

Contribution to the knowledge of the animal xenodiversity along Calabrian coasts (southern Italy, central Mediterranean)

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*In this paper a contribution to the knowledge of marine and brackish water alien species recorded along the Calabrian coasts (Southern Italy, Central Mediterranean) during the period 2000-2013 is given. The study area is located in the center of the Mediterranean. Records of alien species come from 13 years of both field and opportunistic fishing surveys. Also a bibliographical search in the scientific literature and public and private archives was performed. Eighteen of marine alien species recorded: 1 cnidarian, 11 molluscs, 3 crustaceans, and 4 bony fishes; in addition to these, was considered also the presence of four bony fish, that have naturally spread into the Mediterranean: *Sphoeroides pachygaster*, *Gymnothorax moringa*, *Pseunes pellucidus* and *Zenopsis conchifera*. The highest number of records comes from the Messina Strait. The most common and widest observed species were *Percnon gibbesi*, *Callinectes sapidus*, *Fistularia commersonii* and *Procambarus clarkii*. The record of *Ruditapes philippinarum* in the Foce Crati is the first for the Ionian Sea and for the Central Mediterranean. *Gymnothorax moringa* is here recorded for the first time in the Mediterranean.*

Key words: Introduced species, Biogeography, *Ruditapes philippinarum*, *Gymnothorax moringa*, lessepsian migration, *Sphoeroides pachygaster*

INTRODUCTION

Alien, Non-indigenous (NIS), exotic, non-native or allochthonous are species, subspecies or lower taxa, present in the wild, introduced outside of their natural range and beyond their natural dispersal potential (ZENETOS *et al.*, 2010). In many cases, their presence in the given region is due to intentional or unintentional introduction resulting from human activities. Natural shifts in distribution ranges do not qualify a species as a NIS (OLENIN *et al.*, 2010), but let include that species in the xenofauna of a region. The introduction and the spread of alien species are considered among the main threats to biodiversity at different scales and extent (HULME *et al.* 2009), both in the terrestrial and in the marine context (BAX *et al.*, 2003; MOLNAR *et al.* 2008; OCCHIPINTI-AMBROGI *et al.*, 2011). In fact, alien species may displace and reduce populations of native species (KUPFERBERG 1997; WILSON 1997; HODDLE 2004; SPERONE *et al.* 2010) and can influence the way by which they use habitat resources (HERLBOLD & MOYLE 1986; WILLIAMSON 1996).

The ecological implications of these invasions are of primary importance and concern to the entire biosphere. A first and valuable tool for managing invasive species of conservation importance is the knowledge of their presence and localization in the territory and the confirmation of their successful reproduction in natural conditions (CRESCENTE *et al.* 2014). For this reason, alien species inventories are increasingly being published in the scientific literature and considerable international effort is devoted to gather and process information about the current situation in several parts of the globe. The Mediterranean Sea is one of the seas of the world most affected by biological invasions in terms of how long the invaders have been present (OCCHIPINTI-AMBROGI, 2000; STREFTARIS *et al.*, 2005), in number of alien species detected (COSTELLO *et al.*, 2010) and in the unprecedented rate of introduction (ZENETOS, 2009; 2010; ZENETOS *et al.*, 2012). From 1978, when POR (1978) confirmed 128 proven lessepsian immigrants, the number of records of alien species have been considerably increased: recently ZENETOS *et al.* (2010;

2012) reported that 995 species of the Mediterranean fauna can be considered alien, and they have increased the total species richness of the Mediterranean Sea by 5.9%. The colonization processes of alien species differ in relation to the way and the place of introduction and, then, to the climatic and ecological characteristics of the site in which it was entering the Mediterranean. The vast majority of alien species have been introduced in the Eastern Mediterranean (718), less in the Western Mediterranean (328) and Central Mediterranean (267) and least in the Adriatic Sea (171). Among these, thermophilic species account for 88.4% of the introduced species in the Eastern Mediterranean, 72.8% in the Central Mediterranean, 59.3% in the Western Mediterranean and 56.1% in the Adriatic. Cold water species represent a small percentage of the introduced species (between 4.2% and 21.6%) and are more numerous in the Adriatic and less in the Eastern Mediterranean (ZENETOS *et al.*, 2010). This paper aims to present the state-of-art on the presence and acclimatization status of alien species along the coasts of Calabria, a region that lies in the Central Mediterranean. Freshwater species occurring in estuarine waters have been also considered. In the colonization process of the Mediterranean, the Central Mediterranean (and particularly Calabria and Sicily) represents a strategic site for monitoring biological exchanges between Western and Eastern Mediterranean (NICOLAIDOU *et al.*, 2012; SPERONE *et al.*, 2012). So, the information we give could represents a useful tool in order to better understanding and forecasting the colonization process of alien species in the Mediterranean.

