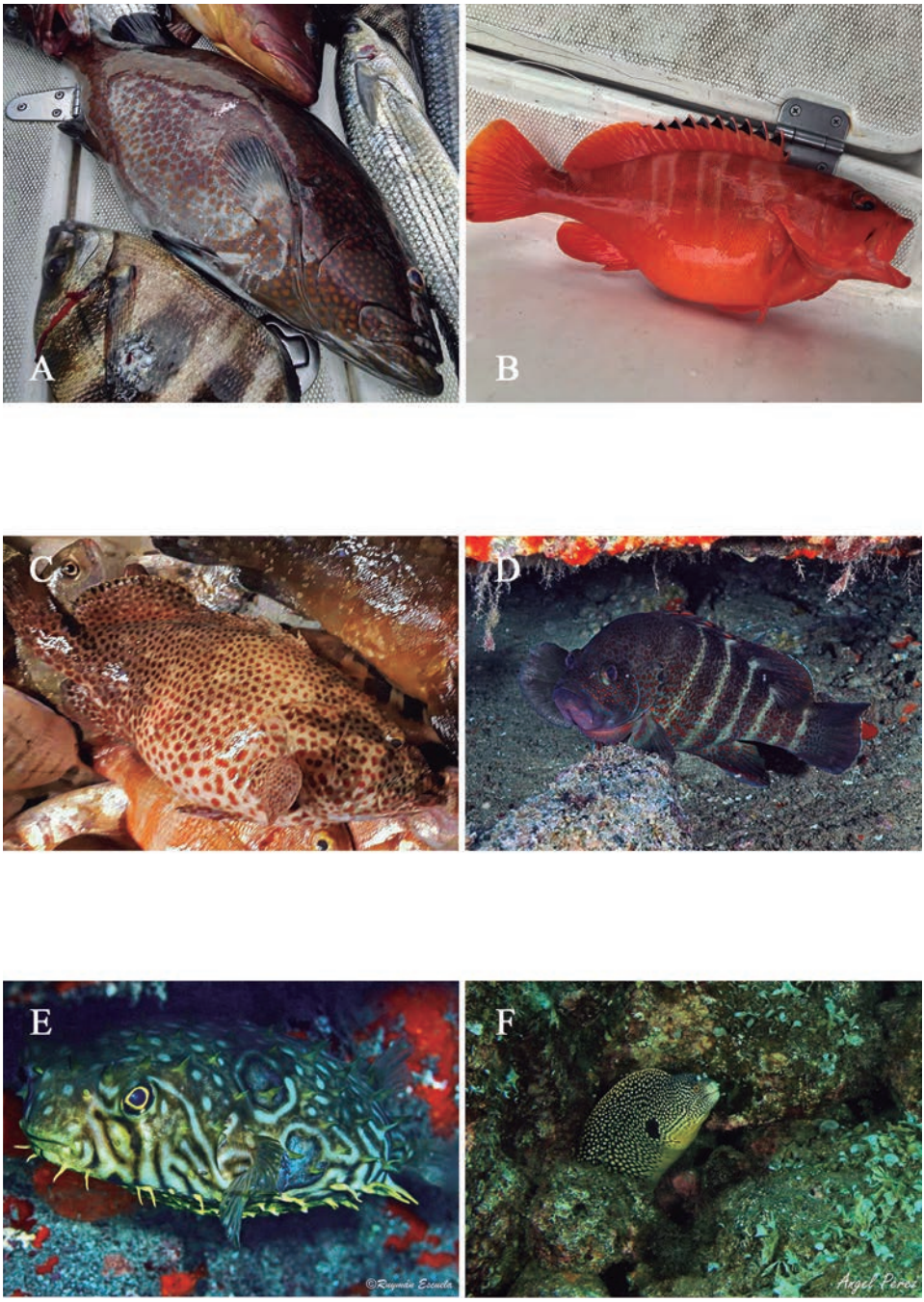

Figure 1.- A: *Mycteroperca tigris*; **B:** *Epinephelus fasciatus*; **C:** *Epinephelus adscensionis*; **D:** *Cephalopholis nigri*; **E:** *Chilomycterus spinosus mauretanicus*; **F:** *Muraena melanotis*.

