

**Rapid Communication****Undergoing invasion of the fangtooth moray *Enchelycore anatina* (Lowe, 1838) in the western Ionian Sea, Central Mediterranean**

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**Received:** 10 July 2019**Accepted:** 18 December 2019**Published:** 9 March 2020**Thematic editor:** Stelios Katsanevakis**Copyright:** © Marletta and LombardoThis is an open access article distributed under terms of the Creative Commons Attribution License ([Attribution 4.0 International - CC BY 4.0](https://creativecommons.org/licenses/by/4.0/)).**OPEN ACCESS****Abstract**

The present short note explores the westward expansion of the non-indigenous fangtooth moray *Enchelycore anatina* (Lowe, 1838) within the Mediterranean Sea. Indeed, this species that is native to the Atlantic Ocean, has extended its distribution range into the Mediterranean Sea, reaching firstly the eastern part of the basin. In the last decades, the fangtooth moray has been reported in the central Mediterranean Sea, representing a further westward expansion within the Basin. This record of the fangtooth moray is the third report from Italian territorial waters and the second one for Sicilian waters. In this study, two new individuals of the species are reported along the Ionian coast of Sicily. The rapid expansion of this fish species within the Mediterranean might be the result of its long pelagic larval stage. The fangtooth moray is an active predator, which can heavily impact native communities, thus it is necessary to keep monitoring the occurrence and expansion of this species within the Mediterranean.

**Key words:** non-indigenous fish, Muraenidae, Atlantic migration, range-expanding species, Sicily

**Introduction**

The fangtooth moray *Enchelycore anatina* (Lowe, 1838) belongs to the family Muraenidae and is a subtropical species widely distributed in the eastern Atlantic, from St. Helena Island in the south to the Azores in the north (Golani et al. 2002). This species is considered as an Atlantic range-expanding species within the Mediterranean (Zenetos et al. 2012). The fangtooth moray has been first caught in the Mediterranean in 1979 at a depth of 50 m, off the Israeli coast (Ben-Tuvia and Golani 1984). Since then, in the Mediterranean *E. anatina* has been recorded within eastern and central sectors (Figure 1). In fact it has been observed in Greece (Golani et al. 2002; Kalogirou 2010; Pirkenseer 2013; Kapiris et al. 2014; Dailianis et al. 2016), Turkey (Altan 1998; Yokes et al. 2002; Okuş et al. 2004; Can and Bilecenoglu 2005; Ergüden et al. 2013; Teker et al. 2019), Syria (Saad 2005), Israel (Lipej et al. 2011), Cyprus (Katsanevakis et al. 2009; Iglésias and Frotté 2015), western Ionian Sea (Guidetti et al. 2012;



**Figure 1.** Eastern and central sectors of the Mediterranean Sea where *Enchelycore anatina* (Lowe, 1838) has been previously reported. The red dots show the known records in the Mediterranean depicting the spatio-temporal spread of the species: 1 – Tel Aviv (Israel), Ben-Tuvia and Golani 1984; 2 – Elafonissos Island (Greece), Golani et al. 2002; 3 – Fethiye Bay (Turkey), Altan 1998; 4 – Antalya Bay (Turkey), Yokes et al. 2002; 5 – Mersin coast (Turkey), Can and Bilecenoglu 2005; 6 – Datca Peninsula (Turkey), Okuş et al. 2004; 7 – Coast of Syria (Syria), Saad 2005; 8 – Island of Bisevo, Vis (Croatia), Lipej et al. 2011; 9 – Coast of Cyprus (Cyprus), Katsanevakis et al. 2009; 10 – Kolimbia Bay, Rhodes Island (Greece), Kalogirou 2010; 11 – Hertliyya north of Tel-Aviv (Israel), Lipej et al. 2011; 12 – Island of Susac (Croatia), Lipej et al. 2011; 13 – Northern Haifa Bay (Israel), Lipej et al. 2011; 14 – Iskenderun Bay (Turkey), Ergüden et al. 2013; 15 – Apulian coast (Italy), Guidetti et al. 2012; 16 – Bijelac Islet near Lastovo Island (Croatia), Dulčić et al. 2014; 17 – Plemmirio marine reserve (Italy), Katsanevakis et al. 2014; 18 – National Marine Park of Zakynthos (Greece), Kapiris et al. 2014; 19 – Kalamaki beach (Greece), Pirkenseer 2013; 20 – Island of Malta (Malta), Deidun et al. 2015; 21 – Agio Anargyroi (Cyprus), Iglésias and Frotté 2015; 22 – Lopud Island (Croatia), Bartulović et al. 2017; 23 – Kyklades Archipelago (Greece), Dailianis et al. 2016; 24 – Phaselis (Turkey), Teker et al. 2019 (for details see Supplementary material Table S1).

