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Non-indigenous polychaetes along the coasts of Italy: a critical review

Joachim LANGENECK[1], Marco LEZZI[2], Michela Del PASQUA[3], Luigi MUSCO[4], Maria Cristina GAMBI[4], Alberto CASTELLI[1] and Adriana GIANGRANDE[5]

[1] Department of Biology, University of Pisa, via Derna 1, Pisa, Italy
[2] ARPAE, Regional Agency for Environmental Prevention and Energy of Emilia-Romagna, Oceanographic Unit Daphne - V. le Vespucci 2, Cesenatico (FC), Italy
[3] Institute of Environmental Protection and Research (ISPRA), Loc. Brondolo, Chioggia (VE), Italy
[4] Stazione Zoologica Anton Dohrn, Villa Comunale, Napoli, Italy
[5] Laboratory of Marine Biology and Zoology, DiSTeBA, University of Salento, Lecce, Italy

Corresponding author: jlangeneck@biologia.unipi.it

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Abstract

Non-indigenous species (NIS) represent one of the most relevant threats to biodiversity, ecosystem functioning, and human activities, and their occurrence and spread have been the subject of numerous works and revisions. However, the information available is rather confused for several taxa, including polychaetes, which are characterised by having a high number of cryptogenic and questionable species. This work aims at providing a revised checklist of alien polychaetes occurring along the coasts of Italy, based on the examination of newly collected and deposited material and on the critical analysis of published and gray literature, and whenever possible on the re-examination of historical material. Of the 86 polychaete species reported as NIS in Italian waters, 25 are confirmed as alien species, while 3 are cryptogenic, and 40 should be considered questionable. Finally, 18 species were excluded from checklists of non-indigenous species, either because they are native, or because they represent misidentifications of other species. The high number of cryptogenic and questionable species points at the need for molecular studies and taxonomic revisions for the majority of polychaete taxa reported as NIS, in order to clarify their taxonomy, origin, introduction pathways and spreading patterns.

Keywords: Alien species; Annelida; cryptogenic species; Mediterranean Sea.

Introduction

Non-indigenous species (NIS) have become the focus of a number of studies worldwide because of their impact on native assemblages and human activities (Pimentel *et al.*, 2001; Wittenberg & Cock, 2001; Mooney, 2005; Vilá *et al.*, 2010). Regarding the Mediterranean Sea, a number of papers reporting new records and range expansion of NIS are published very frequently, and this information is periodically summarised in annotated checklists, reviews and atlases (e.g. Zenetos *et al.*, 2005a; Galil, 2009; Zenetos *et al.*, 2010; Occhipinti-Ambrogi *et al.*, 2011; Zenetos *et al.*, 2012; Golani *et al.*, 2013; Marchini *et al.*, 2015; Zenetos *et al.*, 2017). A periodical critical review of the information available on non-indigenous species is necessary to correctly assess both the reliability of new records and the actual range of NIS, as well as their impact on native assemblages and possible eradication strategies. CIESM Atlases (Zenetos *et al.*, 2005b; Galil *et al.*, 2008; Golani *et al.*, 2013; Verlaque *et al.*, 2015) represent important and useful sources in summarising all knowledge available about several taxa reported in the Mediterranean Sea. However, the majority of works focus on spread and impact of non-indigenous fish, molluscs, decapod crustaceans and recently macrophytes, whereas the majority of phyla are currently poorly studied, except in the frame of more general works (Zenetos *et al.*, 2005a, 2010, 2017; Occhipinti-Ambrogi *et al.*, 2011). Polychaetes are one of these scarcely studied groups, and even in the well-studied Mediterranean basin, comprehensive revisions of NIS belonging to this group have not yet been published.

The study of non-indigenous species in polychaetes is hindered by several issues mainly pertaining to taxonomy and biogeography in the group. While a number of taxa, including fish and molluscs, showed an increase of newly described species in the 18th and 19th century, which were subsequently put in synonymy in the second half of the 20th century, polychaetes show a completely different trend. In fact, this group had a first increase of new taxa in the 19th century, and a sudden drop in their number in the first half of the 20th century. This drop was mainly due to the work of the most pre-eminent polychaetologist of that time, Pierre Fauvel (Fauvel, 1923a, 1927), who synonymised the majority of described species with relatively few, allegedly cosmopolitan species. As a consequence, the hypothesis that polychaetes were a low-diversity group with extremely wide species distributions, and thus a poor biogeographical indicator (Ekman, 1953), was not confuted until recently (Fauchald, 1984). In fact, molecular data added new information to the actual diversity of polychaetes, suggesting that it is remarkably higher than traditionally hypothesised (Nygren, 2014). In this frame, it seems obvious that the temporal criteria employed by the CIESM atlases to include a species among the Mediterranean NIS list ["*A species must be a relative newcomer to the Mediterranean Sea, i.e., a) not having appeared before the 1920s for Lessepsian species, ... and b) not before the 1960s for the others (before 1950s for the crustaceans)*"] are not suitable for a revision of non-indigenous polychaetes. The majority of currently valid polychaete species have been described after the 1960s, showing an increase after the 2000s because of the use of molecular techniques and the revamping of taxonomic studies, which had been neglected in previous decades. In fact, several new records for the Mediterranean Sea refer to recently described species, whose taxonomy was clarified only recently (D'Alessandro *et al.*, 2016a; Schimmenti *et al.*, 2016), and new species keep also being discovered in thoroughly investigated coastal environments (Giangrande *et al.*, 2015; Lezzi *et al.*, 2016a; Langeneck *et al.*, 2017; Lezzi, 2017; Lezzi & Giangrande, 2018a). Moreover, several genera including a single, or few, described species with an extremely wide distribution are likely to represent species complexes (Westheide & Schmidt, 2003; Langeneck *et al.*, 2019a). It appears clear, therefore, that any temporal criterion applied to define a non native polychaete is subject to mistakes and ultimately arbitrary. This uncertain, often quickly developing, and sometimes complex taxonomy implies that several of the alleged polychaete NIS should be considered cryptogenic or questionable, rather than truly alien (Carlton, 1996; Çinar, 2013). The problem of cryptogenic species is not negligible with regards to polychaetes, as in Çinar's (2013) review on polychaete NIS worldwide approximately 17% of the species are considered cryptogenic. If the definition of NIS was restricted only to the species whose native range and spatio-temporal dynamics of invasion are precisely known, this percentage would turn out to be far higher. A critical revision of non-indigenous polychaetes in Italian waters, therefore, cannot stem from a univocal temporal criterion, but should rely on a critical evaluation of taxonomy, biogeography and ecology of each single species.

Polychaetes usually represent a major component of benthic assemblages in the marine environment, and their identification is crucial in order to have a clearer idea of biodiversity and to understand ecosystem functioning. Moreover, the correct identification of NIS is one of the key points of the recently developed Marine Strategy Framework Directive (MSFD), with which all members of the European Union should comply (Olenin *et al.*, 2010), and of the IAS Regulation (EU Regulation 1143/2014) that fulfils the Target 5 of the EU 2020 Biodiversity Strategy. In this frame, the Italian Peninsula is a particularly important area in the Mediterranean basin, as it represents the geographical barrier between the Western and the Eastern sub-basins, thus representing the gateway towards the Western Mediterranean Sea for Lessepsian invaders. Moreover, its central position in the Mediterranean Sea makes it a crossover area sensitive to several invasion pathways (Zenetos *et al.*, 2012; Katsanevakis *et al.*, 2014). A comparative analysis of lists of non-indigenous polychaetes for Italian Seas can however easily highlight discrepancies, which are due to progress in taxonomy and to the range extensions of invaders, but also to the use of different criteria for the definition of NIS (Zenetos *et al.*, 2005a; Castelli *et al.*, 2008; AA.VV., 2011; Zenetos *et al.*, 2017; Servello *et al.*, 2019). The aim of this work is to critically revise the checklist of non-indigenous polychaetes in Italian Seas, based both on the critical evaluation of literature, and on the examination of old and new material, and to present an integrated checklist of polychaete NIS, that can be employed as a baseline for environmental monitoring and for further revisions.

Material and Methods

The critical reappraisal of polychaete xenodiversity in Italian Seas started from the comparison of available and partially discrepant checklists of NIS. We identified eight sources of lists of non-indigenous species, namely: 1) the first annotated list of all Mediterranean NIS (Zenetos *et al.*, 2005a); 2) the most recent checklist of Italian polychaete fauna (Castelli *et al.*, 2008); 3) the Italian NIS list compiled by Occhipinti Ambrogi *et al.* (2011); 4) the atlas of Mediterranean NIS available on the ISPRA platform (AA.VV., 2011) and the 2018 MSFD report (ISPRA, 2019); 5) the reviewed annotated list of all Mediterranean NIS, with following integrations (Zenetos *et al.*, 2010; 2012; 2017); 6) the most recent list of non-indigenous species in the Italian Seas provided by the Italian Society of Marine Biology (GSA SIBM, 2018); 7) the last revision of marine NIS in Italian waters (Servello *et al.*, 2019); 8) the EASIN database. We added to these lists recent new records of polychaetes with type localities outside of the Mediterranean/Eastern Atlantic Ocean, or literature explicitly considering some polychaete species as non-indigenous. Whenever possible, the available material was re-examined, focusing in particular on doubtful records. Non-indigenous polychaetes reported by checklists have been re-analysed thoroughly and further divided in the following four categories:

a) *Alien species*: all species whose status of NIS can be confirmed were assigned to this category.

b) *Cryptogenic species*: following Carlton (1996) we defined cryptogenic all species with reasonably clear taxonomy that are not demonstrably native or introduced.

c) *Questionable species*: we regarded as dubious all species of uncertain occurrence in Mediterranean environments; these are chiefly species that have been reported only once in Italian waters, whose records were not supported by morphological studies and lack reference material, and which in most cases are likely to be misidentifications of native species. Following Tsiamis *et al.* (2018) we also included in this category species commonly recorded in Mediterranean environments, but showing discrepancies in morphology and/or ecology that might suggest the occurrence of an overlooked undescribed native species.

d) *Excluded species*: lastly, we excluded from this checklist all native species erroneously reported as NIS, and all species whose report in the Mediterranean Sea is due to misidentification of native species.

The origin of all species was reconstructed on the basis of the type locality, except when available data suggested that the species was already a NIS in its type locality (e.g. Faasse & Giangrande, 2012; Lezzi & Giangrande, 2018a). The biogeographic categories employed were Mediterranean, E Atlantic, W Atlantic, Indian, W Pacific, E Pacific, Arctic and Antartic (Table 1).

Results

Alien species

Family Amphinomidae Lamarck, 1818

Linopherus canariensis Langerhans, 1881

= *Linopherus acarunculatus* (Monro, 1937) *sensu* Ben-Eliahu, 1976

Material examined. Castellammare del Golfo, Tyrrhenian Sea (38.0427° N, 12.8733° E), 0.2 m, 06/2013: 2 specimens.

Remarks. Although the type locality of this species is in the North-Eastern Atlantic Ocean (Canary Islands: Langerhans, 1881), its recent appearance in the Eastern part of the Mediterranean Sea (Ben-Eliahu, 1976 as *L. acarunculatus*; Çinar, 2009), and the colonisation dynamics observed (Cosentino & Giacobbe, 2011) strongly support the NIS status of *L. canariensis*. Despite some issues about the taxonomy of the genus, mainly related to an incomplete understanding of intraspecific variability (Peixoto & Santos, 2015), *L. canariensis* seems to thrive chiefly in enriched, potentially hypoxic environments (Cosentino & Giacobbe, 2011), and is still rarely reported along Italian coasts. The current new record from the Gulf of Castellammare (southern Tyrrhenian Sea) represents the second occurrence of the species in Italian waters and considerably extends its distribution.

Family Capitellidae Grube, 1862

Notomastus aberans Day, 1957

Material examined. Porto Pozzo, Sardinia, Tyrrhenian Sea (41.1891° N, 9.2858° E), 0.2 m, 07/2015: 1 specimen. Monfalcone, Gulf of Trieste, Adriatic Sea (45.7463° N, 13.5854° E), 15 m, 10/1995: 7 specimens.

Remarks. Notomastus aberans is a widespread species along the Italian coast, occurring in muddy sediment of harbour environments and organically enriched substrata. It was firstly recorded by Harmelin (1968) after its description from South Africa (Day, 1957). Harmelin (1969) found this species on *Halophila stipulacea* beds in the Eastern Mediterranean Sea (Crete) and on SFBC biocoenoses *sensu* Pérès and Picard (1964) in the western Mediterranean Sea. The absence of records of morphologically compatible specimens in the XIX and early XX century (see Claparède, 1868; 1870; Lo Bianco, 1893; Fauvel, 1927; Fauvel, 1940) suggests that the species was introduced and had a rapid expansion throughout the Mediterranean basin in the second half of the 20th century. Along the Italian coast, *N. aberans* was first recorded during the 1980s (Gravina & Somaschini, 1990). The species is currently widespread in all Italian seas (Castelli *et al.*, 2008).

Family Cirratulidae Carus, 1863

Chaetozone corona Berkeley & Berkeley, 1941

Material examined. Mar Grande of Taranto, Ionian Sea (40.4340° N, 17.2387° E), 12 m, 03/2018: 2 specimens.

Remarks. Chambers *et al.* (2011) doubt the validity of the Mediterranean records and the presence of the species in the Mediterranean (mainly on the basis of its Pacific distribution) but Le Garrec *et al.* (2017) present evidence of a wide distribution of the species in the Bay of Biscay, suggesting that *C. corona* is an established alien species along the coasts of Europe and was probably introduced via shipping from its native distribution.

The first Mediterranean records of *C. corona* come from muddy sand in the Izmir Bay (Çinar & Ergen, 2007), where it reaches densities that vary from 10 to 70 ind/m^2. However, Çinar & Ergen (2007) suggested that past records (from 1989), wrongly assigned to *Chaetozone setosa* McIntosh, 1911, reached densities of 430 ind/m^2. Grossi *et al.* (2017) recorded the same species in muddy and sandy bottoms along the Adriatic coast, with densities of 30 ind/m^2 in north Adriatic and 500 ind/m^2 in the harbour of Bari. Other records made by Munari *et al.* (2017) showed its occurrence in the Tyrrhenian sea.

Despite its recently reported abundance, *C. corona* was not recorded and/or described in the past centuries (e.g. Claparède 1868; 1870, Lo Bianco 1893). Nor did Fauvel (1940), whose study was focused in the Adriatic polychaetes, find a similar species, finding instead only *C. setosa*. Given the difference between the two species (absence of eyes in *C. setosa*, with hooks starting far from the anterior end), and the presence of individuals morphologically close to *C. setosa* along the Italian coast (ML & JL pers. Obs.), it is possible to speculate that *C. corona* was introduced after the 1930s. In addition to the absence of historical observations, the species shares an ecology with other NIS (opportunistic species occurring in polluted areas and harbour environments), and showed high densities that are compatible to the strong population blooms that are often observed in NIS. It can be therefore considered an established NIS in European waters.

Table 1. Comparison between different lists of polychaete NIS occurring in Italian waters. The origin was based on the type locality, except in cases where contrasting evidence is available. A= alien; C= cryptogenic; Q= questionable; E (nat.)= Excluded because native; E (mis.)= Excluded because misidentification or mis-spelling; (abs.)= absent from the checklist; n.a.= not available. Confirmed alien species in bold. Species marked with a star are confirmed as NIS in other Mediterranean areas.