MATERIAL AND METHODS

Study area

Calabria is located at the very south of Italy and it lies in the centre of the Mediterranean Sea (Fig. 1). The region is a long and narrow peninsula between the Tyrrhenian and the Ionian Seas, and it is separated from Sicily by the Strait of Messina. Together with Sicily and the Tunisian coast, Calabria divides the Mediterra-

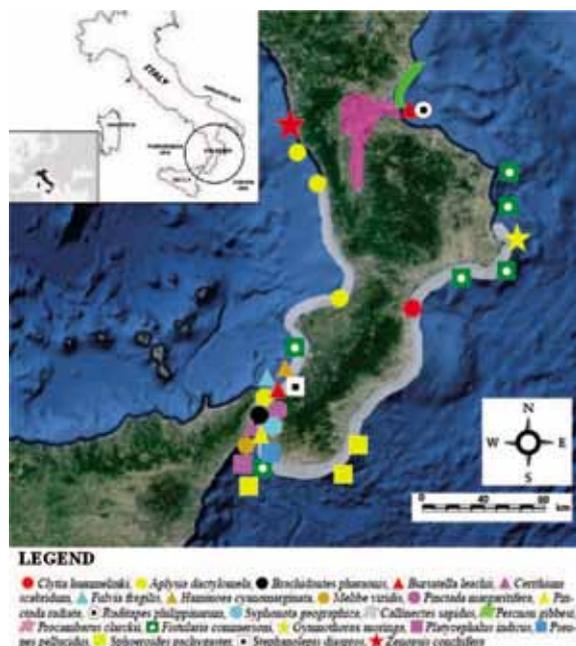


Fig. 1. Study area and distribution of alien species

near Sea into western and eastern parts: so the Tyrrhenian coast of Calabria lies in the western Mediterranean, while the Ionian one lies in the eastern Mediterranean. The Ionian continental shelf is not particularly wide, and the depth along the coast drops suddenly. The Strait of Messina is one of the two conjunction points between the western and eastern basins of the Mediterranean Sea. The sea floor of this basin could be considered a mount-like formation and the Strait is divided into two different sides: the northern side lies in the Tyrrhenian while the southern side lies in the Ionian. The two basins have different chemical-physical and biological characteristics. As Calabria belongs to two distinct of the European Union's Marine Strategy Framework Directive (MSFD), we considered separately the records from the Ionian Sea and those from the Tyrrhenian Sea (Western Mediterranean, WMED).

Data collection

Records of alien species presented in this work come from 13 years of both field and opportunistic fishing surveys, from 2000 to 2013, and by various collaborations with fishermen, fisheries departments and marine police. In particular, commercial and recreational fisheries

landings and sightings records were considered. Also a bibliographical search in the scientific literature and public and private archives was performed. Our attention has been devoted to pluricellular animal: so from this survey algae, macrophytes and protozoa have not been considered.

According to ZENETOS *et al.* (2010), we defined the acclimatization status of each species using the following terminology:

- Established (E): Introduced or feral population of species settled in the wild with free-living, self-maintaining and self-perpetuating populations.
- Casual: Casual species are those having been recorded only once (no more than twice for fish) in the scientific and grey literature and are presumed to be non-established in the area.
- Invasive: Species defined as established aliens that have overcome biotic and abiotic barriers and are able to disseminate away from their area of initial introduction through the production of fertile offspring with noticeable impact.

True aliens were separated from species which have naturally spread to regions beyond their usual range. Identification and all common names used in this paper followed the World Register of Marine Species (WoRMS <www.marinespecies.org>) and contributing databases (like FishBase). All data that directly or indirectly provided information about the presence of alien species in the study area were considered. Each confirmed record was georeferenced by GPS coordinates, and biometric (total length, weight) and ecological (depth, distance from shoreline, date of observation, climatic parameters) data were also registered.