Katsanevakis et al. 2014), Maltese waters (Deidun et al. 2015) and Adriatic coasts (Lipej et al. 2011; Dulčić et al. 2014; Bartulović et al. 2017). These reports show that this species probably established reproductive populations in the Mediterranean waters (Kalogirou 2010). This dispersal success over a broad geographical range could putatively be attributed to the fangtooth moray's long pelagic larval stage (Golani et al. 2006). *E. anatina* is a demersal inshore species usually inhabiting rocky bottoms at depths of 3–60 m (Kalogirou 2010), but it has even been reported in shallower waters (Dailianis et al. 2016). It is a nocturnal predator mainly feeding on benthic fish, cephalopods and crustaceans, reaching 120 cm in total length (Göthel 1992; Kalogirou 2010). The main characteristics of this fish are a very elongated body with large yellowish blotches arranged in longitudinal rows, a dorsal fin which is very long and originating above branchial opening, and an anal fin which is confluent with the caudal fin. The head is



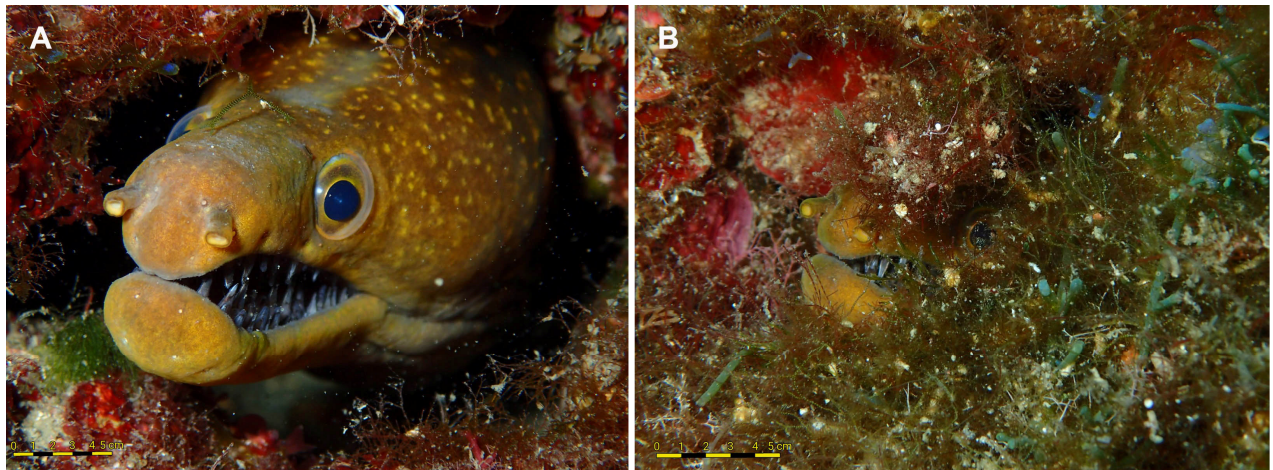
**Figure 2.** A) Geographical location of the study area (arrow) in the eastern coast of Sicily, Ionian Sea; B) Detail of the areas (red dots) of Santa Maria La Scala and Aci Trezza, where the *E. anatina* specimens were recorded.

pointed with an elevated occipital region. The anterior nostril is tubular, while the posterior one can be round- to oval-shaped and opens in front of eyes. The mouth is large and the jaws are arched with fang-like teeth visible even when the mouth is closed (Golani et al. 2002).