Species	**Origin**	Zenetos *et al.* (2005a)	Castelli *et al.* (2008)	Zenetos *et al.* (2010; 2012; 2017)	Occhipinti Ambrogi *et al.* (2011)	ISPRA (2011; 2019)	GSA SIBM (2018)	Servello *et al.* (2019)	EASIN (update 2019)	This work
Alciopidae										
Rhynchonereella petersi	E Atlantic	(abs.)	**A**	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	E (nat.)
Ampharetidae										
Isolda pulchella	W Atlantic	(abs.)	**A**	**A**	**A**	**A**	(abs.)	(abs.)	**A**	*Q*
Amphinomidae										
Eurythoe complanata	W Atlantic	*Q*	E (nat.)	**A**	(abs.)	**A**	(abs.)	***C***	***C***	*Q*
Linopherus canariensis	E Atlantic	**A**	(abs.)	**A**	**A**	**A**	**A**	**A**	**A**	**A**
Notopygos crinita	W Atlantic	*Q*	(abs.)	**A**	**A**	**A**	(abs.)	**A**	(abs.)	E (mis.)
Notopygos megalops	W Atlantic	(abs.)	**A**	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	*Q*	*Q*
Capitellidae										
Leiochrides australis	W Pacific	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	*Q*
Mediomastus capensis	E Atlantic	*Q*	**A**	**A**	**A**	***C***	(abs.)	(abs.)	*Q*	*Q*
Neopseudocapitella brasiliensis	W Atlantic	**A**	**A**	**A**	**A**	**A**	(abs.)	(abs.)	**A**	*Q*
Notomastus aberans	Indian	(abs.)	**A**	**A**	**A**	**A**	(abs.)	**A**	**A**	**A**
Cirratulidae										
Chaetozone corona	E Pacific	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	**A**	**A**	***C***	**A**
Kirkegaardia dorsobranchialis	E Atlantic	*Q*	E (nat.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	E (mis.)
Dorvilleidae										
Dorvillea similis	Indian	(abs.)	(abs.)	**A**	(abs.)	(abs.)	(abs.)	**A**	**A**	**A**
Ophryotrocha diadema	E Pacific	(abs.)	**A**	**A**	**A**	(abs.)	**A**	**A**	**A**	**A**
Ophryotrocha japonica	W Pacific	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**
Protodorvillea egena	E Atlantic	*Q*	**A**	**A**	**A**	**A**	(abs.)	(abs.)	*Q*	*Q*

continued

Table 1 continued

Species	**Origin**	Zenetos *et al.* (2005a)	Castelli *et al.* (2008)	Zenetos *et al.* (2010; 2012; 2017)	Occhipinti Ambrogi *et al.* (2011)	ISPRA (2011; 2019)	GSA SIBM (2018)	Servello *et al.* (2019)	EASIN (update 2019)	This work
EUNICIDAE										
Eunice floridana	W Atlantic	(abs.)	E (nat.)	*Q*	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	*Q*
**Leodice antennata*	Indian	(abs.)	E (nat.)	**A**	(abs.)	(abs.)	(abs.)	**A**	**A**	*Q*
Lysidice collaris	Indian	*Q*	**A**	**A**	**A**	**A**	(abs.)	**A**	**A**	**A**
Lysidice hebes	W Atlantic	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	E (mis.)
FABRICIIDAE										
Fabriciola ghardaqa	Indian	**A**	**A**	**A**	**A**	**A**	(abs.)	**A**	**A**	*Q*
Novafabricia infratorquata	W Atlantic	(abs.)	**A**	**A**	**A**	**A**	(abs.)	(abs.)	**A**	*Q*
FLABELLIGERIDAE										
Diplocirrus hirsutus	E Atlantic	(abs.)	(abs.)	(abs.)	(abs.)	*Q*	(abs.)	(abs.)	(abs.)	*Q*
GLYCERIDAE										
Glycera capitata	E Atlantic	(abs.)	(abs.)	(abs.)	(abs.)	*Q*	(abs.)	(abs.)	**A (loc.)**	E (mis.)
HESIONIDAE										
Leocrates chinensis	W Pacific	(abs.)	E (nat.)	*Q*	(abs.)	(abs.)	(abs.)	(abs.)	*Q*	E (mis.)
Podarkeopsis capensis	E Atlantic	(abs.)	E (nat.)	**A**	(abs.)	(abs.)	(abs.)	**A**	**A**	*Q*
LUMBRINERIDAE										
Abyssoninoe hibernica	E Atlantic	(abs.)	(abs.)	(abs.)	(abs.)	*Q*	(abs.)	(abs.)	(abs.)	E (nat.)
Gallardoneris iberica	E Atlantic	(abs.)	(abs.)	(abs.)	(abs.)	*Q*	(abs.)	(abs.)	(abs.)	E (nat.)
Lumbrinerides acutiformis	W Pacific	(abs.)	**A**	**A**	**A**	**A**	(abs.)	**A**	(abs.)	*Q*
Lumbrinerides neogesae	E Atlantic	**A**	**A**	**A**	**A**	**A**	(abs.)	**A**	**A**	*Q*
Lumbrineris acutifrons	E Atlantic	(abs.)	(abs.)	(abs.)	(abs.)	**A**	(abs.)	(abs.)	**A**	E (mis.)
Lumbrineris perkinsi	W Atlantic	**A**	**A**	**A**	(abs.)	**A**	(abs.)	**A**	**A**	*Q*
Lumbrineris pinaster	E Atlantic	(abs.)	(abs.)	(abs.)	(abs.)	*Q*	(abs.)	(abs.)	(abs.)	E (nat.)
MALDANIDAE										

continued

Table 1 continued

Species	Origin	Zenetos *et al.* (2005a)	Castelli *et al.* (2008)	Zenetos *et al.* (2010; 2012; 2017)	Occhipinti Ambrogi *et al.* (2011)	ISPRA (2011; 2019)	GSA SIBM (2018)	Servello *et al.* (2019)	EASIN (update 2019)	This work
Metasychis gotoi	W Pacific	**A**	**A**	**A**	(abs.)	**A**	(abs.)	**A**	**A**	*Q*
Nereididae										
Neanthes agulhana	E Atlantic	(abs.)	(abs.)	**A**	**A**	**A**	(abs.)	**A**	**A**	*Q*
Nereis jacksoni	W Pacific	(abs.)	E (nat.)	**A**	(abs.)	(abs.)	(abs.)	**A**	**A**	**A**
**Nereis persica*	Indian	**A**	(abs.)	**A**	(abs.)	**A**	(abs.)	(abs.)	**A**	*Q*
Platynereis cf. *australis*	W Pacific	*Q*	**A**	**A**	**A**	**A**	(abs.)	(abs.)	(abs.)	*Q*
Pseudonereis anomala	Indian	**A**	(abs.)	**A**	(abs.)	**A**	**A**	**A**	**A**	**A**
Oenonidae										
Oenone cf. *fulgida*	Indian	**A**	E (nat.)	**A**	(abs.)	(abs.)	(abs.)	(abs.)	**A**	*Q*
Onuphidae										
Diopatra hupferiana	E Atlantic	*Q*	**A**	**A**	**A**	**A**	(abs.)	**A**	**A**	*Q*
Longibrachium atlanticum	W Atlantic	**A**	**A**	**A**	**A**	**A**	(abs.)	(abs.)	**C**	*Q*
Orbiniidae										
Naineris setosa	W Atlantic	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	**A**	**A**	**A**	**A**
Paraonidae										
Levinsenia demiri	Mediterranean	(abs.)	(abs.)	(abs.)	(abs.)	*Q*	(abs.)	(abs.)	(abs.)	E (nat.)
Paraonis fragilis	W Atlantic	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	***C***
Pilargidae										
Sigambra parva	Indian	(abs.)	(abs.)	**A**	(abs.)	*Q*	(abs.)	(abs.)	**A**	*Q*
Phyllodocidae										
Hesionura serrata	Indian	(abs.)	(abs.)	**A**	(abs.)	**A**	(abs.)	**A**	**A**	*Q*
Sabellidae										

continued

Table 1 continued

Species	**Origin**	Zenetos *et al.* (2005a)	Castelli *et al.* (2008)	Zenetos *et al.* (2010; 2012; 2017)	Occhipinti Ambrogi *et al.* (2011)	ISPRA (2011; 2019)	GSA SIBM (2018)	Servello *et al.* (2019)	EASIN (update 2019)	This work
Amphicorina pectinata	W Pacific	**A**	**A**	**A**	**A**	**A**	(abs.)	(abs.)	**A**	*Q*
Bispira polyomma	Unknown	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	**A**	**A**
Branchiomma bairdi	W Atlantic	(abs.)	(abs.)	**A**	(abs.)	**A**	(abs.)	(abs.)	**A**	**A**
Branchiomma boholense	W Pacific	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	**A**	**A**	**A**	**A**
Branchiomma luctuosum	Indian	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**
Desdemona ornata	Indian	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**
Acromegalomma claparedei	Indian	(abs.)	**A**	**A**	**A**	**A**	(abs.)	(abs.)	**A**	*Q*
Acromegalomma vesiculosum	E Atlantic	(abs.)	(abs.)	(abs.)	(abs.)	*Q*	(abs.)	(abs.)	(abs.)	E (mis.)
SCALIBREGMATIDAE										
Hyboscolex longiseta	Indian	(abs.)	**A**	*Q*	**A**	**A**	(abs.)	(abs.)	*Q*	*Q*
SERPULIDAE										
Ficopomatus enigmaticus	W Pacific	**A**	**A**	**A**	(abs.)	**A**	**A**	**A**	**A**	**A**
Hydroides dianthus	Mediterranean	***C***	**A**	**A**	(abs.)	**A**	(abs.)	(abs.)	**A**	E (nat.)
Hydroides dirampha	Unknown	***C***	**A**	**A**	(abs.)	**A**	**A**	**A**	***C***	**A**
Hydroides elegans	Unknown	***C***	**A**	**A**	(abs.)	**A**	**A**	**A**	***C***	**A**
Hydroides cf. *inornata*	Indian	**A**	(abs.)	**A**	(abs.)	**A**	(abs.)	(abs.)	(abs.)	*Q*
Hydroides sanctaecrucis	W Atlantic	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	**A**	(abs.)	E (mis.)
Pileolaria berkeleyana	E Pacific	**A**	**A**	**A**	**A**	**A**	(abs.)	**A**	**A**	**A**
Spirobranchus tetraceros s.l.	Unknown	**A**	(abs.)	**A**	(abs.)	**A**	**A**	**A**	**A**	**A**
Spirorbis marioni	E Pacific	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**	**A**
SPIONIDAE										
Dispio uncinata	E Pacific	E (nat.)	**A**	**A**	(abs.)	(abs.)	(abs.)	(abs.)	**A**	*Q*
Polydora colonia	W Atlantic	(abs.)	(abs.)	**A**	**A**	**A**	(abs.)	**A**	**A**	*Q*
Polydora cornuta	W Atlantic	**A**	(abs.)	**A**	(abs.)	**A**	(abs.)	**A**	**A**	**A**
**Prionospio pulchra*	W Pacific	**A**	(abs.)	**A**	(abs.)	(abs.)	(abs.)	(abs.)	**A**	*Q*
Prionospio pygmaea	E Pacific	**A**	**A**	**A**	**A**	**A**	(abs.)	**A**	**A**	*Q*

continued

Table 1 continued

Species	**Origin**	Zenetos *et al.* (2005a)	Castelli *et al.* (2008)	Zenetos *et al.* (2010; 2012; 2017)	Occhipinti Ambrogi *et al.* (2011)	ISPRA (2011; 2019)	GSA SIBM (2018)	Servello *et al.* (2019)	EASIN (update 2019)	This work
**Prionospio sexoculata*	E Atlantic	(abs.)	E (nat.)	**A**	(abs.)	(abs.)	(abs.)	(abs.)	**A**	*Q*
Pseudopolydora paucibranchiata	W Pacific	(abs.)	(abs.)	**A**	(abs.)	(abs.)	(abs.)	**A**	**A**	**A**
SYLLIDAE										
Erinaceusyllis belizensis	W Atlantic	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	*Q*
Erinaceusyllis serratosetosa	W Pacific	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	**A**	**A**	*Q*
Streptosyllis arenae	W Atlantic	*Q*	**A**	(abs.)	(abs.)	**A**	(abs.)	(abs.)	(abs.)	E (mis.)
Syllis alosae	W Atlantic	(abs.)	**A**	**A**	(abs.)	(abs.)	(abs.)	(abs.)	*Q*	*Q*
Syllis hyllebergi	Indian	(abs.)	(abs.)	**A**	**A**	**A**	(abs.)	**A**	**A**	**A**
Syllis pectinans	W Pacific	(abs.)	(abs.)	**A**	(abs.)	(abs.)	**A**	**A**	**A**	**A**
Trypanosyllis gigantea	Antarctic	(abs.)	**A**	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	E (mis.)
TEREBELLIDAE										
Loimia medusa	Indian	(abs.)	**A**	*Q*	**A**	**A**	(abs.)	**A**	*Q*	*Q*
Paramphitrite birulai	Arctic	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	**A**	(abs.)	***C***
Pista unibranchia	Indian	**A**	**A**	**A**	**A**	**A**	(abs.)	**A**	**A**	*Q*
Pistella lornensis	E Atlantic	(abs.)	(abs.)	(abs.)	(abs.)	**A**	(abs.)	(abs.)	(abs.)	*Q*
Streblosoma comatus	E Pacific	(abs.)	(abs.)	**A**	**A**	**A**	(abs.)	**A**	**A**	E (mis.)
Streblosoma hesslei	Indian	**A**	**A**	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	E (mis.)
Streblosoma pseudocomatus	Unknown	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	(abs.)	***C***
Alien species		26	39	57	32	48	16	43	51	**25**
Cryptogenic species		n.a.	n.a.	n.a.	n.a.	1	n.a.	1	5	**3**
Questionable species		9	n.a.	4	n.a.	8	n.a.	n.a.	7	**40**

Family Dorvilleidae Chamberlin, 1919

Dorvillea similis (Crossland, 1924)

Material examined. La Spezia, Ligurian Sea (44.0824° N, 9.8277° E), 0.5 m, 06/2018: 11 specimens. Capraia Island, Tyrrhenian Sea (43.0513° N, 9.8367° E), 1 m, 05/2019: 6 specimens.

Remarks. This species was described for artificial docks off Suez (Crossland, 1924). The first record in Southern Turkey by Çinar (2009) suggests that the species is already widespread in the Eastern Mediterranean Sea. Afterwards *D. similis* was reported for the Eastern Aegean Sea (Corsini-Foka *et al.*, 2015). The species was found in Italian waters very recently (Dragičević *et al.*, 2019); its occurrence is confirmed here by further records in the Ligurian Sea, which backdate its occurrence at least to 2018. However it is not unlikely that the species is already widespread in Italian waters, and that its occurrence has been overlooked due to similarities with the native *Dorvillea rubrovittata* (Grube, 1855), from which it can be surely distinguished only by examination of the jaw apparatus, especially in the case of fixed individuals (Dragičević *et al.*, 2019).

Ophryotrocha diadema Åkesson, 1976

Remarks. The species was found only at Porto Empedocle, but its being reported in three consecutive years suggests that it has established a self-sustaining population (Simonini *et al.*, 2009). The identity of this species was checked through experimental crossing with a Pacific strain of *O. diadema*. It is possible that this species is now more widespread along Italian coasts, but the lack of studies dealing with the taxonomy of *Ophryotrocha* in the last years hindered its detection.

Ophryotrocha japonica Paxton & Åkesson, 2010

Remarks. According to Simonini *et al.* (2009) the species is now widespread along the whole Italian peninsular coastline, missing only in Sardinia and Sicily. Interfertility with Pacific strains of *O. japonica* confirms the identity of this species that, unlike *O. diadema*, should be considered a successful invader of Italian harbours.

Family Eunicidae Berthold, 1827

Lysidice collaris Grube, 1870

Material examined. Capraia Island, Tyrrhenian Sea (43.0390° N, 9.8466° E), 5 m, 06/2014: 1 specimen; Castellammare del Golfo, Tyrrhenian Sea (38.04274° N, 12.87332° E), 0.2 m, 06/2013: 2 specimens.

Additional material: ***Lysidice margaritacea*** Claparède, 1868 – Menorca, Balearic Sea (39.9517° N, 3.8184° E), 5 m, 06/2014: 6 specimens. Stintino, Sardinia, Sea of Sardinia (40.8724° N, 8.2113° E), 5 m, 06/2014: 7 specimens. Calafuria, Tyrrhenian Sea (43.4650° N, 10.3414° E), 0.5 m, 11/2012: 1 specimen; 05/2013: 1 specimen.

Remarks. Kurt Şahin & Çinar (2009) highlighted the occurrence in the Mediterranean Sea of two similar species traditionally referred to as *L. collaris*, redescribing *L. collaris* (based on Red Sea individuals) and *Lysidice margaritacea* Claparède, 1868 (native). These two species can be distinguished mainly on the basis of the number of teeth on the Maxillae II, the number of teeth on pectinate chaetae and the length of the compound chaetae (Kurt Şahin & Çinar, 2009). Where the majority of material from Italian coasts examined should be assigned to *L. margaritacea*, nevertheless most of the specimens belonging to the genus *Lysidice* reported as borers in *Posidonia oceanica* sheats, in meadows of the island of Ischia (Gulf of Naples) (Vasapollo & Gambi, 2015), as well as some individuals collected in other Tyrrhenian localities, actualy belong to *L. collaris*.

Family Nereididae Blainville, 1818

Nereis jacksoni Kinberg, 1866

Material examined. Castellammare del Golfo, Tyrrhenian Sea (38.04274° N, 12.87332° E), 0.2 m, 06/2013: 2 specimens.

Remarks. This Indo-Pacific species is considered alien in the Mediterranean Sea. Although some records may refer to misidentifications of the native *Nereis funchalensis* Langerhans, 1880 and *Nereis usticensis* Cantone, Catalano & Badalamenti, 2003 (Viéitez *et al.*, 2004; Gravina *et al.*, 2016), Gravina *et al.* (2016) report several specimens of *N. jacksoni* for the Adriatic and Tyrrhenian Sea. The new record confirms the occurrence of this species in the Tyrrhenian Sea. The distribution of *N. jacksoni* along the Italian coasts is still uncertain, due to possible confusions with other *Nereis* with multidentate homogomph falcigers.

Pseudonereis anomala Gravier, 1900

Remarks. This species has been reported for Italian waters only recently (D'Alessandro *et al.*, 2016b). In the Eastern Mediterranean Sea it is a successful and widespread Lessepsian immigrant, that showed the capability to overcompete native Nereididae in coastal environments (Çinar & Altun, 2007). Its spread along Italian coasts deserves a close monitoring.

Family Orbiniidae Hartman, 1942

Naineris setosa Verrill, 1900

Material examined. Livorno port, Tyrrhenian Sea (43.5491° N, 10.2968° E), 1 m, 11/2015: 3 specimens; 1 m, 04/2016: 2 specimens; 3 m, 04/2016: 3 specimens; 1 m, 10/2019: 4 specimens. Mar Grande of Taranto, Ionian Sea (40.43402° N, 17.23872° E), 12 m, 03/2019: 1 specimen.

Remarks. After the first record in a semi-enclosed environment at Brindisi (Blake & Giangrande, 2011), the species has been reported for Boughrara Lagoon, in Tunisia (Khedri *et al.*, 2014) and later for Santa Gilla Lagoon (Sardinia, Tyrrhenian Sea) (Atzori *et al.*, 2016). Data hereby presented allow to extend its distribution to Taranto (Ionian Sea) and Livorno (Tyrrhenian Sea). Until now the species has been reported chiefly from ports or areas close to port environments, and its occurrence is likely related to shipping or aquaculture, even though the actual vector is yet unknown. The observation of juvenile specimens in fouling communities of the port of Livorno (Tempesti *et al.*, 2020) suggests that hull fouling might have contributed to the spreading of this highly tolerant, opportunistic species across port areas in the whole Mediterranean Sea, as already suggested by Atzori *et al.* (2016). On the other hand, although the first Mediterranean record of the species refers to aquaculture plants (Blake & Giangrande, 2011), and the Taranto specimen was found under fish farm cages, this introduction pathway could be easily excluded for Tunisian and Tyrrhenian localities due to the absence of important fish farms in their proximity. This species might actually be more widespread in the Mediterranean Sea, but its occurrence might have been overlooked due to its resemblance to the native *Naineris laevigata* (Grube, 1855).