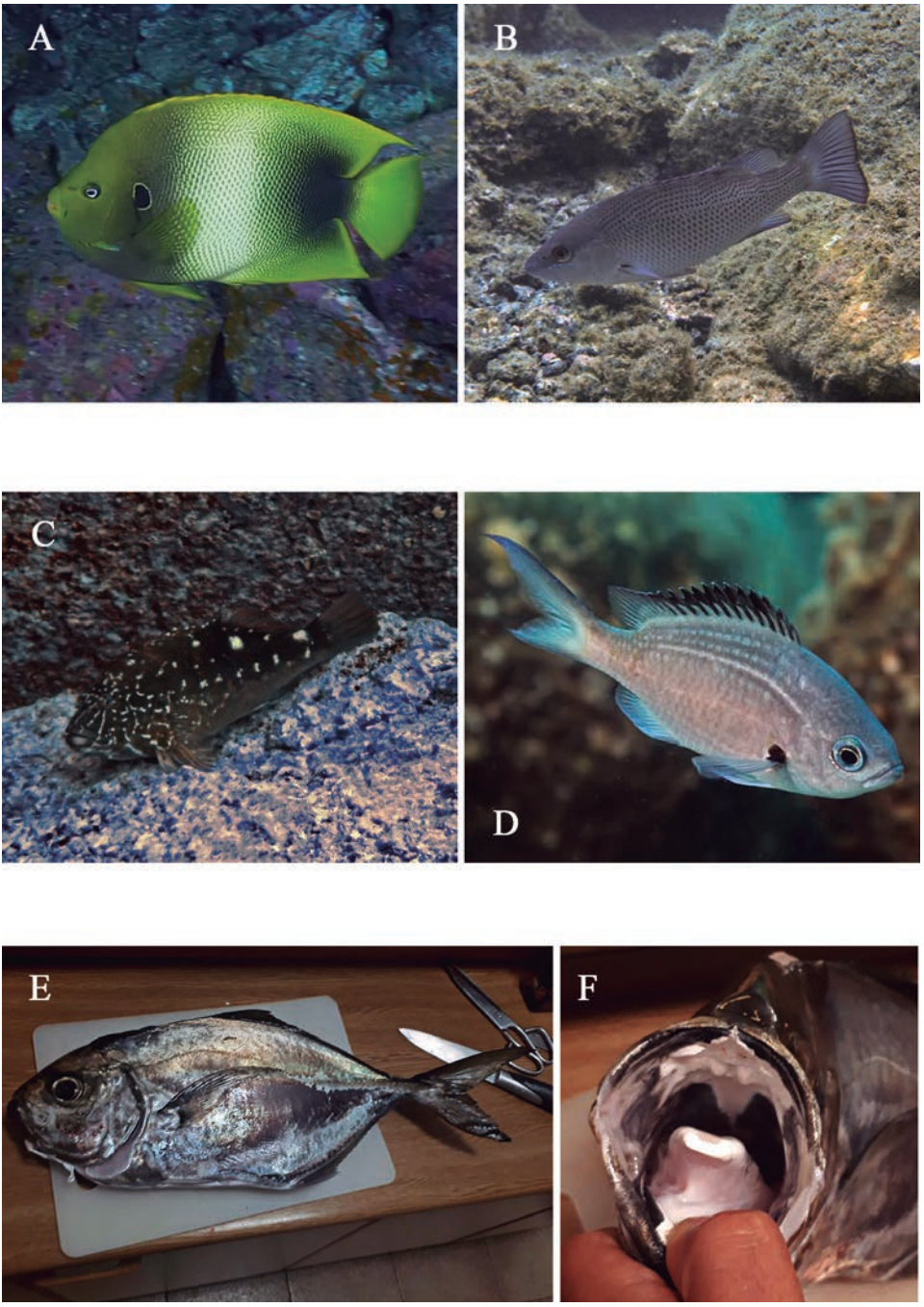

Figure 2.- A: *Holacanthus africanus*; **B:** *Lutjanus griseus*; **C:** *Cirrhitus atlanticus*; **D:** *Chromis multilineata*; **E:** *Uraspis secunda*; **F:** Interior of the mouth of *Uraspis secunda*.

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