The aim of this short note is to report the third record of fangtooth moray in the western Ionian Sea (the second one in Sicily) and to document the secondary westward expansion of this species within the Mediterranean.

### Materials and methods

This short note reports on the sighting of two specimens of fangtooth moray found: the first in Aci Trezza (37°33'41.57"N; 15°09'26.97"E; Aci Castello, Catania, Sicily) and the second one in Santa Maria La Scala (37°37'02"N; 15°10'20"E; Acireale, Catania, Sicily), respectively. Both of these areas are located along the northern sector of the Ionian coasts of Sicily (Figure 2A).



**Figure 3.** *E. anatina* specimens photographed at (A) Aci Trezza (Photo: M. Lombardo) and at (B) Santa Maria La Scala (Photo: A. Lombardo).

In Aci Trezza (Figure 2B) there is a Marine Protected Area named Ciclopi Islands. The seabed in this area has a sloping topography, from the coastline to about 40 m depth, and consists of basaltic bedrock locally covered with large volcanic blocks (Sciuto et al. 2017). Santa Maria La Scala (Figure 2B) is a fishing town situated in the Timpa Nature Reserve, a protected area extending on the emerged part of Acireale coastal strip. The Timpa Nature Reserve encompasses a coastal slope which extends for 6 km. Santa Maria La Scala sea floor resembles the morphology of the Timpa, being a rocky steep slope extending to a depth range of 20–30 m (Catra et al. 2006). A recreational diver photographed the specimen recorded at Aci Trezza with an Olympus TG4 underwater camera; while the other individual was shot with an Action Camera SJCAM SJ4000, during an underwater survey conducted by the authors.

## Results

The fangtooth moray of Aci Trezza (Figure 3A) was sighted for the first time in September 2016 in a crevice between boulders on a rocky slope at a depth of 16 m. This specimen has persisted in this area for the past 3 years, in fact it has always been found in the same crevice. On the other hand, the specimen of Santa Maria La Scala (Figure 3B) was photographed in June 2017 in a rocky crevice at a depth of 15 m. This individual was only sighted two times and was smaller than the other one. In all the sightings, only the head was visible, while the other part of the body was hidden within the rocks. However, the peculiar characteristic of the arched jaws, the nostrils and the livery of the head, allowed for the positive identification of the species. The fangtooth moray is distinguished from the indigenous moray of the Mediterranean Sea, *Muraena helena* Linnaeus, 1758, since the latter species has no arched jaws, and both posterior and anterior nostrils have tubes (Guidetti et al. 2012). Moreover, as reported in Deidun et al. (2015), *E. anatina* shows a fearless behavior in approaching SCUBA divers, compared to the more prudent movements exhibited by *M. helena*.



## Discussion

The present records of *E. anatina*, a species widely distributed in the eastern Atlantic, from where it entered the Mediterranean Sea, represents the third report from Italian territorial waters and the second one from Sicily, preceded by the records from the south-eastern Apulian coast (Guidetti et al. 2012) and the Plemmirio marine reserve (Katsanevakis et al. 2014). Since the species has been previously reported in the western Ionian Sea and in Sicily, this report could represent a sign of establishment of *E. anatina* in this marine area.

Supplementary material Table S1 shows the number of known records (which corresponds to the red dots in Figure 1) of the fangtooth moray in the eastern and central sectors of the Mediterranean Sea. The number of records depicts the spatio-temporal spread of the species. From these reports, it can be observed that this species commonly lives in shallow waters and prefers rocky bottoms rich in crevices and holes. Sometimes, the fangtooth moray has been found in vertical walls or in rocky slopes. Indeed, similarly to the individual photographed in 2007 on the small island of Bisevo, Croatia, (Lipej et al. 2011), both specimens of this short note were found in steep rocky wall, covered with a sciaphilous assemblage. Therefore, the fangtooth moray is a species that usually stays concealed among rocks, waiting for prey to come along.