Family Sabellidae Latreille, 1825

Bispira polyomma Faasse & Giangrande, 2012 (Fig. 1)

Material examined. Chioggia, Venice Lagoon, Adriatic Sea (45.2195° N, 12.2647° E), 3 m, 09/2014: 1 specimen.

Remarks. The only available specimen corresponds well to the original description, and *B. polyomma* is the only species of *Bispira* Krøyer, 1856 with six rows of radiolar eyes and six-eight coloured bands (in correspondence to radiolar eyes) on the crown (Faasse & Giangrande, 2012). This is the first Mediterranean record of this species, previously reported for the South-Western coast of the Netherlands (Faasse & Giangrande, 2012), even if records of *Bispira fabricii* (Krøyer, 1856) from ports of Normandy (France) (Breton, 2014) are likely to be referred to this species. Although the origin of the species is currently unknown, in Atlantic transitional environments it showed population dynamics typical of invasive species (Faasse & Giangrande, 2012), and for this reason its spread in Mediterranean environments should be closely monitored. The invasion pathways for this species are currently unknown, even if Faasse & Giangrande (2012) suggested that it might have been introduced either through hull fouling or with oyster trade. Both pathways could easily explain its occurrence in the Venice Lagoon.

Fig. 1: *Bispira polyomma* Faasse & Giangrande, 2012 sampled off Chioggia. A. branchial crown, showing several rows of radiolar eyes; B: body without the branchial crown.

Branchiomma bairdi (McIntosh, 1885)

Material examined. Villa Igiea, Sicily, Southern Tyrrhenian Sea (38.1451° N, 13.3721° E), 1 m, 07/2016: 1 specimen. Marina di Ragusa, Sicily, Strait of Sicily (36.7800° N, 14.5483° E), 1 m, 09/2016: 3 specimens. Port Vell, Barcelona, Spain, Balearic Sea (41.3778° N, 2.1869° E), 1 m, 11/2016: 3 specimens. Alicante, Spain, Balearic Sea (38.3407° N, 0.4806° W), 1 m, 11/2016: 1 specimen.

Remarks. Branchiomma bairdi, native of the Great Caribbean Region (McIntosh, 1885), was first recorded in the Mediterranean Sea by Çinar (2009) for the Southern coast of Turkey (Levantine Sea, eastern Mediterranean). This species was later recorded along the Italian coasts by Giangrande *et al.* (2012) in Faro coastal lake (Messina, Ionian Sea). However, the re-examination of this material revealed it to be *B. boholense*, as did all the subsequent Italian records of *B. bairdi* for the Tyrrhenian and Adriatic Sea (Arias *et al.*, 2013; Stabili *et al.*, 2014) which was revised by combining morphological and molecular data (Del Pasqua *et al.*, 2018). Although *Branchiomma bairdi* and *B. boholense* are difficult to distinguish relying only on morphological data, especially on dead material (Del Pasqua *et al.*, 2018), through an identification based only on morphological inferences, present data confirm the occurrence of *B. bairdi* along the Sicilian coasts (Villa Igiea and Marina di Ragusa, Southern Tyrrhenian Sea and Strait of Sicily, respectively).

Branchiomma boholense (Grube, 1878)

Material examined. Livorno port, Tyrrhenian Sea (43.5491° N, 10.2968° E), 0.5 m, 10/2014: 1 specimen; 1 m, 04/2016: 132 specimens. Lacco Ameno, Ischia Island, Tyrrhenian Sea (40.7530° N, 13.8908° E), 2.5 m, 2012: 8 specimens. Sant'Anna, Ischia Island, Tyrrhenian Sea (40.7269° N, 13.9606° E), 2.5 m, 2012: 14 specimens. Castello Aragonese, Ischia Island, Tyrrhenian Sea (40.7317° N, 13.9638° E), 2.5 m, 2012: 6 specimens. Mar Grande of Taranto, Ionian Sea (40.43402° N, 17.23872° E), 2 m, 04/2015: 9 specimens.

Remarks. This species was first recorded in the Mediterranean Sea off the cost of Israel in 1927 (Knight-Jones *et al.*, 1991), and the first record for the central Mediterranean Sea (Malta) dates back to 1929. This is therefore one of the first non-indigenous polychaetes occurring in the Mediterranean Sea, although it has been correctly identified only recently (Knight-Jones *et al.*, 1991). Later, all the reports of *B. boholense* for the Mediterranean were considered questionable and corrected as *B. bairdi* (Çinar, 2005; 2009; Giangrande *et al.*, 2012). Recently, a combined morphological and molecular study by Del Pasqua *et al.* (2018) clarified the taxonomic status of *B. boholense* in the Mediterranean Sea and along the Italian coasts, revealing that the previous records of this species for the Tyrrhenian Sea and the South Adriatic Sea (Arias *et al.*, 2013a; Stabili *et al.*, 2014), erroneously identified as *B. bairdi*, should represent *B. boholense*.

Based on bibliographical data, *B. boholense* remained restricted to the Southern and Eastern Mediterranean Sea for several decades (Knight-Jones *et al.*, 1991); its recent expansion northwards (Giangrande *et al.*, 2012; Arias *et al.*, 2013a; Del Pasqua *et al.*, 2018) has been most likely fostered by the current phenomenon of meridionalisation of the Mediterranean Sea. The subtropical affinity of the species is consistent with its recruitment occurring in summer (Lezzi *et al.*, 2016b, as *B. bairdi*), contrasting with many native sabellid species recruiting in winter (Lezzi & Giangrande, 2018b).

Along the Italian coasts *B. boholense* is particularly abundant in confined zones and areas degraded by anthropogenic impacts, including naturally acidified waters (Arias *et al.*, 2013a). In the Tyrrhenian Sea this species was also collected on *Posidonia oceanica* patches and dead matter covered with *Caulerpa prolifera*, as well as below a mussel (*Mytilus galloprovincialis*) aquaculture system (Arias *et al.*, 2013a). *Branchiomma boholense* is an opportunistic species characterised by an annual life cycle and by quick population dynamics (Lezzi *et al.*, 2016b); although this is one of the first species to colonise clean artificial substrate, it is also able to thrive on mature fouling, thus successfully competing with other structuring filter feeders as *M. galloprovincialis* (Lezzi & Giangrande, 2018b).

Branchiomma luctuosum Grube, 1869

Material examined. Santa Giusta Pond, Sea of Sardinia (39.8715° N, 8.5830° E), 2 m, 11/2002: 28 specimens. Livorno port, Tyrrhenian Sea (43.5491° N, 10.2968° E), 1 m, 04/2016: 9 specimens; 11/2018: 15 specimens. Tortolì Pond, Tyrrhenian Sea (39.9522° N, 9.6825° E), 0.5 m, 05/2016: 10 specimens. Ustica Island, Tyrrhenian Sea (38.6924° N, 13.1756° E), 5 m, 04/2014: 8 specimens.

Remarks. The first record of this species for the Mediterranean Sea dates back to 1978–1979 along the Italian coasts (Lago Lucrino, Tyrrhenian Sea) (Knight-Jones *et al.*, 1991). Since then, the species has been recorded frequently along all Italian coasts, as well as in some other Mediterranean localities (Çinar *et al.*, 2006; El Haddad *et al.*, 2012; Faulwetter *et al.*, 2017). While in Italian waters *B. luctuosum* is extremely widespread, and shows the features of a true invasive species (Licciano *et al.*, 2002), in other Mediterranean countries this species does not seem to have a great invasion success, and records are still scattered.

Although the majority of records refer to highly impacted environments, chiefly ports, *B. luctuosum* has been found also in pristine environments (for instance on *Cystoseira*-dominated assemblages) and in brackish ponds, where it can also colonise soft bottoms. This seems to be an opportunistic, highly euryhaline species, showing the ability to successfully colonise a wide range of environments. As in *B. boholense*, recruitment occurs in summer, but *B. luctuosum* is characterised by a longer life cycle, spanning at least two years (Mastrototaro *et al.*, 2015).

Desdemona ornata Banse, 1957

Material examined. Calich Pond, Sardinia, Sea of Sardinia (40.5972° N, 8.2954° E), 1 m, 03/1995: 5 specimens. Casaraccio Pond, Sardinia, Sea of Sardinia (40.9125° N, 8.2198° E), 1 m, 06/1994: 4 specimens; 03/1995: 164 specimens. Salina di Portoferraio, Elba Island, Tyrrhenian Sea (42.8036° N, 10.3176° E), 0.5 m, 09/1985: 3 specimens. Livorno, Tyrrhenian Sea (43.5491° N, 10.2968° E), 3 m, 04/2016: 4 specimens.

Remarks. This species has been recorded for the first time in a transitional environment on Elba Island, Tyrrhenian Sea (Lardicci & Castelli, 1986) and subsequently reported for the mouth of the Magra River (Ligurian Sea) (Morri *et al.*, 1990), Calich and Casaraccio ponds (Sea of Sardinia) (Castelli *et al.*, 1996; Martinelli *et al.*, 1997) and for the Venice Lagoon (Adriatic Sea) (Maggiore & Keppel, 2007; Prevedelli *et al.*, 2007; Tagliapietra *et al.*, 2016). The species appears restricted to brackish and enclosed environments, but it is now widespread in European waters (Faasse, 2016).

This is a small, opportunistic species that has quick, explosive population dynamics (Rossi, 2002), and whose abundance can strongly vary between different microhabitats and different years (Martinelli *et al.*, 1997; 1999). The introduction pathway is currently unknown, but the pattern observed (with the first record in brackish environments of the Mediterranean, and a later detection on the European Atlantic coast) recalls that of other invaders associated with oyster farming, like the bryozoans *Tricellaria inopinata* d'Hondt & Occhipinti-Ambrogi, 1985 (Dyrynda *et al.*, 2000). The first introduction in European water might be due to ballast waters, and mussel and oyster farming may have worked as possible secondary dispersal vectors.

Family Serpulidae Rafinesque, 1815

Ficopomatus enigmaticus (Fauvel, 1923)

Material examined. Calich Pond, Sea of Sardinia (40.5972° N, 8.2954° E), 0.5 m, 05/2012: 25 specimens; 0.2 m, 05/2013: 10 specimens. Viareggio port, Tyrrhenian Sea (43.8636° N, 10.2408° E), 0.2 m, 05/2012: 15 specimens. Fiume Morto, Pisa, Tyrrhenian Sea (43.7341° N, 10.2833° E), 0.2 m, 04/2009: 25 specimens; Navicelli Canal, Pisa, Tyrrhenian Sea (43.6481° N, 10.3587° E), 0.5 m, 06/2013: 35 specimens; 01/2014: 68 specimens; 05/2014: 25 specimens; 1 m, 11/2018: 10 specimens. Livorno port, Tyrrhenian Sea (43.5491° N, 10.2968° E), 1 m, 04/2016: 71 specimens. San Leopoldo Canal, Marina di Grosseto, Tyrrhenian Sea (42.7395° N, 10.9702° E), 0.5 m, 12/1985: 10 specimens. Burano Lake, Tyrrhenian Sea (42.3989° N, 11.3779° E), 0.5 m, 06/1991: 12 specimens; 10/1991: 26 specimens. Lamone River Mouth, Adriatic Sea (44.5263° N, 12.2737° E), 0.2 m, 05/1983:

22 specimens.

Remarks. Although this species has type locality in European waters, in an artificial canal opening into the English Channel (Fauvel, 1923b), its sudden appearance in well investigated environments suggested that it represented a newly introduced species (Cognetti, 1954). Although *F. enigmaticus* has currently an almost cosmopolitan distribution, it is commonly believed that its native range is in the Southern part of Australia (Styan *et al.*, 2017, and references therein). This species occurs chiefly in brackish environments and is a quickly growing, opportunistic species that is able to thrive in heavily polluted environments. Styan *et al.* (2017) identified two cryptic lineages within Australian individuals corresponding to the description of *F. enigmaticus*; the absence of molecular data for European individuals, however, does not allow to infer the number of lineages introduced in European waters, even if the strong morphological variability detected among European populations (Cognetti, 1954) might suggest the occurrence of more than one lineage.

Hydroides dirampha Mörch, 1863

Material examined. Livorno port, Tyrrhenian Sea (43.5491° N, 10.2968° E), 1 m, 04/2016: 470 specimens; 0.5 m, 11/2016: 25 specimens.

Remarks. Bianchi (1981) reported this species as a thermophilic NIS, scarcely widespread along Italian coasts, and commonly occurring mainly in Southern Italian ports; conversely, its presence in colder areas, such as the Ligurian Sea, was typically related to local water warming due to thermal power plants. Based on our data, *H. dirampha* is now widespread along the whole coastline, probably also because of the meridionalisation of the Mediterranean Sea (Bianchi, 2007). Although the first Mediterranean records of this species are quite old (Claparède, 1870 *fide* Zibrowius, 1970), the strict association of this species with artificial substrates corroborates its status of NIS, although molecular data are needed to clarify its origin.

Hydroides elegans (Haswell, 1883) [*nomen protectum*]

= *Hydroides abbreviata* Krøyer *in* Mörch, 1863

= ?*Eupomatus pectinatus* Philippi, 1844

Material examined. Porto Torres, Sea of Sardinia (40.8417° N, 8.3930° E), 0.5 m, 05/2013: 2 specimens. Santa Giusta Pond, Sea of Sardinia (39.8715° N, 8.5830° E), 1 m, 11/2001: 240 specimens; 1 m, 11/2002: 737 specimens. Viareggio port, Tyrrhenian Sea (43.8608° N, 10.2356° E), 0.2 m, 04/2009: 30 specimens. Livorno port, Tyrrhenian Sea (43.5491° N, 10.2968° E), 1 m, 04/2016: 51 specimens. Portoferraio, Elba Island, Tyrrhenian Sea (42.8110° N, 10.3257° E), 8 m, 11/1982: 1 specimen. Orbetello Lagoon, Tyrrhenian Sea (42.4418° N, 11.2118° E), 0.2 m, 12/1992: 5 specimens. Marina di Ravenna, Adriatic Sea (44.4951° N, 12.3556° E), 15 m, 1987: 1 specimen.

Additional material: ***Hydroides norvegica*** Gunnerus, 1768 – Sardinian Slope, Sea of Sardinia (40.5456° N, 7.6612° E), 1500 m, 09/2009: 2 specimens; 1800 m, 09/2009: 1 specimen.

Remarks. Although *H. elegans* was originally described from Australia (Haswell, 1883), *Hydroides abbreviata* Krøyer *in* Mörch, 1863 (considered a senior synonym – see Bastida Zavala & ten Hove, 2002) has type locality in the Caribbean Sea. Moreover, the drawing of the operculum of *Eupomatus pectinatus* by Philippi (1844) shows a strong correspondence with *H. elegans.* Although Philippi (1844) did not state any type locality, and his description is quite poor, based on Philippi's biography it can be argued that the studied material was collected in the Tyrrhenian Sea, possibly in the Gulf of Naples (Read *et al.*, 2017). This suggests that *H. elegans* occurred in the Mediterranean Sea at least since the first half of the XIX century, even if it was historically confused with the native *Hydroides norvegica* Gunnerus, 1768, typically occurring on white corals in the bathyal stage (Zibrowius, 1970). As this species is strictly associated with heavily anthropised environments in the Mediterranean Sea, we regard it as a confirmed NIS, although molecular data are likely needed to clarify its origin.

Pileolaria berkeleyana (Rioja, 1942)

Remarks. This serpulid species is native to the East Pacific and it was first recorded in the Mediterranean along the Italian coasts, in the Ligurian and Tyrrhenian Seas (Castelli *et al.*, 1995). However, a more recent checklist by Castelli *et al.*, (2008) reported this species only for the Ligurian and Ionian Sea. This species is considered established in the Western Mediterranean region where it was introduced through hull fouling (Zenetos *et al.*, 2005a; 2010).

Spirobranchus tetraceros (Schmarda, 1861) *sensu lato*

Remarks. This species, first described for Australia, has an Indo-Pacific origin and it is considered to have a circumtropical distribution that includes the Suez Canal, Indian Ocean, South Africa, Australia, Malaysia, Japan, China and the Caribbean (Ben-Eliahu & ten Hove, 1992; Fiege & Sun, 1999). *Spirobranchus tetraceros* was first recorded in the Mediterranean in Lebanon in 1965 (Laubier, 1966) as *Spirobranchus giganteus coutierei* Gravier, 1908. Successive Mediterranean records were registered in Rhodes, Greece (Por, 1992), in Abu Kir Bay, the Egyptian Mediterranean (Selim *et al.*, 2005), and in the Turkish Levantine Sea (Çinar, 2006). In Italian seas, *S. tetraceros* was first recorded by Ulman *et al.* (2017) in the touristic marina of Siracusa (Sicily, Ionian Sea).

This species is considered a Lessepsian migrant that has entered the Mediterranean through the Suez Canal (Ben-Eliahu & ten Hove 1992; Zenetos *et al.*, 2010). It is typical of hard substrates, including artificial ones. The wide morphological variability detected among individuals assigned to this species strongly suggests that *S. tetraceros* represents a species complex (Ben-Eliahu & ten Hove, 2011; Perry *et al.*, 2018); although the complex is widespread in the Indopacific region, and the species occurring in the Mediterranean Sea should be considered a NIS, pending a much needed revision of the complex we here chose to refer to it as *S. tetraceros sensu lato*.