RESULTS

We confirmed for the study area the presence of 18 alien species: 1 cnidarian (*Clytia hummelinki*), 11 molluscs (*Aplysia dactylomela*, *Brachidontes pharaonis*, *Bursatella leachii*,



Fig. 2. Some of the alien species recorded for the Calabria region: a. *Procambarus clarckii* from Foce Crati; b. *Bursatella leachii* in reproduction from Foce Crati; c. *Percnon gibbesi* from Capo Bruzzano; d. *Callinectes sapidus* from Laghi di Sibari; e. *Fistularia commersoni* from Messina Strait

Cerithium scabridum, *Fulvia fragilis*, *Haminoea cyanomarginata*, *Melibe viridis*, *Pinctada margaritifera*, *Pinctada radiata*, *Ruditapes philippinarum*, *Syphonota geographica*), 3 crustaceans (*Callinectes sapidus*, *Percnon gibbesi*, *Procambarus clarckii*), and 3 bony fishes (*Fistularia commersoni*, *Platycephalus indicus*, *Stephanolepis diaspros*); in addition to these, we considered also the presence of four bony fishes that have naturally spread into the Mediterranean: *Zenopsis conchifera*, *Gymnothorax moringa*, *Pseunes pellucidus* and *Sphoeroides pachygaster* (Figures 1-2). In Table 1 the checklist of our records is reported. The presence of the all species in the study are was confirmed by original direct observations from the authors, except for *Aplysia dactylomela*, *Brachidontes pharaonis*, *Cerithium scabridum*, *Clytia hummelinki*, *Fulvia fragilis*, *Haminoea cyanomarginata*, *Melibe viridis*, *Pinctada margaritifera*, *Pinctada radiata*, *Pseunes pellucidus*, *Sypho-*

nota geographica, *Stephanolepis diasprosi* and *Zenopsis conchifera*, whose presence was confirmed from bibliographic research (Francesco Turano, unpublished data; BOERO *et al.*, 1997; MOJETTA, 1998; GRAVILI *et al.*, 2008; CROCETTA *et al.*, 2009; GRAVILI *et al.*, 2010; CROCETTA, 2012; CROCETTA & GALIL, 2012; ZENETOS *et al.*, 2012). The most common and widest observed species was surely *Percnon gibbesi* that is distributed continuously along Calabrian coasts from about Cetraro (Tyrrhenian side) to Crotona (Ionian side). And it has been observed both on sandy and rocky substrates. *Procambarus clarckii* has colonized the whole Crati river system, from the river source to the river mouth, inhabiting also the transitional waters of the Foce del Crati Natural Regional Reserve. *Bursatella leachii* was observed both on the Ionian side and in the Messina Strait with many specimens. The reproduction of this species was observed too (Fig. 2b).

Table 1. List of the alien species reported for the Calabria region. (Legend: E established, NE not established, C casual, I invasive, A aquaculture, L lessepsian, S shipping, SB shipping ballast, SF shipping fouling, U unknown, G natural range expansion through the Strait of Gibraltar)