Overall, 48.3% of Atlantic marine species introduced in the Mediterranean Sea succeeded in spreading eastwards within the Basin. This is due to the prevailing water circulation in the western Mediterranean driven by the Atlantic current. The incoming surface Atlantic stream flows along the southern side of the Mediterranean Sea in a west–east direction, and then, off the Tunisian coast, along the western flank of the Sicily Channel, rises to the north of the western basin in a cyclonic movement (Albérola and Millot 1995). Therefore, it has been hypothesized that the dispersal of Atlantic range-expanding species and their propagules is driven by this hydrodynamic regime (Lasram et al. 2009). There is extensive evidence to show that ocean currents allow marine species to disperse over extremely long distances (e.g. Shanks et al. 2003). Species whose larvae and eggs have wider dispersal ability are expected to attain broader geographic ranges (Emlet 1995; Gaston 2003). Guidetti et al. (2012) have suggested that the rapid expansion of *E. anatina* could be attributed to its long pelagic larval stage, enabling this moray to cross long distances. Moreover, the colonization success of Atlantic species into the Mediterranean has been positively related to the climate match between their native and their colonized environment (Wolf et al. 1998; Duncan et al. 2001). Indeed, a species expanding into an area within the same latitudinal range can experience similar environmental conditions (e.g. temperature) and successfully establish in the new area (Lasram et al. 2009). This theory could explain how the fangtooth moray entered the Mediterranean Sea but not its pattern of spread within the Basin. In fact, this species was originally

recorded in the eastern Mediterranean, apparently bypassing the entire western part of the Basin. A similar event occurred for another non-indigenous species, the opisthobranch *Aplysia dactylomela* Rang, 1828. Valdés et al. (2013) confirmed that this species has an Atlantic origin, but it was first recorded in 2002 in the Sicily Channel (Trainito 2003) and then expanded into the Adriatic, central and eastern Mediterranean (Crocetta and Galil 2012). There are several hypotheses, related with historical and contemporary events which could justify the pattern of spread of this species in Mediterranean.

Another analogous case of an Atlantic range-expanding species with an anomalously higher distribution in the eastern Mediterranean than in the western Mediterranean is that of Atlantic tripletail *Lobotes surinamensis* (Bloch, 1790). This fish is considered as a rare occurrence in the western Mediterranean (Riera et al. 1999) and was reported in some areas of the eastern and central Mediterranean waters (Tortonese 1975; Fischer et al. 1987), although records from the Strait of Sicily have recently become more common (Camilleri et al. 2005). This species for which the majority of Mediterranean records hailed from the eastern Mediterranean (Tortonese 1975), is extending westwards and northwards its range within the same basin, with well-established populations (Deidun et al. 2010).

One hypothesis explaining the “shuttling” of Atlantic range-expanding species into eastern swathes of the Basin is based on the weakening of the Almería-Oran Front, putatively due to climate change, and the powerful Algerian Current, which could have carried the pelagic larvae of *E. anatina* directly in the eastern Mediterranean. Another hypothesis to explain the same phenomenon is that *E. anatina* could have been introduced directly into the eastern Mediterranean by human-mediated vectors, most notably shipping (through ballast water). The ballast water pathway appears to be the most feasible in view of the species’ extended pelagic larval stage. Therefore, in this context, it would be useful to step up monitoring efforts within key shipping crossroads in the Basin, including the Sicily Channel (Azzurro et al. 2014). In fact, the introduction of non-native species in the Mediterranean can modify food web structure and energy canalization (Libralato et al. 2002). The fangtooth moray is an active predator that could heavily affect native communities directly (via predator-prey interactions) and indirectly (via food web or habitat alterations) (Stergiou and Karpouzi 2002; Sala et al. 2011). Furthermore, when such gradual replacement of native species by non-indigenous ones happens in a semi-closed basin which is a hotspot of biodiversity, it contributes to the breakdown of regional distinctiveness of the Earth’s biota and to the global biotic homogenization (Vitousek et al. 1997; McKinney and Lockwood 1999). As a result, continuous monitoring and *in situ* observations are needed to understand how non-indigenous species can modify ecosystem functioning and change native fish community structure (Katsanevakis et al. 2014).

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#### Supplementary material

The following supplementary material is available for this article:

**Table S1.** Known records of *E. anatina* in the Mediterranean Sea with information on the year of observation, number of specimens, depth and habitat of finding.

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