Spirorbis marioni Caullery & Mesnil, 1897

Material examined. Capraia Island, Tyrrhenian Sea (43.0513° N, 9.8367° E), 1 m, 05/2019: 25 specimens.

Remarks. This species is native to the East Pacific and it is considered to have a tropical distribution including the East Pacific and East Atlantic (Bianchi, 1981). In the Mediterranean Sea, *S. marioni* was first recorded in the North-Western part of the basin (Genoa and Marseilles) by Zibrowius & Bianchi (1981). This corresponds to the first Italian record as well. Subsequently the species was also registered for the Tyrrhenian Sea (Castelli *et al.*, 1995).

Spirorbis marioni is considered established in the whole Mediterranean Sea and it seems to have entered the Mediterranean via shipping through the Straits of Gibraltar (Zenetos *et al.*, 2010). This serpulid species inhabits hard substrates of shallow and calm waters in bays and harbours, but exceptionally it can also be found in relatively deep biotopes (30 m) (Bianchi, 1981).

Family SPIONIDAE Grube, 1850

Polydora cornuta Bosc, 1802

Remarks. This species is widespread in the Mediterranean and in the Black Sea (Tena *et al.*, 1991; Çinar *et al.*, 2005; Dağli & Ergen, 2008; Simboura *et al.*, 2008; Radashevsky & Selifonova, 2013; Bertasi, 2016). Bertasi (2016) reported this species as abundant in brackish lagoons of the Northern Adriatic Sea and retrieved it in samples collected in the 1990s, suggesting that its missed detection is due to misidentification with *Polydora ciliata* (Johnston, 1838). This is confirmed by Radashevsky & Selifonova (2013) for Levant and Black Seas. Although the species is currently known only for brackish environments in the Northern Adriatic Sea, a careful re-examination of material identified as *P. ciliata* might lead to its identification in other areas.

Pseudopolydora paucibranchiata (Okuda, 1937)

Material examined. San Teodoro Pond, Tyrrhenian Sea (40.8117° N, 9.6758° E), 0.5 m, 07/2015: 2 specimens.

Remarks. This species, originally described for the Northern Pacific Ocean, is currently widespread in the Eastern Mediterranean Sea (Simboura *et al.*, 2010; Dağli *et al.*, 2011) and along the Atlantic European coast (Faasse, 2016, and references therein). Although the identification of European material was sometimes considered doubtful (Mackie & Erséus, 1997; Radashevsky, 2012), the species has been mainly reported for impacted, often brackish coastal environments, which are prone to NIS introductions. In Italian waters this species was officially reported for Ischia Island by Gambi *et al.* (2016), who however pointed out that material identified as *Pseudopolydora antennata* (Claparède, 1869) by Fresi *et al.* (1983; 1984) for Ischia harbour actually corresponded to *P. paucibranchiata*. The species is therefore present in the Southern Tyrrhenian Sea at least since 1977 (Gambi *et al.*, 2016), however further details will be provided by a specific study (Radashevsky *et al.*, unpublished data). Here we confirm its occurrence in the central Tyrrhenian Sea, in San Teodoro Pond, where the species has presumably arrived through oyster farming (Faasse, 2016).

Family SYLLIDAE Grube, 1850

Syllis hyllebergi (Licher, 1999)

Material examined. Varano Lake, Adriatic Sea (41.8724° N, 15.7063° E), 2 m, 11/2014: 1 specimen.

Remarks. The earliest Mediterranean records of this species (misidentified as *Syllis cornuta* Rathke, 1843) refer to specimens collected off Cyprus and Israel (Ben-Eliahu, 1977a); the species had already been reported from the Red Sea as *S. cornuta* (Ben-Eliahu, 1972) and *Syllis bouvieri* (Gravier, 1900) (Fenchel & Hylleberg, 1973) and the holotype has been selected among the material referenced by this last publication. This species has been reported for Italian waters by Cosentino (2011); the present record represents the second occurrence of the species in Italian waters and considerably extends the distribution of *S. hyllebergi.* It is noteworthy that both Italian records refer to coastal brackish ponds, which are typically characterised by a high occurrence of NIS.

The first record of *S. hyllebergi* in the Eastern Mediterranean Sea dates to only two years later the collection of the type material (1971 *vs* 1969), and this might raise doubts on the biogeography of the species (Cosentino, 2011). However, the scarcity of Mediterranean records, the absence of the species in the Western part of the basin, and the occurrence of *S. hyllebergi* in confined environments support the hypothesis of a human-mediated introduction. For this reason we here consider it as a NIS.

Syllis pectinans Haswell, 1920

Material examined. Livorno Port, Tyrrhenian Sea (43.5491° N, 10.2968° E), 0.5 m, 12/2013: 2 specimens; 1 m, 04/2016: 1 specimen; 1 m, 11/2016: 1 specimen. Pialassa della Baiona, Adriatic Sea (44.5108° N, 12.2656° E), 0.5 m, 05/2013: 1 specimen.

Remarks. Although this species has not been historically considered a NIS in the Mediterranean Sea (López *et al.*, 1996; San Martín, 2003; Çinar *et al.*, 2008), it is widespread in the Pacific Ocean, and only recently reported in the Mediterranean basin. Its peculiar morphological features, which allow a ready distinction from other Mediterranean congeneric species, suggest that *S. pectinans* is a recently introduced species (Lipej *et al.*, 2017; López & Richter, 2017). Moreover, several Mediterranean records pertain to stressed environments, such as ports and coastal ponds, that are known to be particularly prone to hosting NIS (Çinar *et al.*, 2008; Lipej *et al.*, 2017; present data).

Cryptogenic species

Family PARAONIDAE Cerruti, 1909

Paraonis fragilis (Webster, 1879)

= *Aricidea fragilis* Webster, 1879

= *Aricidea jeffreysii* (McIntosh, 1878) *sensu* Fauvel, 1940 (*fide* Strelzov, 1973)

= *Aricidea fragilis mediterranea* Laubier & Ramos, 1974 *partim*

Material examined. Piombino, Tyrrhenian Sea (42.9342° N, 10.5531° E), 15 m, 04/2017: 150 specimens; 11/2017: 136 specimens; 04/2018: 79 specimens; 11/2018: 198 specimens; Mar Grande of Taranto, Ionian Sea (40.43402° N, 17.23872° E), 12 m, 2018: 21 specimens.

Remarks. This species has been reported only recently in the Mediterranean Sea (Langeneck *et al.*, 2018a); however, there are historical records dating back to the late 1930s (Strelzov, 1973). A possible source of confusion about this species is due to the description of *Aricidea fragilis mediterranea* Laubier & Ramos, 1974 (currently considered synonymous with *Aricidea pseudoarticulata* Hobson, 1972), that also included non-type specimens that can be identified as *A. fragilis* (Laubier & Ramos, 1974; Langeneck *et al.*, 2018a). The first record of this species as *A. jeffreysii* (Fauvel, 1940) is contemporary to that of *M. gotoi*, and this species might have been introduced in that period in the Adriatic Sea. The fast population dynamics observed and the occurrence of local blooms point at a possible alien origin of this species, but following Langeneck *et al.* (2018a) we prefer to consider it cryptogenic.

According to Langeneck *et al.* (2019b), the genus *Aricidea* Webster, 1879 should be considered a junior synonym of *Paraonis* Grube, 1873. The species is here moved to *Paraonis* accordingly.

Family Terebellidae Johnston, 1846

Paramphitrite birulai (Ssolowiew, 1899)

Remarks. This species has been only recently recorded in the Northern Adriatic Sea (Loia *et al.*, 2017). Considering that this area is overall well-known, Loia *et al.* (2017) suggest that *P. birulai* is a recent introduction in the Mediterranean Sea; however, considering its boreal affinities, it could also be a relict species. In agreement with Loia *et al.* (2017) we here regard *P. birulai* as a cryptogenic species in the Mediterranean Sea.

Streblosoma pseudocomatus Lezzi & Giangrande, 2018

= *Streblosoma comatus* (Grube, 1859) *sensu* Çinar (2009)

Material examined. Mar Grande di Taranto, Ionian Sea (40.4340° N, 17.2387° E), 3 m, 09/2014: 1 specimen; 12 m, 03/2018: 3 specimens; 03/2019: 1 specimen.

Remarks. Lezzi & Giangrande (2018a) recently described three new species of *Streblosoma* from the Italian Coast. Among them, *S. pseudocomatus* corresponds to *Streblosoma comatus* (Grube, 1859) *sensu* Çinar (2009). The identification of the Levant Sea specimens as *S. comatus* by Çinar (2009) relied chiefly on the re-description by Glasby & Hutchings (1987). However, according to Lezzi & Giangrande (2018a), Glasby & Hutchings (1987) based their re-description on type material including a *Streblosoma* species, while Grube's (1859) original description clearly refers to a *Thelepus* species. *Streblosoma comatus* was therefore transferred to *Thelepus*; the South-American Pacific *Streblosoma* species described by Glasby & Hutchings (1987) as *S. comatus* appears very similar to *S. pseudocomatus*, and the type locality of this species is in the Gulf of Taranto, a locality particularly affected by biological invasions (Occhipinti-Ambrogi *et al.*, 2011; Lezzi *et al.*, 2017). For this reason, although the type locality of *Streblosoma pseudocomatus* is in the Mediterranean Sea, we consider it a cryptogenic species.

Questionable species

Family Ampharetidae Malmgren, 1866

Isolda pulchella Müller *in* Grube, 1858

Remarks. After the first record in Italian waters (Cantone, 2001), this species has been reported only once from Tunisia (Zaâbi *et al.*, 2012) in the Mediterranean Sea, but appeared later along the Portuguese coast (Ravara & Moreira, 2013). Its status as non-indigenous species, supported by all checklists, appears however questionable. Although Müller (1858), describing this species from Brazil, did not specify a precise type locality and a collection depth, the fact that he had the opportunity to examine the live animal suggests that this is a shallow water species. This is confirmed by Brazilian studies, which identify *I. pulchella* as a tropical species typically associated with tidal flats and estuarine environments, where this species can be dominant (da Cunha Lana & Guiss, 1991; Ribeiro *et al.* 2018). By contrast, all records in European waters refer to few specimens collected below 60 m depth (Cantone, 2001; Zaâbi *et al.*, 2012; Ravara & Moreira, 2013). This discrepancy in ecological features might suggest that these specimens belong to a different, possibly undescribed species occurring in the Eastern Atlantic Ocean, and possibly spreading along the North-Eastern Atlantic coast and in the Mediterranean Sea as a consequence of water warming. Awaiting taxonomic clarifications we here prefer to consider it questionable.

Family Amphinomidae Lamarck, 1818

Eurythoe complanata (Pallas, 1766)

Material examined. Livorno Port, Tyrrhenian Sea (43.5491° N, 10.2968° E), 0.5 m, 10/2019: 1 specimen.

Remarks. According to Barroso *et al.* (2010), individuals historically identified as *E. complanata* belong to at least three cryptic (or pseudocryptic) lineages; these authors, however, did not examine Mediterranean material from the molecular point of view. Arias *et al.* (2013b) identified Mediterranean individuals as both *E. complanata s.l.* and *Eurythoe laevisetis* (Fauvel, 1914), without checking their identity by means of molecular markers. Moreover, Kinberg (1857) described for the Eastern Mediterranean Sea *Eurythoe syriaca*, possibly belonging to the *E. complanata* species complex. As already Pallas (1766) stressed the possible association between this species and ship keels, an early introduction through naval traffic cannot be excluded. A number of Amphinomidae are commonly found in association with floating structures (Borda *et al.*, 2012), and a similar behaviour has previously been suggested as a possible explanation for the unusual degree of connectivity observed in species not yet ever found as rafters (Ahrens *et al.*, 2013; Schulze *et al.*, 2017). Moreover, like other Amphinomidae this is a common pest species in tropical aquaria, where it feeds on corals and more generally marine invertebrates, and introduction events might also be related to aquarium maintenance (Calado *et al.*, 2007; Goemans, 2012).

As molecular data are not available, and the identity of the pre-Lessepsian *E. syriaca* is still uncertain (see also Çinar, 2008), the possibility that Mediterranean material identified as *E. complanata* belongs to a native species cannot be ruled out, and we here consider this species questionable.

Notopygos megalops McIntosh, 1885
= !*Notopygos crinita* Grube, 1855

Remarks. This species was reported in the Mediterranean Sea only by Cantone & Fassari (1982) who did not provide figures for their specimens. However, as pointed out by Faulwetter *et al.* (2017), Mediterranean individuals have likely been identified on the basis of Fauvel (1923a), whose description shows clear differences compared to a recent redescription of the species (Yáñez-Rivera & Carrera-Parra, 2012). These discrepancies might suggest that North-Eastern Atlantic material examined by Fauvel (1914; 1923a) belongs to an undescribed species, and cast doubts on the correctness of the few Mediterranean records (Faulwetter *et al.*, 2017). For this reason, we here consider this species questionable in Mediterranean waters. Unfortunately, we were not able to examine the material from Cantone's collection.

Family Capitellidae Grube, 1862

Leiochrides australis Augener, 1914
= *Leiochrides* sp. *sensu* Gravina & Somaschini, 1990

Material examined. Antignano, Livorno, Tyrrhenian Sea (43.4952° N, 10.3225° E), 6 m, 06/2019: 1 specimen. Molunat, Croatia, Adriatic Sea (42.4416° N, 18.4329° E), 5 m, 06/2014: 2 specimens. Tivat, Montenegro, Adriatic Sea (42.3941° N, 18.5594° E), 5 m, 06/2014: 9 specimens.

Remarks. This species was first reported along the Tyrrhenian, Ionian and South Adriatic coasts (Gravina *et al.*, 1996); subsequently it was also collected along the Northern Adriatic shoreline (Mikac, 2015). The examined material confirms the occurrence of this species in the central Adriatic Sea. *L. australis* is peculiar among Mediterranean Capitellidae not only for its morphological features, but also because it is one of the few Capitellidae commonly occurring on photophilous algae communities and on *Posidonia oceanica* meadows (Gravina *et al.*, 1996). However, the taxonomy of the genus *Leiochrides* is currently uncertain (Jeong *et al.*, 2017) and the possibility that it represents an overlooked native species cannot be excluded. For this reason we list it as questionable.

Mediomastus capensis Day, 1961

Material examined. Casaraccio Pond, Sea of Sardinia (40.9125° N, 8.2198° E), 1 m, 03/1994: 5 specimens; 12/1994: 6 specimens. Santa Giusta Pond, Sea of Sardinia (39.8715° N, 8.5830° E), 2 m, 11/2002: 59 specimens. Marina di Ravenna, Adriatic Sea (44.4951° N, 12.3556° E), 15 m, 07/1987: 1 specimen.

Remarks. Mediomastus capensis was the first species of its genus ever recorded from the Italian coast (1981: Gambi e Giangrande, 1985) although it had been previously recorded in Spain (Campoy 1979). It usually occurs in photophilous assemblages, *Cymodocea* meadows, artificial substrates and shallow muddy sediments (Gravina and Somaschini 1988; 1990). Due to its small size, records previous to 1981 may have been misidentified as *Heteromastus filiformis* (Claparède, 1864); the same probably occurred to *Mediomastus fragilis* Rasmussen, 1973 (Gravina and Somaschini 1988). Given these considerations, and given the cryptic diversity of cosmopolitan species such as those belonging to the Capitellidae family (see Tomioka *et al.* 2016), we consider *M. capensis* a questionable species.

Neopseudocapitella brasiliensis Rullier & Amoureux, 1979

Material examined. Mar Grande di Taranto, Ionian Sea (40.4340° N, 17.2387° E), 12 m 03/2018: 2 specimens.

Remarks. This is the only extant species of the genus *Neopseudocapitella* Rullier & Amoureux, 1979, and it has never been redescribed after the first description, whose drawings are only schematic. In the Mediterranean Sea, *N. brasiliensis* has been reported for the first time by Zavodnik *et al.* (1985), who found this species in the harbour of Rovinj. It was reported afterwards for Alfacs Bay, Spain (Capaccioni-Azzati *et al.*, 1992) and is now considered widespread in the whole Mediterranean Sea (Çinar, 2005; Castelli *et al.*, 2008; Çinar *et al.*, 2014b; Faulwetter *et al.*, 2017). The species is often reported for slightly enriched environments (Zavodnik *et al.*, 1985; Capaccioni-Azzati *et al.*, 1992; present data).

According to Parapar *et al.* (2015), Mediterranean specimens show discrepancies from the original description, in particular regarding the presence of eyes and the occurrence of capillary chaetae until the 37th chaetiger (until the 20th-25th in the originale description). It is possible that the genus *Neopseudocapitella* actually displays a higher diversity than commonly considered, and that Mediterranean records refer to an undescribed species. Due to the scarce knowledge about this species and the high likelihood that it represents a species complex, we here consider it questionable in the Mediterranean Sea.

Family Dorvilleidae Chamberlin, 1919

Protodorvillea egena (Ehlers, 1913)

Remarks. The species is known only for the Ionian Sea (Cantone *et al.*, 1991; Cantone, 2001) without any description of the examined specimens, and it has not been reported for the Mediterranean Sea afterwards. The possibility that it represents a misidentification of the native *Protodorvillea kefersteini* (McIntosh, 1869) cannot be ruled out in our opinion, especially in light of the co-occurrence of the two species in the same sample (Cantone *et al.*, 1991); for this reason we consider it questionable.