Name	First finding year in the Mediterranean	Finding year in the Calabrian seas		Calabrian distribution	Population status		Likely vectors
		WMED	Ionian		Italy*	Calabria	
CNIDARIA							
<i>Clytia hummelinki</i> (Leloup, 1935)	1996	-	1996	Copanello	I	E	SF
MOLLUSCA							
<i>Aplysia dactylomela</i> Rang, 1828	2003	2009	-	Messina Strait, Tyrrhenian	E	E	U (G?)
<i>Brachidonte pharaonis</i> (Fisher, 1870)	1969	2009	-	Messina Strait	E	E	L + S
<i>Bursatella leachii</i> De Blainville, 1871	1968	2009	2012	Messina Strait, Foce Crati	E	E	L
<i>Cerithium scabridum</i> Philippi, 1848	1976	2009	-	Messina Strait	E	E	L + S
<i>Fulvia fragilis</i> (Forskål in Niebuhr, 1775)	2003	2009	-	Messina Strait	E	C	L + S
<i>Haminoea cyanomarginata</i> Heller & Thomson T., 1983	2007	2009	-	Messina Strait	C	C	U (L?)
<i>Melibe viridis</i> (Kelaart, 1858)	1984	1988	-	Messina Strait	E	C	U (SB?)
<i>Pinctada margaritifera</i> (Linnaeus, 1758)	1899	1889	-	Messina Strait	C	C	A
<i>Pinctada radiata</i> (Leach, 1814)	1967	2009	-	Messina Strait	E	E	U (L?)
<i>Ruditapes philippinarum</i> (Adams & Reeve, 1850)	1983	-	2012	Foce Crati	I	E	A
<i>Syphonota geographica</i> (Adams & Reeve, 1850)	2001	2009	-	Messina Strait	C	E	U (L?)
CRUSTACEA DECAPODA							
<i>Callinectes sapidus</i> Rathbun, 1896	1949	-	2012	Sibari, Foce Crati	E	E	A
<i>Perenon gibbesi</i> (H. Milne Edwards, 1853)	1999	2003	2003	whole region	I	I	SB
<i>Procambarus clackii</i> (Girard, 1852)	2006	-	2009	Sibari, Foce Crati	C	E	A
PISCES							
<i>Fistularia commersonii</i> Rüppel, 1838	2002	2010	2011	Messina Strait, S-Tyrrhenian, C-Ionian	I	E	L
<i>Gymnothorax moringa</i> (Cuvier, 1829)	2011	-	2011	Le Castella	-	E	G?
<i>Platycephalus indicus</i> (Linnaeus, 1758)	1953	1970	-	Messina Strait	NE	C	L
<i>Pseustes pellucidus</i> Luken, 1880	1955	1995	-	Messina Strait	E?	E	G
<i>Sphoeroides paclygaster</i> (Müller & Troschel, 1848)	1984	-	2007	Palizzi, Brancaleone, Reggio Calabria	E	E	G
<i>Stephanolepis diaspros</i> Fraser-Brunner, 1940	1967	1988	-	Messina Strait	E	C	L
<i>Zenopsis conchifera</i> (Lowe, 1852)	2007	2010	-	Diamante	-	E	G

* from Occhipinti-Ambrogi *et al.*, 2011



Fig. 3. Specimen of *Gymnothorax moringa* from Le Castella

Aplysia dactylomela, *Brachidontes pharaonis*, *Cerithium scabridum*, *Clytia hummelinki*, *Fulvia fragilis*, *Melibe viridis*, *Pinctada radiata*, *Pseunes pellucidus*, *Syphonota geographica*, *Spherooides pachygaster*, *Ruditapes philippinarum*, *Callinectes sapidus* and *Fistularia commersoni* were found just in few sites but with locally abundant and reproductive populations. Finally, *Haminoea cyanomarginata*, *Pinctada margaritifera*, *Platycephalus indicus*, *Stephanolepis diaspros* and *Zenopsis conchifera* were observed only in one site with just one specimen.

Also *Gymnothorax moringa* was observed just in one site located along the central Ionian side of the region. It was a pregnant female about 110 cm total length (Figure 3). The specimen was caught at a depth of about 8 m on a rocky bottom. To our knowledge, this is the first record of this specie for the Mediterranean.

Seven (31,8%) of the observed alien species are lessepsian migrators, four (18,2%) are species imported for aquaculture purposes, one (4,5 %) has been arrived due to shipping ballast and another one (4,5%) due to shipping fouling. The origin of five species (*Aplysia dactylomela*, *Haminoea cyanomarginata*, *Melibe viridis*, *Pinctada radiata*, *Syphonota geographica*) is unknown, while for *Gymnothorax moringa*, *Pseunes pellucidus*, *Spherooides pachygaster* and *Zenopsis conchifera* a natural range expansion through the Strait of Gibraltar could be confirmed.

DISCUSSION

Excluding *Gymnothorax moringa*, *Pseunes pellucidus*, *Spherooides pachygaster* and *Zenopsis conchifera*, the 18 alien species confirmed for Calabria represent respectively the 6,7% of alien Cnidaria, the 35,5% of alien Mollusca, the 11,5 % of alien Crustacea and the 27,3 % of alien Osteichthyes reported for the Italian waters (OCCHIPINTI-AMBROGI *et al.*, 2011).

The crab *Percnon gibbesi* was the most common species we observed. This is one of the most widely distributed grapsids in the world, with a range extending from California to Chile, from Florida to Brazil, and from Madeira to the Gulf of Guinea (MANNING & HOLTHUIS, 1981). From 1999, when it was first recorded in Lino-sa, the species has invaded the Mediterranean (SGHAIER *et al.*, 2011), probably due to shipping ballast. Although this species had already been reported for the Calabria (FACCIA & BIANCHI, 2007; KATSANEVAKIS *et al.*, 2011), data reported in the present paper not only confirm its presence along the Tyrrhenian side, but also expand its distribution all over the Ionian coast. On the basis of our observations this species could be considered as invasive for the study area.