Family Eunicidae Berthold, 1827

Leodice antennata (Savigny *in* Lamarck, 1818)

Remarks. This species has been reported from the Levant Sea as a Lessepsian immigrant (Kurt Şahin & Çinar, 2009), and also the record of *Leodice miurai* (Carrera-Parra & Salazar-Vallejo, 1998) for Mediterranean Egyptian waters (Dorgham *et al.*, 2013) probably refers to juveniles of *L. antennata*. However, although the species has been also recorded on soft bottoms, the majority of records refer to algal assemblages in rocky environments (Kurt Şahin & Çinar, 2009). The few records in Italian waters are not accompanied by descriptions or illustrations, and refer mostly to soft bottoms (Cantone *et al.*, 1991; 2003; Cantone, 1999), where the species is often accompanied by the native and superficially similar *Eunice vittata* (Delle Chiaje, 1828) (Cantone *et al.*, 1991; Cantone, 1999). Based on personal observations, *E. vittata* shows some variability as regards colour and shape of antennae, and individuals of *L. antennata* reported from the Ionian Sea might represent a misidentification of the native species. Unfortunately, we did not have the opportunity to examine the material from Cantone's collection. Therefore, the reports of *L. antennata* from Italy are questionable.

Leodice floridana (Pourtalès, 1867)

Remarks. This species is native of the tropical western Atlantic Ocean. According to Faulwetter *et al.* (2017) the identity of Mediterranean specimens identified as *L. floridana* is uncertain, as they have never been described in any scientific publication, and the majority of records refer to gray literature (e.g. technical reports). Italian records chiefly refer to coralligenous outcrops in the Northern Adriatic Sea (Casellato *et al.*, 2007; Casellato & Stefanon, 2008), which are scarcely human impacted and therefore unlikely to be colonised by NIS; by contrast, surveys in port environments never highlighted the occurrence of this species. The examination of individuals of *Eunice* sp. from coralligenous environments highlighted the occurrence of a relatively small species with features close to *Eunice pennata* (Müller, 1776) and *L. floridana*, but possibly distinct from both species, and most likely native. Considering the absence of reliable records and of descriptions of the species in Italian waters, we here consider this species questionable.

Family Fabriciidae Rioja, 1923

Novafabricia infratorquata (Fitzhugh, 1983)

Material examined. Otranto, Adriatic Sea (40.1488° N, 18.4942° E), 5 m, 07/2000: 2 specimens.

Remarks. Novafabricia infratorquata was originally described for Belize and recorded for the Western Mediterranean Sea by Bick (2005) and for the South-Eastern Adriatic Sea by Licciano & Giangrande (2006). However, morphological discrepancies towards topotypic material have been already stressed by Bick (2005) regarding body pigmentation, the ratio of branchial crown length to body length, the abdominal uncini and the ratio of manubrium length to dentate region length. Similar discrepancies were highlighted by Licciano & Giangrande (2006), who raised doubts about the correct identification of Mediterranean individuals, but refrained from considering it as a different species, possibly because of the few specimens available. On the basis of the morphological differences reported, which are considered taxonomically informative in Fabriciidae taxonomy, and of the recent discovery of new Mediterranean species of this family (Giangrande *et al.*, 2013, 2014) we consider this species questionable in the Mediterranean Sea.

Aside from the records of the species in the Balearic Sea (Bick, 2005), *N. infratorquata* has been reported from photophilous algae assemblages in the Southern Adriatic Sea (Licciano & Giangrande, 2006) and at Ischia island in the Gulf of Naples (Giangrande *et al.*, 2014).

Rubifabriciola ghardaqa (Banse, 1959)

Remarks. The first (and only) record of this species for the Mediterranean Sea is reported for the South Adriatic coast (Brindisi, Apulia) with two individuals by Giangrande & Montanaro (1999). *Rubifabriciola ghardaqa* has been considered a Lessepsian migrant, introduced in the Mediterranean Sea from the Suez Canal (Giangrande & Montanaro, 1999). The material on which the record was based is however lost, and the absence of further records of the species suggests that we should consider this species questionable.

Although, according to WoRMS, this species is still assigned to *Fabriciola* Friedrich, 1939, Huang *et al.* (2011) assigned it to *Rubifabriciola* along with several other red-eyed species previously assigned to *Fabriciola*. The correct combination should therefore be *Rubifabriciola ghardaqa.*

Family Flabelligeridae Saint-Joseph,1894

Diplocirrus hirsutus (Hansen, 1882)

Remarks. The occurrence of this Arctic species in the Mediterranean Sea is considered questionable, especially in shallow environments (Mikac, 2015). Conversely, the deep record SMF 11285 determined by D. Fiege (reported by Faulwetter *et al.*, 2017) might represent a true occurrence of this species. However, knowledge of the family Flabelligeridae is still incomplete known for the Mediterranean Sea, the revision of the genus *Diplocirrus* by Salazar-Vallejo & Buzhinskaja (2011) did not take into account any Mediterranean specimen, and the possibility that these individuals represent an undescribed species cannot be ruled out in our opinion.

Family Hesionidae Grube, 1850

Podarkeopsis capensis (Day, 1963)

Material examined. Calich Pond, Sea of Sardinia (40.5972° N, 8.2954° E), 1 m, 03/1995: 30 specimens. Santa Giusta Pond, Sea of Sardinia (39.8715° N, 8.5830° E), 2 m, 11/2001: 49 specimens; 11/2002: 78 specimens. Varano Lake, Adriatic Sea (41.8724° N, 15.7063° E), 3 m, 11/2014: 7 specimens. Pialassa della Baiona, Adriatic Sea (44.5108° N, 12.2656° E), 0.5 m, 05/2013: 10 specimens.

Remarks. The taxonomy of the genus *Podarkeopsis* in the Mediterranean Sea is uncertain; the two native species *Podarkeopsis arenicola* (La Greca, 1946) and *Podarkeopsis galangaui* Laubier, 1961 are poorly known and usually missing from the available identification keys, and this might have led to the occurrence of *P. capensis* in Mediterranean environments being overestimated (Faulwetter *et al.*, 2017). A possible clue for distinction between the three species is represented by the environment: *P. capensis* occurs chiefly in brackish environments, while *P. arenicola* is associated to fine sands, and *P. galangaui* to muddy bottoms. The difficult and often uncertain taxonomy of Hesionidae, however, might have accounted for the relatively late identification of this species (Gravina & Giangrande, 1988) and, waiting for better insights on the taxonomy of the genus *Podarkeopsis*, we think that this species should be considered questionable.

Family LUMBRINERIDAE Schmarda, 1861

Lumbrinerides acutiformis (Gallardo, 1968)

Remarks. This species has been reported for the Mediterranean Sea on the basis of a single individual (Albertelli *et al.*, 1995), which seems to be currently lost. However, this individual was identified most likely based on the keys by Perkins (1979) and Miura (1980), which are based on characters, such as the beginning of hooks, which have later been demonstrated to show a wider range of variability (Gravina & Cantone, 1991; Miura, 2017). The actual identity of this individual is therefore uncertain, and considering that the species has never been reported again in the Mediterranean Sea, we prefer to consider it questionable.

Lumbrinerides neogesae Miura, 1980

Remarks. The material recorded by Gravina & Cantone (1991) shows that this species is widespread and relatively common along the Italian coasts. Gravina & Cantone (1991) highlighted slight differences between their individuals and the original description (Miura, 1980), which could be a clue of a similar, yet different species. It is likely that the late detection of this species along the Italian coasts is due to its small size, and it is actually a native species, rather than a NIS. Awaiting a more detailed study of the available material, we here consider it questionable.

Lumbrineris cf. ***perkinsi*** Carrera-Parra, 2001

= *Lumbrineris inflata* Moore, 1911 *sensu* Giangrande *et al.* (1981)

Examined material. Porto Santo Stefano, Tyrrhenian Sea (42.4359° N, 11.1217° E), 1 m, 06/2019: 47 specimens.

Remarks. The first record of this species for Italian waters, as *Lumbrineris inflata* (Giangrande *et al.*, 1981), was not followed up by subsequent records for almost forty years, even though the species was reported for the Eastern Mediterranean Sea (Çinar, 2009). Records for Greece are dubious (Faulwetter *et al.*, 2017) but the species has been found in photophilic assemblages of the Mediterranean coast of Israel (Langeneck & Lezzi, *pers. obs.*). Recently, the species was reported for the port of Brindisi, Southern Adriatic Sea (ISPRA, 2019; the identity of the specimens was confirmed by a photograph of the jaw apparatus, courtesy of A. M. Pastorelli), and the material here examined confirms its occurrence in the Tyrrhenian Sea, 38 years after the first record. The population of Ischia harbour reported by Giangrande *et al.* (1981) was not found afterwards and it is believed to have undergone local extinction.

Even if this species is unmistakable among Mediterranean Lumbrineridae because of its MIII with four teeth and MIV with two teeth, its actual identity is currently uncertain. Within the genus *Lumbrineris* only three species are characterised by four teeth in the MIII, namely *Lumbrineris albifrons* Crossland, 1924, *Lumbrineris cervicalis* Treadwell, 1922, and *L. perkinsi*, described for the eastern tropical Atlantic, eastern tropical Pacific, and western tropical Atlantic Ocean, respectively (Treadwell, 1922; Crossland, 1924; Carrera-Parra, 2001, 2006). Differences between these species are currently uncertain, and it is not easy to understand which one occurs in the Mediterranean Sea. Moreover, individuals identified as *L. inflata*, but obviously corresponding to this group of species, occur in the Red Sea (Fauvel, 1955; Ben-Eliahu, 1976; Amoureux *et al.*, 1980; Langeneck, *pers. obs.*), supporting Çinar's (2009) hypothesis of a migration through the Suez Canal. *Lumbrineris* species with four teeth in the MIII most likely represent a species complex with tropical or sub-tropical affinity, and their presence in the Mediterranean Sea is recent and likely due to human activities. Because of the uncertainties surrounding the identity of this species, we here regard it as questionable.

Family MALDANIDAE Malmgren, 1867

Metasychis gotoi (Izuka, 1902)

Examined material. Viareggio, Tyrrhenian Sea (43.7903° N, 9.8584° E), 80 m, 07/2017: 2 specimens.

Remarks. This is the first polychaete explicitly recorded as non-indigenous in the Mediterranean Sea (Fauvel, 1934, 1940) and the first observations date back to before 1933; it has been traditionally considered as an early Lessepsian immigrant, but its original description in cold waters off Japan suggests a low likelihood for this hypothesis (Simboura & Zenetos, 2005). Its introduction can be due to ballast water, that came into use after 1870 (Carlton, 1985). The ecological features observed in the Mediterranean Sea closely match those observed in the native range. However, this is the only species of the genus *Metasychis* Light, 1991, and according to Zenetos *et al.* (2018), the possibility that this is an undescribed, overlooked native species cannot be ruled out. For this reason, we hold it as questionable.

Family NEREIDIDAE Blainville, 1818

Neanthes agulhana Day, 1963

Material examined. Stintino, Sardinia, Sea of Sardinia (40.8724° N, 8.2113° E), 5 m: 06/2014: 3 specimens. Capraia Island, Tyrrhenian Sea (43.0390° N, 9.8466° E), 0.5 m, 03/2014: 1 specimen; 5 m, 06/2014: 2 specimens. Molunat, Croatia, Adriatic Sea (42.4416° N, 18.4329° E), 5 m, 06/2014: 2 specimens.

Remarks. In Italian waters this species was first reported for the Southern Adriatic Sea (Zenetos *et al.*, 2010) and subsequently recorded in the Sicilian Strait (Musco *et al.*, 2013), in the Northern Tyrrhenian Sea (Bedini *et al.*, 2015) and in the central Adriatic Sea (Spagnolo *et al.*, 2019); present data allow to confirm its occurrence in the Adriatic and Tyrrhenian Seas and to extend its distribution to the Sea of Sardinia. Considering that this is a species typically associated with photophilous algae, and its colour pattern makes it almost unmistakable, it is likely that it is a relatively recent arrival in Italian waters. However, there are differences in parapodial structures between the redescription of Mediterranean specimens (Viéitez *et al.*, 2004) and the original description (Day, 1963). For this reason, in agreement with López & Richter (2017) we consider it questionable.

Nereis persica Fauvel, 1911

Remarks. The first record of this species in Italian waters (Fresi *et al.*, 1984) was later demonstrated to be a misidentification of the native *Nereis funchalensis* (Langerhans, 1880) (Gravina *et al.*, 2016). Although Mikac (2015) reports one new record for the Eastern Adriatic Sea, the similarity with other *Nereis* spp. with multidentate homogomph falcigers (*N. funchalensis*, *N. jacksoni* and *N. usticensis*) suggests to take this record with caution. Therefore, the reports of this species from Italy are questionable.

Platynereis* cf. *australis (Schmarda, 1861) (Fig. 2)

Material examined. Sacca Barbamarco, Po River Delta, Adriatic Sea (44.9830° N, 12.4862° E), 0.5 m, 11/1990: 3 specimens.

Remarks. This species has recently been identified as a species complex (Read, 2007); in the Mediterranean Sea the only report is that of North-Adriatic individuals (Castelli *et al.*, 2008). A re-examination of the material on which the record was based showed that these individuals (Fig. 2) clearly belong to the genus *Platynereis* Kinberg, 1865, and are devoid of homogomph falcigers, as expected for adult individuals belonging to the *P. australis* complex (Day, 1967; Read, 2007). However, the absence of the pygidium, which is highly diagnostic in the *P. australis* complex (Read, 2007), does not allow a more accurate identification. Moreover, the poor preservation conditions of the individuals, as well as the difficulties encountered in the examination of the pharynx, compel to be cautious towards the identification of these specimens. Lastly, this species has never againbeen reported in the Mediterranean Sea, and its current occurrence along the Italian coasts should be considered questionable.

Family Oenonidae Kinberg, 1865

Oenone fulgida (Savigny *in* Lamarck, 1818)

= *Oenone* sp. *sensu* Cantone (1996)

Material examined. Castellammare del Golfo, Tyrrhenian Sea (38.04138° N, 12.88595° E), 5 m, 12/1987: 1 specimen; 11/1990: 2 specimens. Rosh Hanikra, Israel, Levant Sea (33.0866° N, 35.1033° E), 6 m, 06/2009: 1 specimen.

Remarks. The examined Italian individuals show relatively small size and closely match the first official Mediterranean record by Çinar (2005) and the examined individual from the Mediterranean coast of Israel. Çinar (2005) considered *O. fulgida* as a possible Lessepsian mi-

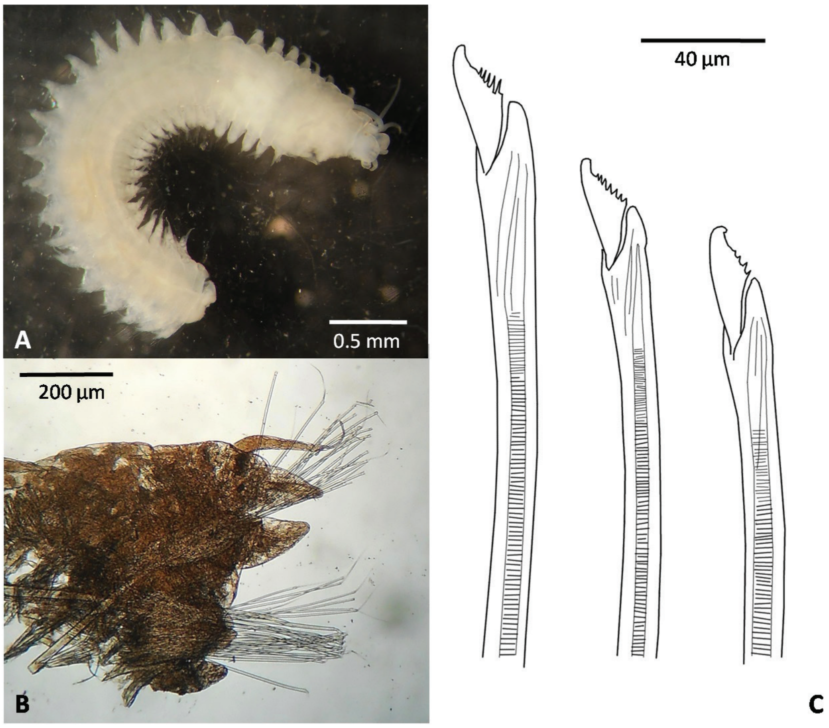

Fig. 2: *Platynereis* cf. *australis* (Schmarda, 1861) from Sacca Barbamarco, Adriatic Sea. A: anterior part of the smallest individual; B: midbody parapodium of the largest individual, showing the absence of notopodial falcigers; C: neuropodial falcigers from midbody.

grant, and its occurrence on the Israeli coast might support this view. However, Mediterranean specimens show differences from other descriptions of this species; these differences have been ascribed to the small size of the individual, that might retain juvenile features (Çinar, 2005; Castelli, *pers. obs.*; Kristian Fauchald, *in litt.*), but could also point at a different species. *O. fulgida* is the only species of the genus *Oenone* Savigny *in* Lamarck, 1818, and its extremely wide distribution points to the possibility of a species complex. For this reason, the identification of Mediterranean individuals with this species is only tentative, awaiting further revisions of this group. This species has been reported also for the Northern Adriatic Sea (Casellato & Stefanon, 2008). It is most likely a thermophilous species, possibly expanding its range towards the Northern part of the basin, however, based on present data, it is impossible to determine if it is a true NIS, rather than an overlooked native species.

Family Onuphidae Kinberg, 1865

Diopatra hupferiana (Augener, 1918)

Remarks. The only records for this species are those by Cantone & Fassari (1982) and Cantone *et al.* (1991) for the Ionian Sea; most likely, Mediterranean records as *Epidiopatra hupferiana hupferiana* and *E. hupferiana monroi* Day, 1967 should be assigned to the same taxon. Uncertainties about the correct assignment to any of the two subspecies of this South-Atlantic species could point to an undescribed species of the genus *Diopatra* (with which *Epidiopatra* Augener, 1918 has been synonymised – see Budaeva & Fauchald, 2011); the diversity of *Diopatra* in Mediterranean waters has been recently reassessed (Arias & Paxton, 2014; Çinar *et al.*, 2014a) and it is not unlikely that specimens identified as *D. hupferiana* represent an undescribed native species, or possibly juveniles of an already described *Diopatra* species.

Longibrachium atlanticum (Day, 1973)

Remarks. This species has been reported in the Mediterranean Sea only once (Cantone *et al.*, 1997) and is listed as non-indigenous by AA.VV. (2011) and by Castelli *et al.* (2008). However, Cantone *et al.* (1997) highlighted differences in the number of spiny hooks at the 4th parapodium and in the maxillary formula towards the original description of *L. atlanticum*, which might suggest that the recorded specimen possibly represents an undescribed native species, likely occurring elsewhere in the Mediterranean Sea, and confused with other Onuphidae.

Family Phyllodocidae Örsted, 1843

Hesionura serrata (Hartmann-Schröder, 1960)

Remarks. This is an interstitial species, relatively widespread in the Mediterranean basin (Viéitez *et al.*, 2004; Eleftheriou *et al.*, 2011); its relatively recent detection is most likely due to its minute size and to the difficult taxonomy of the genus *Hesionura* Hartmann-Schröder, 1958 (de Oliveira *et al.*, 2018), rather than a recent introduction in the Mediterranean Sea. Awaiting more complete material on this genus we prefer to consider this species questionable.

Family Pilargidae Saint-Joseph, 1899

Sigambra parva (Day, 1963) (Fig. 3)

Material examined. Livorno port, Tyrrhenian Sea (43.5491° N, 10.2968° E), 3 m, 04/2016: 1 specimen. Piombino, Tyrrhenian Sea (42.9342° N, 10.5531° E), 15 m, 2016-2017: 3 specimens. Gulf of Follonica, Tyrrhenian Sea (42.8848° N, 10.7226° E), 33 m, 10/2019: 3 specimens. Mar Grande of Taranto, Ionian Sea (40.4340° N, 17.2387° E), 12 m, 07/2018: 2 specimens.

Additional material. ***Sigambra tentaculata*** (Treadwell, 1941) – Gulf of Follonica, Tyrrhenian Sea (42.9304° N, 10.6984° E), 4 m, 06/1981: 1 specimen; 8 m, 07/1987: 1 specimen; 12/1987: 1 specimen. Elba Island, Tyrrhenian Sea (42.8226° N, 10.3299° E), 5-12 m, 10/1983: 2 specimens. Montecristo Island, Tyrrhenian Sea (42.3365° N, 10.3487° E), 8 m, 06/2012: 1 specimen. Marina di Ravenna, Adriatic Sea (44.4951° N, 12.3556° E), 15 m, 07/1987: 24 specimens. Monfalcone, Adriatic Sea (45.74633° N, 13.58537° E), 15 m, 10/1995: 6 specimens.

Remarks. Although *S. parva* was originally described for South Africa, its late detection in European waters is likely due to its confusion with *Sigambra tentaculata* (Treadwell, 1941) (Moreira & Parapar, 2002). The examined material perfectly corresponds to the redescription by Moreira & Parapar (2002) and is morphologically and ecologically distinct from specimens identified as *S. tentaculata*: apart from the morphological differences retrieved by Moreira & Parapar (2002), *S. tentacula-*

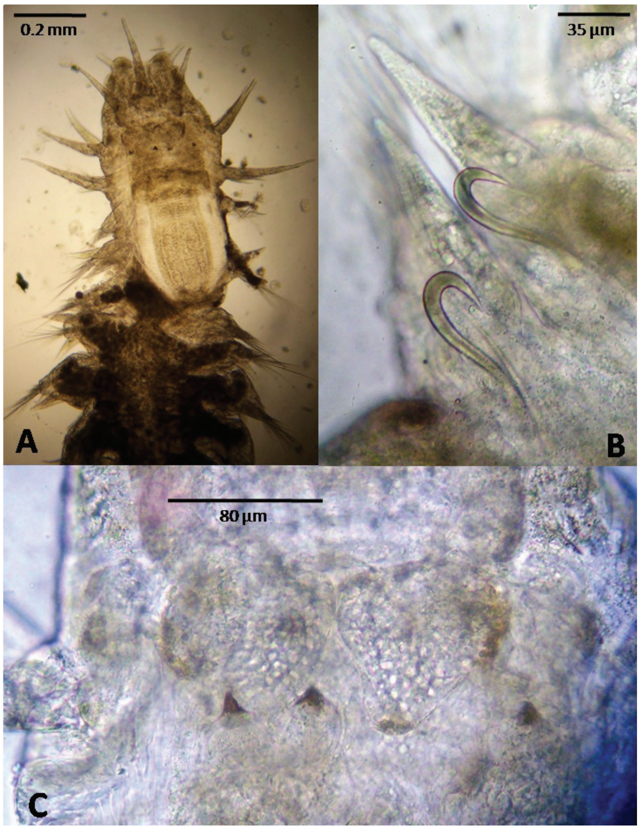

Fig. 3: *Sigambra parva* (Day, 1963) sampled in the port of Livorno, Tyrrhenian Sea. A: anterior end of a live specimen; B: detail of acicular hooks; C: close up of the pharynx showing the diagnostic three pharyngeal teeth.

ta occurs chiefly on fine sand, while *S. parva* has been collected until now in organically enriched environments, such as ports and fish farms. The association with human impacted environments might support the possible status of NIS of this species, but on the other hand, the introduction vector is uncertain, and the genus *Sigambra* is in need of revision. Moreover, *Sigambra parva* was probably misidentified as *S. tentaculata* due the difficulties in detect morphological differences without the literature available today. Given the possibility of it being a species complex with sub-tropical affinity, we choose as a precaution to consider it questionable. The examined specimens represent the first record of this species for Italian waters.

Family Sabellidae Latreille, 1825

Acromegalomma claparedei Gravier, 1908

Remarks. According to Giangrande *et al.* (2015), Mediterranean material identified as *A. claparedei* shows differences from the original description (Gravier, 1908) and could belong to an undescribed, native species. For this reason, we here consider this species questionable.

Amphicorina pectinata (Banse, 1957)

Remarks. This species, with type locality in the Pacific Ocean (Banse, 1957) was recorded for the first time by Abbiati *et al.* (1991) and often considered a NIS (Occhipinti-Ambrogi *et al.*, 2011). However, both Giangrande *et al.* (1999) and López & Tena (1999) highlighted discrepancies between Mediterranean species and the type material. López & Tena (1999), in their description of *Amphicorina triangulata*, suggested that all Mediterranean records of *A. pectinata* might refer to this native species. Awaiting taxonomic clarifications, possibly based on SEM observations and molecular data, we prefer to consider this species questionable in the Mediterranean Sea.

Family Scalibregmatidae Malmgren, 1867

Hyboscolex longiseta Schmarda, 1861

Remarks. This species, typically occurring in the Southern Hemisphere (Kudenov & Blake, 1978) has been reported from the Mediterranean Sea in the 1970s-1980s (Cantone *et al.*, 1978; Fassari, 1982; Lanera *et al.*, 1989) and then never again retrieved. The absence of further records is suspicious, and Mediterranean records of *H. longiseta* might actually represent juvenile specimens of the native *Scalibregma celticum* Mackie, 1991, only recently reported for the Mediterranean Sea, due to the unclear taxonomy of Scalibregmatidae (Çinar, 2005; Lomiri *et al.*, 2012). In agreement with Simboura *et al.* (2010), we here consider the presence of *H. longiseta* in the Mediterranean Sea questionable.

Family Serpulidae Rafinesque, 1815

Hydroides cf. ***inornata*** Pillai, 1960 (Fig. 4)

Material examined. Livorno port, Tyrrhenian Sea (43.5491° N, 10.2968° E), 1 m, 04/2016: 1 specimen.

Remarks. Hydroides inornata was originally described from Sri Lanka by Pillai (1960). However, based on the similar opercular morphology, Ishaq & Mustaquim (1996) suggested to synonymise *H. inornata* with *Hydroides operculata* (Treadwell, 1929). A recent molecular study by Sun *et al.* (2017a) revealed that *H. operculata* is a complex of morphologically similar species and suggested to re-instate *H. inornata* as a valid species. The examined specimen (Fig.4) corresponds to the redescription by Sun *et al.* (2017a) and represents the first occurrence of this species in the Mediterranean Sea; however, it shows discrepancies towards the original description (Pillai, 1960), especially in the proportion between the longer spine of the verticil and the remaining ones. For this reason, awaiting further records and possibly molecular data, we prefer to consider this record questionable.

Although *H. operculata* had been previously reported as a Lessepsian migrant for the Mediterranean (Zibrowius & Bitar, 1981; Ben-Eliahu & ten Hove, 1992; Çinar, 2006), the identity of this material was questioned by Sun *et al.* (2017a). At least specimens examined by Çinar (2006) do not correspond to *H. inornata* and most likely represent a different (possibly undescribed) species of the *Hydroides operculata* complex.

Family Spionidae Grube, 1850

Dispio uncinata Hartman, 1951

Remarks. According to Surugiu (2016) and Delgado-Blas *et al.* (2018), Mediterranean and more generally European records of *D. uncinata* most likely refer to newly described native species of genera *Dispio* and *Scolelepis*. Accordingly, we here consider this species questionable in Italian waters.

Polydora colonia Moore, 1907

Remarks. Polydora colonia was originally described from the North-western Atlantic Ocean (Moore, 1907) and later reported from the South-western Atlantic (Blake, 1983; Neves & Rocha, 2008) and the Mediterranean Sea (Aguirre *et al.*, 1986). The only record of the species in

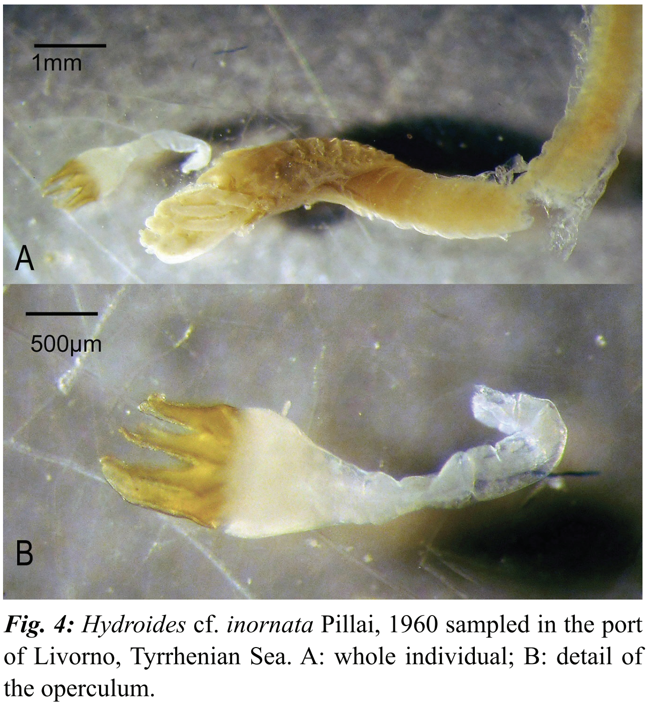

Fig. 4: *Hydroides* cf. *inornata* Pillai, 1960 sampled in the port of Livorno, Tyrrhenian Sea. A: whole individual; B: detail of the operculum.

Italian waters (Occhipinti-Ambrogi *et al.*, 2011) is unfortunately not accompanied by any description of the species or illustrations.

Although David & Williams (2012), upon re-examination of the material, confirmed the identification by Aguirre *et al.* (1986), it should be pointed out that *P. colonia* in North-western Atlantic environments shows a strict association with sponges, and the association of Mediterranean specimens with algae (Aguirre *et al.*, 1986; Tena *et al.*, 2000) suggests that it could represent a different species. David & Williams (2012) suggested that the species should be treated as cryptogenic throughout its distributional range, awaiting molecular investigations. Given the scarcity of data about this species in the Mediterranean Sea, awaiting new records, we consider it questionable in Italian waters.

Prionospio pulchra Imajima, 1990

Remarks. This species, originally described for the Pacific Ocean, was reported as non-indigenous for the Eastern Atlantic Ocean (Moreira *et al.*, 2000) and the Eastern Mediterranean Sea (Pancucci-Papadopoulou *et al.*, 2005; Dağli & Çinar, 2011). Dağli & Çinar (2011) suggested on the basis of drawings reported in Giangrande & Gambi (1982) that the morphotype of *Prionospio cirrifera* Wirén, 1883 identified in the brackish Lake of Sabaudia, actually corresponds to *P. pulchra*. Unfortunately, we were not able to re-examine the material, which is presumably lost. Although the Lake of Sabaudia was strongly affected by a number of biological invasions, especially through mussel farming (Macali *et al.*, 2013; Stasolla *et al.*, 2014), and the occurrence of *P. pulchra* is somewhat likely, the evidence presented is therefore low. Awaiting further material, we here prefer to consider this species questionable in Italian waters.

Prionospio pygmaea Hartman, 1961

Remarks. This species was recorded for the first time by Martinelli *et al.* (1992) for a semi-enclosed environment in Northern Sardinia. The ecological traits of the recorded specimens seem to fit with those of the type material, described for shallow environments with silty sediment (see Hartman, 1955; 1961). However, the description by Martinelli *et al.* (1992) is not detailed and the figures depict only the hooded hooks. Moreover, recent studies off the Tuscan coast (Northern Tyrrhenian Sea) highlighted the occurrence of a species with features recalling both *P. pygmaea* and *Prionospio dayi* (Foster, 1969), but possibly undescribed. The recent description of several new species of the genus *Prionospio* for Mediterranean waters (Dağli & Çinar, 2009; 2011) suggests that the record of *P. pygmaea* for the Mediterranean Sea might actually correspond to an overlooked native species, and for this reason we prefer to consider it dubious.

Although this species has been described as *Prionospio pygmaeus*, and is often reported with this spelling, the genus *Spio* Fabricius, 1785 refers to a goddess in the Greek mythology, and should thus be considered of feminine gender along with all its compounds (Read & Fauchald, 2019). Accordingly, the correct combination is *Prionospio pygmaea*.

Prionospio sexoculata Augener, 1918

Remarks. Although the species is reported and redescribed by Dağli & Çinar (2009) for the Levant Sea, records for Italian waters are somewhat dubious; it is not reported by Lardicci (1989), and the first report is due to Castelli *et al.* (1995) who mentioned the species for the Tyrrhenian Sea without further detail. This report is possibly related to material collected in the Tuscan Archipelago in the years 1985 and 1986 and allegedly deposited in the polychaete collection of the University of Pisa (MSNP). Unfortunately the two available samples included a damaged (unidentifiable) spionid and a *Prionospio* species with several unbranched branchiae (corresponding to the subgenus *Minuspio sensu* Foster, 1971). Therefore, the occurrence of *P. sexoculata* in Italian waters could not be confirmed. It is however noteworthy that Castelli *et al.* (1995; 2008) suggested that Italian records of this species might actually refer to an undescribed *Prionospio*. This is also supported by the fact that *P. sexoculata* was originally described from shallow environments (8 m – see Augener, 1918), while according to the MSNP database, all Tyrrhenian records are deeper (20-86 m).

Family Syllidae Örsted, 1843

Erinaceusyllis belizensis (Russell, 1989)

Material examined. Antignano, Livorno, Tyrrhenian Sea (43.4952° N, 10.3225° E), 1 m, 04/2016: 1 specimen; 4 m, 05/2018: 2 specimens. Porto Santo Stefano, Tyrrhenian Sea (42.4359° N, 11.1217° E), 1 m, 06/2019: 1 specimen. Capraia Island, Tyrrhenian Sea (43.0513° N, 9.8367° E), 1 m, 04/2019: 1 specimen. Mar Grande di Taranto, Ionian Sea (40.43402° N, 17.23872° E), 12 m, 03/2018: 2 specimens; 6 m, 03/2019: 2 specimens.

Remarks. This very small polychaete has been originally described from mangrove environments in Belize. In the Mediterranean Sea it was firstly reported in the Western Mediterranean Sea (Olano *et al.*, 1998) and briefly afterwards for the Eastern part of the basin (Çinar & Ergen, 2002). In Italian waters it was first reported for the Southern Adriatic Sea (Musco, 2012). The current records extend its distribution to the Tyrrhenian and Ionian Seas, where the species is often associated with port environments. However, the subfamily Exogoninae is characterised by very small size, egg brooding and direct development; the majority of invasion vectors are therefore scarcely compatible with their life cycle, and the likelihood of invasion by these species should be considered low. Also considering the numerous instances of cryptic species reported for this family, it is possible that Mediterranean records of *E. belizensis* represent an undescribed native species. For this reason we here prefer to consider this species questionable in the Mediterranean Sea.

Erinaceusyllis serratosetosa (Hartmann-Schröder, 1960)

Materiale examined. Ardenza, Livorno, Tyrrhenian Sea (43.5165° N, 10.3143° E), 2 m, 07/2019: 15 specimens; 09/2019: 1 specimen.

Remarks. The first Mediterranean record of the species appears identical to the original description for the chaetal shape, but also shows discrepancies, for instance in the absence of eyes (San Martín, 2003). The species has later been reported for the Italian coast in the Adriatic Sea (Musco, 2012); its occurrence is confirmed by new data for the Tyrrhenian Sea, close to the port of Livorno. Some Tyrrhenian specimens correspond to the description by San Martín (2003), with eyes extremely reduced or absent, while other specimens are a better match for topotypic material (San Martín, 2005). Intraspecific variation in presence and size of eyes has already been identified in other *Erinaceusyllis* species (Langeneck *et al.*, 2018b). Unlike *E. belizensis*, this species has been reported as a NIS by Zenetos *et al.* (2017), Servello *et al.* (2019) and EC (2019); however, in this case too the direct development and the absence of dispersal phases suggest that this might represent an undescribed native species. For this reason we prefer to consider it questionable, as the other congeneric species.