The red swamp crayfish *Procambarus clarkii* is native to northern America and has been established throughout the world as a result of recreational fishing and commercial introduction for harvest as a food source (GHERARDI *et al.*, 2011). In Europe, it was recorded for the first time in southern Spain in 1970s, but in Italy

its first record dates back to 2006 (OSCOZ *et al.*, 2010; OCCHIPINTI-AMBROGI *et al.*, 2011). The invasion success of *Procambarus clarkii* has been mainly attributed to its broad environmental tolerance and high fecundity (MACEDA-VAIGA *et al.*, 2013). In Italy the species is reported as not established (OCCHIPINTI-AMBROGI *et al.*, 2011), but in Calabria our data let us affirm that this species is established along all the Crati river and mouth and it is becoming invasive, since several specimens have been sighted also from other areas. The population of the Foce Crati is, to our knowledge, the first one reported for transitional waters.

Bursatella leachii is a circumtropical opisthobranch considered as an established and locally invasive alien species in the Mediterranean and in Italy (ZENETOS *et al.*, 2010; OCCHIPINTI-AMBROGI *et al.*, 2011). It was reported in 1940 from the Palestine coast, then it colonized the Levantine basin and later the western Mediterranean. This mollusc is considered as one of the most widespread Lessepsian species as it is very common in the eastern Mediterranean. In Calabria this species could be considered as established: we confirmed its presence in the study area in 2 sites: in the Foce Crati (where we observed breeding specimens) and in the Strait of Messina.

The portunid blue crab *Callinectes sapidus*, a species originating from the western Atlantic, has been introduced into the Mediterranean through transport in ballast water or maybe for aquaculture interest. Several records have been published in recent years, with regard to the species' distribution in the Adriatic (CASTRIOTA *et al.*, 2012; ELEFTHERIOU *et al.*, 2012). In Italy it is reported as an established species. This could be assumed also for Calabria, where the species has successfully colonised the northern part of the Ionian coast. Our records represent the new southernmost sightings of the species for the Italian peninsula.

The origin and vector of transportation of *Aplysia dactylomela* are not clear (NICOLAIDOU *et al.*, 2012; THESSALOU *et al.*, 2012). Some authors considered that the Mediterranean populations had been introduced through the Suez

Canal rather than through the Strait of Gibraltar (CROCETTA & GALIL, 2012). However, recent molecular studies (VALDES *et al.*, 2013) suggested that all Mediterranean populations are of Atlantic origin. In Calabria, the species occurs mainly along the north Tyrrhenian coast. In Italy this species is considered established: on the basis of our data also for the Calabria region we can confirm that this mollusc can be considered established too.

Clytia hummelinki is a circum-tropical hydrozoan. The species is present both in the Atlantic and the Pacific Oceans, and it is difficult, at present, to establish if it entered either from Suez or from Gibraltar, probably as shipping fouling. The species is presently widespread throughout the middle Mediterranean Sea and the Adriatic Sea; in Italy it is considered as invasive, especially along the coast of the Salento Peninsula (GRAVILI *et al.*, 2008). BOERO *et al.* (2005) hypothesized that the rapid expansion of *Clytia hummelincki* might be the result of efficient dispersal of the medusa stage mainly obtained by displacement with currents. The first record of the species in the Mediterranean comes from Copanello, located in the Ionian coast of Calabria (BOERO *et al.*, 1997): in this region the species can be considered as established. No records are known for the Strait of Messina and for the Tyrrhenian coast of Calabria.

Cerithium scabridum is an Indo-Pacific species that has entered the Mediterranean Sea via the Suez Canal. The species is common in shallow waters, on rocky bottoms covered with low or no vegetation, but it mainly prefers pebbles, where it forms dense populations. It has been found at several locations in the Mediterranean Sea (NICOLAIDOU *et al.*, 2012). In Calabria the species is established with a reproductive population located along the Strait of Messina (CROCETTA *et al.*, 2009).

Fulvia fragilis is a very thin shelled bivalve belonging to the cardiid and it is distributed throughout the Indian Ocean. This species has penetrated the Mediterranean Sea, from the Indian Ocean through the Suez Canal (EL LAKHRACH *et al.*, 2012) and presumably via shipping, in the central Mediterranean (GOUD & MIFSUD, 2009).