Syllis alosae San Martin, 1992

Remarks. This species has been reported only once for Otranto (Southern Adriatic Sea) on the basis of three individuals (Giangrande *et al.*, 2003). Although the examined material corresponded to the original description (San Martín, 1992), it was never illustrated, and the specimens are currently lost. For this reason, and considering the absence of further records, we prefer to consider this species questionable.

Family Terebellidae Johnston, 1846

Loimia medusa Savigny, 1822

= *Axionice medusa* (Savigny, 1822)

Remarks. There is growing evidence that this species, originally described for the Red Sea, occurs in the Eastern Mediterranean as an established NIS (Dorgham & Hamdy, 2015; Zenetos *et al.*, 2018). However, the only record in Italian waters refers to few specimens collected in 1987 in the Strait of Sicily (Albertelli *et al.*, 1995); this record was not followed by other findings and a description of the specimens is not available. Moreover, there is some evidence that the allegedly pantropical *L. medusa* represents a species complex (Hutchings & Glasby, 1995). For these reasons, we consider it questionable in Italian waters.

Pista unibranchia Day, 1963

= *Pista unibranchiata* Day, 1963 [*lapsus calami in* Mohammad, 1980; Çinar, 2005; Zenetos *et al.*, 2010; Çinar *et al.*, 2012]

Material examined. Piombino, Tyrrhenian Sea (42.9342° N, 10.5531° E), 15 m, 11/2018: 3 specimens.

Remarks. Pista unibranchia differs from all congeneric species in having a single central branchiae. It was described for South Africa (Day 1963) and recorded for the first time in Italy by Cantone (1981), followed by records in the whole Mediterranean Sea (Çinar, 2005; Zaâbi *et al.*, 2012; Çinar *et al.*, 2014b; López & Richter, 2017; Grimes *et al.*, 2018) and in the North-eastern Atlantic Sea (López & Richter, 2017). In Italian waters this species was frequently recorded in the Ionian Sea and Strait of Sicily (Cantone *et al.*, 1993; 2003; Deidun *et al.*, 2016), but it is considered widespread (Castelli *et al.*, 2008). However, it should be noted that the first Mediterranean record by Cantone (1981) included both individuals with one asymmetric branchia, and individuals with two branchiae of different size, which do not correspond to *P. unibranchia*, and might belong to the recently described *Pista adriatica* Mikac & Hutchings, 2017 and *Pista colini* Labrune, Lavesque, Bonifácio & Hutchings, 2019. It is unclear how many records of the species took in consideration the wrong identification of part of Cantone's material, thus identifying specimens with one pair of branchiae (instead of a single one) as *P. unibranchia*. The actual distribution of *P. unibranchia* might therefore be narrower than previously suggested.

Although the occurrence of *Pista* specimens with a single, asymmetric branchia, morphologically corresponding to *P. unibranchia*, has been confirmed by our data for the Ionian and Tyrrhenian Sea, the recent discovery of new species of this genus in the Mediterranean Sea (Mikac & Hutchings, 2017; Labrune *et al.*, 2019), along with its complex taxonomy and a likelihood of intrinsic cryptic diversity, suggests that this might actually represent an undescribed taxon. Moreover, although the most plausible means of introduction for *P. unibranchia* in the Mediterranean Sea is commonly identified as migration through the Suez Canal (Zenetos *et al.*, 2010; Çinar, 2013), the species is unknown in the Red Sea (Wehe & Fiege, 2002), and the only record for the Persian Gulf corresponds to an intertidal species (Mohammad, 1980), while Day (1963) reported this species between 48 and 60m depth off the Indian coast of South Africa, suggesting that Mohammad's (1980) record does not actually refer to this species. The reproductive strategy of *Pista* species is currently unknown (Hiebert, 2015). However, Terebellidae are known to include both species with lecitotrophic, short-lived planktonic larvae and species brooding larvae in their tube (McHugh, 1993). None of the two developmental modes described for this family is compatible with a dispersal through ballast waters, raising additional doubt on the actual status as NIS of *P. unibranchia*. We therefore suggest that this should be considered a questionable NIS in the Mediterranean Sea.

Pistella lornensis (Pearson, 1969)

Remarks. Pistella lornensis was reported for the first time in the Mediterranean in the Aegean Sea (Arvanitidis, 2000) and then recorded by Musco *et al.* (2013) off the Southern coast of Sicily. Only recently, Mikac & Hutchings (2017) described two new species, *Pistella rovignensis* and *Pista adriatica*, from soft substrates of Northern Adriatic Sea. The same authors suggested that all Mediterranean records of *P. lornensis* might correspond to both *P. rovignensis* and *P. adriatica*. Moreover, *Pista mediterranea* Gaillande, 1970 shows very similar features (Gaillande, 1970) and could have been misidentified as *P. lornensis*. The actual occurrence of *P. lornensis* in the

Mediterranean Sea therefore cannot be confirmed, and previous records need to be checked. Given the difficulty in identifying these organisms, associated with a high pseudocryptic diversity of the genus, we consider the record of *P. lornensis* questionable. Moreover, according to Jirkov & Leontovich (2017) *Pistella lornensis* should be synonymised with *Pista cristata* (Müller, 1776), although, as several changes proposed in this publication, this suggestion has not been widely accepted.

Excluded species

Family Alciopidae Ehlers, 1864

Rhynchonereella petersi (Langerhans, 1880)

Remarks. This is a wide-distribution pelagic species with tropical affinity, occurring in the Atlantic, Pacific and Indian Ocean (Jiménez-Cueto & Suárez-Morales, 2008); only Castelli *et al.* (2008) consider it non-indigenous in the Mediterranean Sea, while it is absent from all other NIS checklists. The occurrence of *R. petersi* in the Mediterranean Sea is likely due to a natural expansion through the Strait of Gibraltar, even though possibly fostered by the increase of surface water temperature. We here regard it as a native species in the Mediterranean Sea.

Family Amphinomidae Lamarck, 1818

Notopygos crinita Grube, 1855

Remarks. This species has been previously listed in Mediterranean checklists (Zenetos *et al.*, 2005a; 2010; Occhipinti-Ambrogi *et al.*, 2011; Servello *et al.*, 2019) following the alleged synonymy between *N. crinita* and *N. megalops* stated by Salazar-Vallejo (1997). However, more complete material showed that the two species are indeed distinct (Yáñez-Rivera & Carrera-Parra, 2012). For this reason, *N. crinita* should be removed from Mediterranean checklists.

Family Cirratulidae Carus, 1863

Kirkegaardia dorsobranchialis (Kirkegaard, 1959)

= *Monticellina dorsobranchialis* (Kirkegaard, 1959)

Remarks. After the first records in the Eastern Mediterranean Sea, this species was considered as a possible Lessepsian immigrant (Harmelin, 1969). Although this hypothesis was considered erroneous by later works, on the basis of the type locality in the tropical Eastern Atlantic Ocean (Zenetos *et al.*, 2005a), the species has occasionally been considered a Lessepsian NIS (Deidun *et al.*, 2016). According to Blake (2016), this species is possibly restricted to the West-African coast, and Mediterranean records refer to the native *Kirkegaardia heterochaeta* (Laubier, 1966) or to undescribed species of the genus. Therefore, Mediterranean records of *Kirkegaardia* Blake, 2016 should be related to native species of the genus, and *K. dorsobranchialis* should be removed from Mediterranean checklists.

Family Eunicidae Berthold, 1827

Lysidice hebes (Verrill, 1900)

Remarks. This species is considered a West-Atlantic vicariant of the widespread *Lysidice unicornis* (Grube, 1840) (Rullier, 1974) with uncertain taxonomic validity (Diaz-Diaz *et al.*, 2016). *L. hebes* has been sporadically reported in the Mediterranean Sea (Box *et al.*, 2010), and in Italian waters as well (Bedini *et al.*, 2014), but all records are included in species checklists, without any comparison with the native *L. unicornis*. It is likely that this naming could have originated from an erroneous synonymy of this species with *L. unicornis* in the Caribbean records (Salazar-Vallejo & Carrera-Parra, 1998). For this reason we exclude this species from the non-indigenous polychaetes recorded in Italian waters.

Family Glyceridae Grube, 1850

Glycera capitata Ørsted, 1843

Remarks. Despite having been commonly reported in Mediterranean checklists (e.g. Castelli *et al.*, 2008; Çinar *et al.*, 2014b; Mikac, 2015), *G. capitata* is considered by Böggemann (2002) a cold species with bipolar distribution whose presence in Mediterranean waters is unlikely. Faulwetter *et al.* (2017) suggest that Mediterranean records can be referred to *Glycera lapidum* Quatrefages, 1866 or *Glycera noelae* Böggemann, Bienhold & Gaudron, 2012.

The species has never been reported in Mediterranean checklists as a non-indigenous species, but it is included in the EC (2019) EASIN database, as it has been reported as a NIS in the Black Sea (Kurt Şahin & Çinar, 2012). This listing might have led to its inclusion as a dubious alien species by ISPRA (2019).

Family Hesionidae Grube, 1850

Leocrates chinensis Kinberg, 1866

Remarks. This species never occurred in the Mediterranean Sea. As explained by Faulwetter *et al.* (2017), it was reported after Hartman (1940) synonymised *L. chinensis* and *Leocrates claparedii* (Costa in Claparède, 1858). The latter species has type locality in the Gulf of Naples and is a common native species in the Mediterranean Sea. Following studies took this proposal in consideration, systematically confusing *L. chinensis* and *L. claparedii*. According to Wang *et al.* (2018), *L. chinensis* and *L. claparedii* are two distinct species, and *L. chinensis* does not occur in the Mediterranean Sea.

Family Lumbrineridae Schmarda, 1861

Abyssoninoe hibernica (McIntosh, 1903)

Remarks. This species has been recorded in the Mediterranean Sea only recently (D'Alessandro *et al.*, 2016a), and was considered a dubious NIS by ISPRA (2019). However, the re-examination of Lumbrineridae samples collected in the 1970s-1980s highlighted the occurrence of the species in the Mediterranean. Its apparent scarcity is due to misidentification as *Lumbrineris emandibulata mabiti* Ramos, 1976 (which in turn most likely should be transferred to *Abyssoninoe* Orensanz, 1990). *A. hibernica* is a species with type locality in the North-eastern Atlantic Ocean, and its relatively recent record in the Mediterranean Sea is due to a renewed attention to polychaete taxonomy, rather than to a recent introduction. For this reason, *A. hibernica* should be considered native in the Mediterranean Sea.

Gallardoneris iberica Martins, Carrera-Parra, Quintino & Rodrigues, 2012

Remarks. Although *G. iberica* is listed by ISPRA (2019) as a dubious NIS in Italian waters, this is a native, historically overlooked species, whose description is due to a recent revamping of Lumbrineridae taxonomy (Martins *et al.*, 2012). Its almost contemporary record with abundant populations in the whole Mediterranean Sea (Bertasi *et al.*, 2014; García Gómez *et al.*, 2015; D'Alessandro *et al.*, 2016a; Katsiaras *et al.*, 2018) confirms its native status.

Lumbrineris acutifrons McIntosh, 1903

Remarks. Lumbrineris acutifrons is a poorly known species; it is not treated in the revision of the genus *Lumbrineris* Blainville, 1828 by Carrera-Parra (2006), and the original description (McIntosh, 1903) suggests that this species should possibly be assigned either to *Abyssoninoe* Orensanz, 1990 or to *Cenogenus* Chamberlin, 1919. However, as the type locality is unknown (presumably in the deep North-eastern Atlantic Ocean, since the holotype was collected in the 1870 Porcupine Expedition) and the description is not very detailed, the actual identity of *L. acutifrons* is currently uncertain.

The record of this species in the Mediterranean Sea (Zenetos *et al.*, 2010; AA.VV., 2011; EC, 2019) is due to a transcription error of *Lumbrinerides acutiformis* (Gallardo, 1967). This interpretation is supported by its report as *Lumbrineris acutifrons* Gallardo, 1967 in Zenetos *et al.* (2010). Although this species is reported as non-indigenous in the 2018 MSFD report (ISPRA, 2019), currently there is no reliable report of *L. acutifrons* for the Mediterranean Sea.

Lumbrineris pinaster Martins, Carrera-Parra, Quintino & Rodrigues, 2012

Remarks. ISPRA (2019) reports this species as a dubious NIS in Italian waters, possibly due to its relatively recent record in the Mediterranean Sea (García Gómez *et al.*, 2015). However, the recent discovery of this species (Martins *et al.*, 2012) is due to a renewed interest for European Lumbrineridae taxonomy, and this species has most likely been misidentified as *Lumbrineris latreilli* Audouin & Milne-Edwards, 1833. The type locality in Portuguese waters strongly supports its native status in the Mediterranean Sea.

Family Paraonidae Cerruti, 1909

Levinsenia demiri Çinar, Dağli & Acik, 2011

Remarks. The genus *Levinsenia* Mesnil, 1897 has been recently revised, with substantial taxonomic changes concerning the Mediterranean species (Çinar *et al.*, 2011; Çinar & Dağli, 2013). The majority of Mediterranean specimens recorded as *Levinsenia gracilis* (Tauber, 1879) should be identified as *L. demiri*, a native species with type locality in the Mediterranean Sea; the occurrence of *L. gracilis* in the Mediterranean is instead uncertain. Perhaps based on the recent detection of the species, *L. demiri* is reported as possibly non-indigenous in ISPRA (2019); this conclusion is however based on an incorrect interpretation of the available literature.

Family Sabellidae Latreille, 1825

Acromegalomma vesiculosum (Montagu, 1813)

Remarks. According to Giangrande & Licciano (2008), this species is absent from the Mediterranean Sea, and Mediterranean records should be assigned to *Acromegalomma lanigerum* (Grube, 1846). The species is cited in ISPRA (2019) as a dubious non-indigenous species; it is, most likely, a misidentification of a native *Acromegalomma*.

Family Serpulidae Rafinesque, 1815

Hydroides dianthus (Verrill, 1873)

Remarks. This species has been historically considered a non-indigenous species, probably with West-Atlantic origin (Bianchi, 1981). Recently, Sun *et al.* (2017b) highlighted a high degree of molecular diversity within Mediterranean populations, and conversely a far lower diversity in populations outside the Mediterranean basin. Thus, it is likely that *H. dianthus* is native to the Mediterranean basin, and alien in the remaining range of occurrence, type locality included. Here we follow Sun *et al.* (2017b) in considering *H. dianthus* native to the Mediterranean Sea.

Hydroides sanctaecrucis Krøyer *in* Mörch, 1863

Remarks. This species is native to the Caribbean and has recently been discovered in several Pacific sites (Lewis *et al.*, 2006; Bastida-Zavala, 2009; Carlton & Eldredge, 2009; Ferrario & Minchin, 2017). It is considered an aggressive fouler and practically impossible to eradicate once it is established. The dispersal of this species beyond its native range seems to be associated with transport by shipping, as well as with shellfish aquaculture (Çinar, 2013; Rech *et al.*, 2018).

Rech *et al.* (2018) recently identified 15 specimens associated with floating debris in the Lagoon of Venice as *H. sanctaecrucis*, suggesting that its presence in the Mediterranean might have been overlooked due to misidentification as the native and widespread *H. dianthus*. However, Rech *et al.* (2018) overtly stated that they did not examine the morphology of the retrieved material, employing 18S rDNA sequences for identification and retrieving a sequence identity ≥97% with reference sequences of *H. sanctaecrucis* deposited on GenBank. A quick search on the same database shows an identity ≥99% between 18S sequences of *H. sanctaecrucis* and several congeneric species, with all *H. sanctaecrucis* sharing a 100% sequence identity; more generally, 18S rDNA sequences have identity close to 100% in closely related species, and are ill-suited for molecular identification (see Tang *et al.*, 2012). Unfortunately, sequences deposited by Rech *et al.* (2018) are currently unavailable from GenBank (08.05.2019), but the relatively low sequence identity retrieved demonstrates that their specimens did not belong to *H. sanctaecrucis*, and the species should be removed from current non-indigenous species checklists.

Family Syllidae Grube, 1850

Streptosyllis arenae Webster & Benedict, 1884

Material examined. *Streptosyllis nunezi* Faulwetter, Vasileiadou, Papageorgiou & Arvanitidis, 2008 – Marina di Pisa, Tyrrhenian Sea (43.6748° N, 10.2702° E), 1.5 m, 07/1985: 1 specimen; 0.5 m, 09/2017: 1 specimen.

Remarks. Faulwetter *et al.* (2008) suggest that Mediterranean and Eastern-Atlantic records of this species should actually be assigned to the recently described, and native, *S. nunezi*. The re-examination of the specimen upon which the first record of this species was based (Castelli & Lardicci, 1986) and of material retrieved from the same locality confirmed that these specimens belong to *S. nunezi*. For this reason, the species should be removed from Mediterranean polychaete checklists.

Trypanosyllis gigantea (McIntosh, 1885)

Remarks. The only Mediterranean record of this species is due to Cognetti (1958), who reported this species from the Lagoon of Venice. However, this record should likely be assigned to the native *Trypanosyllis aeolis* Langerhans, 1879. In agreement with Mikac (2015), we suggest to remove it from Mediterranean checklists.

Family Terebellidae Johnston, 1846

Streblosoma comatus (Grube, 1859)

Remarks. The occurrence of *S. comatus* in Italian waters has been suggested by Çinar (2009) on the basis of the alleged correspondence between *S. comatus* and *Streblosoma hesslei* Day, 1955 *sensu* Giangrande *et al.* (1981). Recently, Lezzi & Giangrande (2018a) demonstrated that *Terebella comata* Grube, 1859 belongs to *Thelepus* Leuckart, 1849, and the species identified with this name occurring in the Mediterranean Sea corresponds to *S. pseudocomatus*. The species should therefore be excluded.