Although in Italy *Fulvia fragilis* is considered established, in Calabria we have knowledge just of one finding site for the species: for this reason we consider its presence as casual.

The Red Sea mussel *Brachidontes pharaonis*, another Lessepsian invasive species, was first recorded in the Mediterranean seven years after the opening of the Suez Canal in 1869. In the past 20 years it has become abundant in midlittoral and infralittoral rocky habitats, especially along the rocky shores of the Eastern Mediterranean (DOGAN *et al.*, 2007). In Italy it is considered as established species and, on the basis of our observations, we can confirm this status also for the Calabria region.

Also *Haminoea cyanomarginata* and *Pinctada radiata* are supposed to be lessepsian migrators; however, these species are absent from the Suez Canal and have, to date, a limited distribution in the Eastern Mediterranean (ZENETOS *et al.*, 2005) and for this reason their origin is not completely clear. *Haminoea cyanomarginata* is a casual species both for Italian and Calabrian seas, while *Pinctada radiata* can be considered as established. The record of *Haminoea cyanomarginata* (CROCETTA *et al.*, 2009) is the first for the central Mediterranean.

Pinctada margaritifera has been imported for aquaculture from Red Sea to Mediterranean to produce pearls. This species is naturally distributed in the Indo-Pacific. In the Mediterranean Sea it is very rare along the Egyptian coast: however, all records are very old and there are no recent sightings of the species. For this reason it cannot be considered established in Italy. In Calabria there is a very old record along the Ionian coast in 1899 (BELLET, 1899).

Ruditapes philippinarum is naturally distributed along Japanese coasts; the species has been introduced in the Mediterranean for marine farming in 1980 in France (BODOY *et al.*, 1981); then, in 1983 it has been introduced also in the Venice lagoons for experimental aquaculture. In 2001 the species has been recorded in the Turkish North Aegean Sea, where is considered accidental (ALBAYRAK *et al.*, 2001). In Italy it is considered invasive, especially in the Adriatic Sea. Our record in the Foce Crati is the first for the Ionian Sea and for the Central Mediterra-

nean, and the local population can be considered established.

Syphonota geographica is another possible Lessepsian migrant to Mediterranean, also if its origin is not completely clear. The species is considered as casual for Italy; we have found just one observation in the Strait of Messina (CROCETTA *et al.*, 2009): this is the first confirmed record for the species in the central Mediterranean.

According to ZENETOS *et al.* (2010), *Melibe viridis* is one of the seven species of tropical indo-Pacific origin which are proven non-Lessepsians. The Suez Canal as a pathway is not ruled out but the vector of *Melibe viridis* introduction is suspected to be ballast waters (TSIAKKIROS & ZENETOS, 2011). In Italy the species is considered as established; in Calabria it has been recorded just one time for the Strait of Messina and for this reason in our region the species can be considered casual.

Fistularia commersoni and *Stephanolepis diaspros* are benthopelagic species originating from the tropical and sub-tropical Indo-Pacific regions: they can both be considered as lessepsian migrators. *Fistularia commersonii* is an active predator that is highly competitive with autochthonous teleost species (KALOGIROU *et al.*, 2007).

Stephanolepis diaspros is usually associated with coastal rocky substrates and it feeds on small invertebrates (ELEFThERIOU *et al.*, 2011). *Fistularia commersonii* experienced a population explosion along the coast of Israel and subsequently spread westward. A similar situation was observed for *Stephanolepis diaspros*. Particularly, reports from the Aegean Sea are becoming even more frequent and demonstrate a rapid expansion in the Mediterranean Sea (KARACHLE *et al.*, 2004). In Italy *Fistularia commersoni* is considered established, especially along the Tyrrhenian coast: for the Calabria region we observed the presence of the species both along the Ionian and the Tyrrhenian side and on the basis of our observations we consider *Fistularia commersoni* as established.

Stephanolepis diaspros is not very common in central Mediterranean, and in Italy it is

considered as a casual species, with only one record from the Gulf of Taranto. The presence of the species confirmed by Turano (unpublished data) in the Messina Strait is the southernmost for the Italian peninsula and one of the westernmost records in the Mediterranean. Also for the Calabria region, it can be considered as a casual species.

Sphoeroides pachygaster is a deep water species, circumglobally distributed in tropical and temperate seas. In the Mediterranean it was reported for the first time in 1979, and, with time, records of this species were continuous and numerous in the last decades both in the western and in the central Mediterranean (PSOMADAKIS *et al.*, 2006). Subsequent findings of the species has led authors to suppose that the introduction of the *Sphoeroides pachygaster* in the Mediterranean is due to a natural range expansion through the Strait of Gibraltar, with a subsequent eastwards diffusion. In Italy the species is considered established due to many records from the whole peninsula (PSOMADAKIS *et al.*, 2006). In Calabria the species has been found along the southern Ionian and the Strait of Messina, and it can be considered as established too.

The Bluefin driftfish *Psenes pellucidus* is present in Atlantic, Indian and western Pacific oceans: so also its presence in the Mediterranean could be related to a natural range expansion through the Strait of Gibraltar. In Italy and in Calabria it can be considered established: in particular, in our study area the species is present in the Strait of Messina.

Zenopsis conchifera is a species inhabiting the Western Indian Ocean and the Atlantic Ocean. The first record of this species in the Mediterranean dates at 2007, when a specimen has been observed in Tunisia. In Italian waters this species has never been sighted. Two specimens of this Atlantic fish were caught on June 2010 by a bottom trawler targeting deep-water red shrimps off Diamante, along the Tyrrhenian side of Calabria (PSOMADAKIS *et al.*, 2012). In the region *Zenopsis conchifera* could be considered as established. Also in this case, a natural range

expansion through the Strait of Gibraltar could be confirmed for the species.

Finally, the spotted moray *Gymnothorax moringa* is a medium to large moray eel found in the Western Atlantic Ocean, from North Carolina and Bermuda to Brazil, including the Gulf of Mexico and the Caribbean. It is also found around Mid - and Eastern Atlantic islands as far south as St. Helena. Our record represents the first evidence of the presence of this species in the Mediterranean. Since the record is related to a pregnant female, we can assume that in Calabria an established population of *Gymnothorax moringa* could be present. About the origin of the species in the Mediterranean, it is reasonable to assume the entrance through the Straits of Gibraltar, although, since it is an aquarium fish, we can not exclude the release or the escape of the species from captivity in the wild.

CONCLUSIONS

This study provides a reference point for the knowledge of the presence and distribution of alien marine species in the Calabria region, which lies exactly in the centre of the Mediterranean. Until now there has been little documentation about this topic, so the present paper represents a starting point for the knowledge and management of xenodiversity in Calabrian waters and, consequently, in the central Mediterranean. Since 75% of our sightings is referred to the Strait of Messina, it is possible to affirm that this area could represent a strategic site for monitoring the marine colonization processes. Long-term monitoring programs should be encouraged in order to acquire further information.

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Prilog poznavanju kseno-raznolikosti životinja duž obale Kalabrije (južna Italija, srednji Mediteran)

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SAŽETAK

Ovaj rad predstavlja prilog poznavanju stranih vrsta pronađenih u morskoj i bočatoj vodi duž Kalabrijske obale (južna Italija, Središnji Mediteran) u razdoblju od 2000. do 2013. godine. Područje istraživanja se nalazi u središtu Mediterana. Evidencija stranih vrsta je proizišla iz 13 godina terenskog rada i oportunističkih istraživanja. Također su izvršena bibliografska pretraživanja u znanstvenoj literaturi u javnim i privatnim arhivima. Ukupno je zabilježeno 18 morskih stranih vrsta: 1 cnidaria, 11 mekušaca, 3 raka i 4 ribe koštunjače koje su se prirodno proširile u Mediteranu: *Spherooides pachygaster*, *Gymnothorax moringa*, *Pseunes pellucidus* i *Zenopsis conchifera*. Najveći broj nalaza dolazi iz Mesinskog tjesnaca. Najčešće i najšire promatrane vrste su *Percnon gibbesi*, *Callinectes sapidus*, *Fistularia commersonii* i *Procambarus clarkii*. Zapis o nalazu vrste *Ruditapes philippinarum*, kod mjesta Foce Crati, je prvi za Jonsko more i središnji Mediteran. *Gymnothorax moringa* je po prvi put zabilježena u Mediteranu.

Ključne riječi: Alohitone vrste, biogeografija, *Ruditapes philippinarum*, *Gymnothorax moringa*, lesepsijske migracije, *Spherooides pachygaster*