Streblosoma hesslei Day, 1955

Remarks. Specimens identified as *S. hesslei* by Giangrande *et al.* (1981) from Ischia (Naples) on the basis of the description should be assigned to the native *Streblosoma nogueirai* Lezzi & Giangrande, 2018, recently described for shallow hard bottoms of the southern Adriatic Sea (Lezzi & Giangrande, 2018a). For this reason, this species should be removed from Mediterranean checklists.

Discussion

Confirmed and unconfirmed polychaete NIS in Italian waters

The comparison between different literature sources (published literature, online databases, national reports) highlighted 86 polychaete species which have been considered as NIS (alien or cryptogenic) in at least one literature source. This number is strikingly high, when compared to the 34 species reported from Spain overall (28 from the Mediterranean part) (López & Richter, 2017), the 47 species from Greece (Faulwetter *et al.*, 2017), the 19 species from Cyprus (Katsanevakis *et al.*, 2009) and the 66 species from Turkey (Çinar *et al.*, 2014b), as well as the overall number of 132 polychaete NIS reported for the whole Mediterranean Sea (Zenetos *et al.*, 2012; 2017). However, a critical revision of the available literature allowed to confirm the status of alien species only for 25 of them, while another 3 were considered cryptogenic. If cryptogenic species are included in NIS, the overall number of confirmed NIS would amount to 28, which is actually close to the number of species reported by López & Richter (2017) for Italy. It is, however, noteworthy that 40 species historically listed as NIS have been considered questionable here, either because the available literature does not allow to be certain on their identification, or because morphological data point at discrepancies between Mediterranean and topotypic material, suggesting that they might actually represent undescribed native species. Conversely, several alien or cryptogenic species have been reported only in recent years (e.g. D'Alessandro *et al.*, 2016; Lipej *et al.*, 2017; Dragičević *et al.*, 2019). Although the number of confirmed NIS is apparently close to that reported by López & Richter (2017), the updated list is clearly different from the one compiled by Occhipinti Ambrogi *et al.* (2011). Lastly, 18 taxa, representing a sizable part of all evaluated species, were excluded, either because they were actually native species mistakenly considered non-indigenous, or because their report was based on the misidentification of native species. The most striking case is represented by the opportunistic serpulid *Hydroides dianthus*, showing an almost cosmopolitan distribution and until recently considered non-indigenous in the Mediterranean Sea; molecular data showed that the Mediterranean hosts the higher number of haplotypes, and most likely represents the native range of the species (Sun *et al.*, 2017b) (Fig. 5).

Comparing our data with previous lists of polychaete NIS in Italian waters, the current estimate is comparable to that by Zenetos *et al.* (2005), slightly lower than that by Occhipinti-Ambrogi *et al.* (2011) and higher than

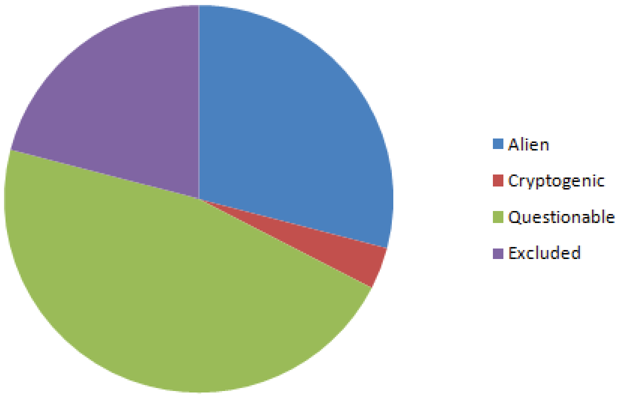

***Fig. 5**:* Repartition of polychaete species reported as NIS in Italian waters in the four categories employed.

the conservative view held by GSA SIBM (2018). It is conversely distinctly lower than the estimates by Castelli *et al.* (2008), Zenetos *et al.* (2010; 2012; 2017), AA.VV. (2011), ISPRA (2019), Servello *et al.* (2019) and EASIN (2019). Although Zenetos *et al.* (2010; 2012; 2017) and ISPRA (2011) listed all polychaetes reported as NIS in Mediterranean waters, and EASIN (2019) includes all NIS reported in European waters, we considered only those species that have been reported for Italian waters, making these data comparable. The presence in Zenetos *et al.* (2010) of some species that are absent in Castelli *et al.* (2008) is due to the fact that they were already widespread in the oriental part of the basin, but their expansion in Italian waters took place only some years later. The variation in estimates of the number of polychaete NIS does clearly depend on changes in their distribution and on a renewed attention towards these taxa in Italian waters; however, it also reflects different approaches to the study of non-indigenous species lists, in particular regarding the categories of questionable and cryptogenic species. Only Zenetos *et al.* (2005) made a distinction between questionable species and confirmed alien species, while all other sources either exclude species, or list them as confirmed alien species. Our survey of available literature highlighted that questionable species account for the 47% of all evaluated taxa, thus representing a sizable fraction of all polychaetes reported as NIS. Several of these taxa have been reported only once, and all from the same, relatively restricted area in the Ionian Sea; the original publications do not include any description of the Mediterranean material, and all attempts to retrieve it from the polychaete collection of the University of Catania did not succeed. The re-examination of the Mediterranean material identified as *Platynereis* cf. *australis* showed that the specimens do not correspond to native *Platynereis* species, but the preservation status of this material prevents a more precise identification.

The repartition of different categories within different families clearly reflects the current status of taxonomic research. Only three families, namely Serpulidae, Sabellidae and Dorvilleidae, include a majority of confirmed alien species (Fig. 6); all these families are well-known from the taxonomic point of view and have been the subject of recent revisions also based on molecular data (Simonini *et al.*, 2009; Sun *et al.*, 2017a; Del Pasqua *et al.*, 2018), which allowed to clarify the identity and NIS status of several taxa. The alien species status of *Ficopomatus enigmaticus* and *Spirobranchus tetraceros s.l.* was confirmed despite the taxonomic uncertainties surrounding these taxa (Styan *et al.*, 2017; Perry *et al.*, 2018) as both represent species complexes with Indo-Pacific affinity, and are certainly non-indigenous in the Mediterranean Sea. The family with the highest number of cryptogenic species is Terebellidae (Fig. 6). Terebellidae included in this category are a good match for topotypic material, but the absence of dispersal stages invites to caution towards this conclusion. Questionable species included 47% of the evaluated taxa, and a very high number of families, whose actual diversity is often understudied, and which most likely include numerous undescribed species even in the Mediterranean Sea. The family with the highest number of taxa in this category was Spionidae, followed by Terebellidae, Syllidae, Capitellidae and Nereididae. All these families are characterised by a notoriously underestimated pseudocryptic diversity, with new species frequently described even from well-known areas (Tomioka *et al.*, 2016; Lavesque *et al.*, 2017; Langeneck *et al.*, 2018b; Lavesque *et al.*, 2019), and molecular data highlighting complex diversity patterns, often with several sympatric cryptic or pseudocryptic lineages (Wäge *et al.*, 2017; Nygren *et al.*, 2018). The list of questionable species points therefore at gaps in the knowledge of Mediterranean polychaete taxonomy, and a number of doubts can be resolved by a thorough re-examination of the material upon which old records were based. Unfortunately, we did not have the chance to re-examine the material of the collection of prof. Grazia Cantone (University of Catania), including several taxa that have been recorded in Italian waters only once, all for the same area in the Ionian Sea (e.g. *Diopatra hupferiana*, *Isolda pulchella*, *Leodice antennata*, *Notopygos megalops*). In the absence of further records, all these species have been considered questionable, often in agreement with other checklists (Faulwetter *et al.*, 2017). Lastly, the highest number of taxa among excluded species belongs to Lumbrineridae, Serpulidae, Syllidae and Terebellidae (Fig. 6). In the case of Lumbrineridae, Syllidae and Terebellidae, this highlights the complex taxonomy of the family, and the frequent occurrence of misidentifications. It is noteworthy that Mediterranean lists included another two exotic taxa, namely *Sphaerosyllis brandhorsti* Hartmann-Schröder, 1965 and *Irmula spissipes* Ehlers, 1913, two poorly known Syllidae (Musco & Giangrande, 2005) which have not been included in the present list as they were never considered non-indigenous species. These records are likely based on specimens of *Erinaceusyllis* sp. and *Dioplosyllis cirrosa* Gidholm, 1962, respectively. Taxonomists, and even more parataxonomists, should therefore be extremely cautious and possibly rely on expert opinion before reporting taxa belonging to these families as NIS. The case of Serpulidae is rather different, as this family is well studied from the taxonomic point of view; *Hydroides dianthus* has been recently removed from Mediterranean NIS lists following Sun *et al.* (2017b), while the record of *Hydroides sanctaecrucis* for the Lagoon of Venice was based on DNA sequences only (Rech *et al.*, 2018), and the low sequence identity with *H. sanctaecrucis*, considering the molecular marker chosen for this study, actually leads to reject this record.

Where do polychaete NIS come from?

The repartition taking into account the origin of the alleged polychaete NIS highlighted similar percentages for the four main biogeographic categories, namely Indian (23%), Western Atlantic (22%), Eastern Atlantic (21%) and Western Pacific (16%). Species with unknown origin and from the Eastern Pacific gave minor contributions, while Mediterranean, Arctic and Antarctic species were

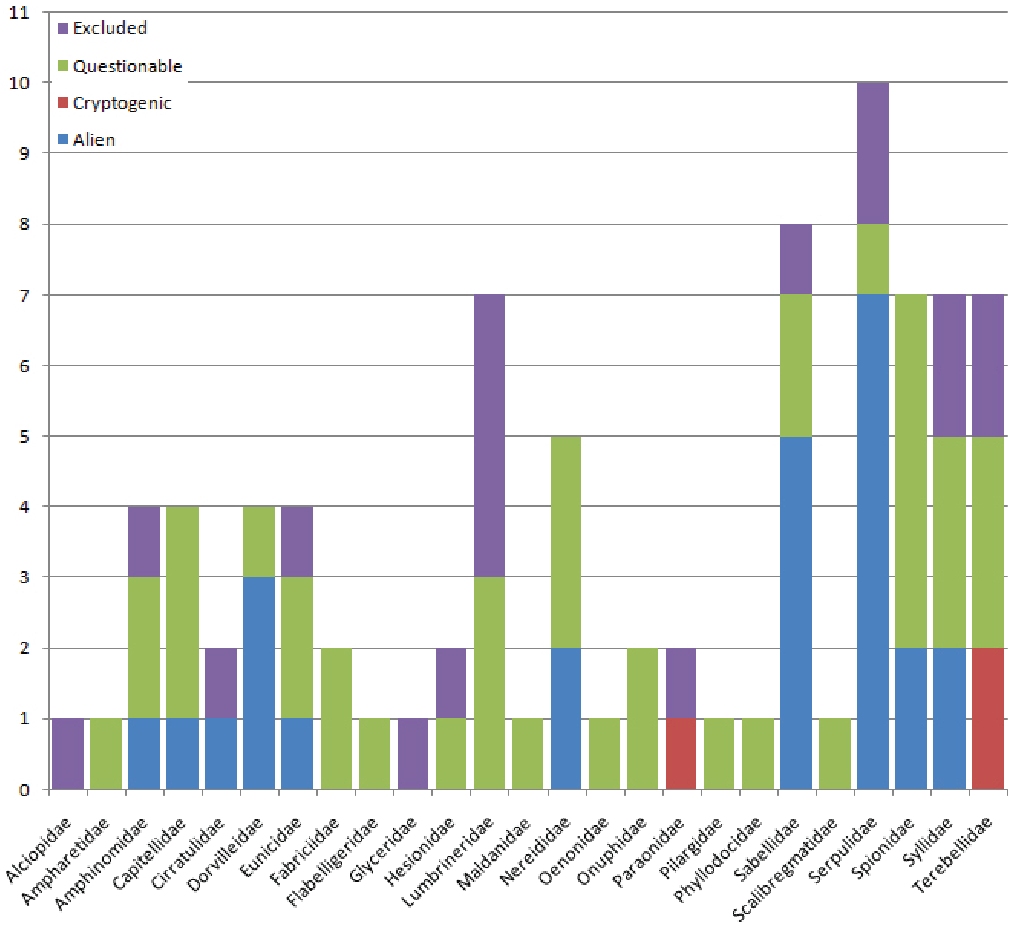

Fig. 6: Repartition of the four NIS categories within each polychaete family.

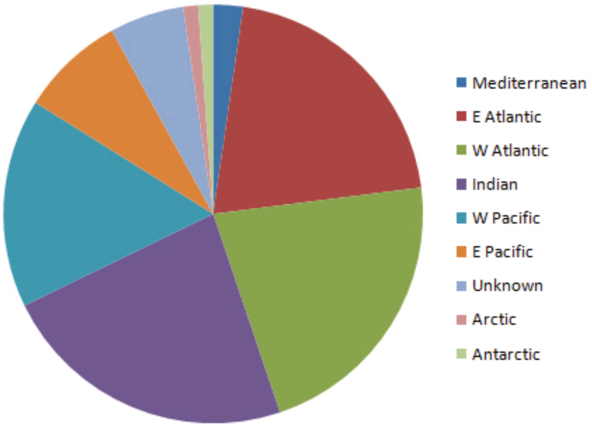

Fig. 7: Repartition of all polychaete NIS reported in Italian waters according to biogeographic origin.

represented by only four species overall, and these were all excluded NIS, with the exception of the Arctic *Paramphitrite birulai*, considered cryptogenic (Fig. 7). This repartition, however, does not match what is observed when separating the four NIS categories. The vast majority of confirmed alien species has Indo-Pacific affinity, with Indian, Western Pacific and Eastern Pacific species representing the 31%, 23% and 15%, respectively. Species with unknown origin accounted for 15% of the confirmed aliens species, while Western Atlantic species and Eastern Atlantic species accounted for 8% each (Fig. 8). The low number of cryptogenic species identified in this study makes comparisons with the other groups unreliable, but it does not include species with Indo-Pacific affinity. These results suggest that in the case of Indo-Pacific species it is relatively easy to sort out whether or not a species is alien, while in the case of species with Atlantic affinity the possibility of a species complex, or a different interpretation of the distributional pattern observed, related to centuries of trans-Atlantic trade (Sun *et al.*, 2017b), often cannot be excluded. The category of questionable species showed a repartition relatively close to the one including all categories, with a similar contribution by Indian (29%), Western Atlantic (23%) and Eastern Atlantic (23%), a slightly lower contribution by Western Pacific (20%), and a lesser contribution by Eastern Pacific (6%) (Fig. 8). Again, this is not surprising, as this category mostly includes taxa whose taxonomy is currently understudied, leading to great uncertainties regardless of the type locality of the taxon considered. Lastly, Atlantic and Mediterranean species represent almost the totality of the excluded species, with a major contribution by Eastern Atlantic (44%), and less pronounced contributions by Western Atlantic (22%) and Mediterranean (11%). This is mainly due to the erroneous inclusion of species with type locality in the North-eastern Atlantic Ocean in NIS lists. These taxa are native to the Mediterranean Sea, and their recent detection is due to an improved interest on taxonomy, rather than to a recent introduction.

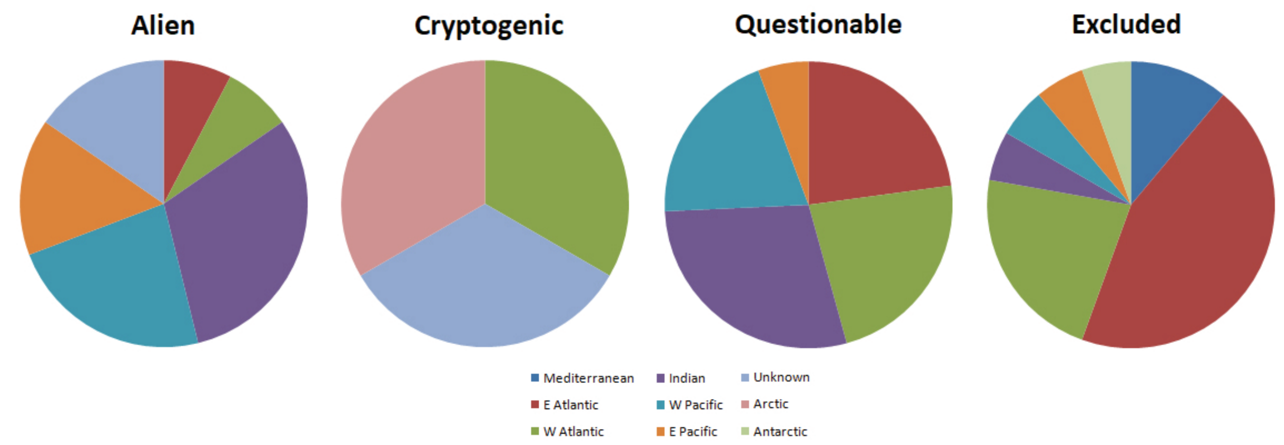

Fig. 8: Percentage contributions of different biogeographic origins to the four NIS categories identified.

This revision highlighted that, out of the 86 polychaete NIS reported from Italy, only 25 can be confirmed as aliens, and 18 should be excluded from lists of non-indigenous species. Approximately half of the polychaetes reported as NIS for Italian waters (51%) should be instead considered cryptogenic or questionable, mainly because of the uncertain taxonomy and the absence of details on their distribution and occurrences. This high percentage of uncertainties in NIS definition highlights the need for further investigations in taxonomy, biogeography and phylogeography of several taxa, belonging to a high number of polychaete families, and the subsequent necessity of a renewed interest in polychaete taxonomy, a field whose importance has been reaffirmed in recent years, but that is still declining in Italy (Terlizzi *et al.*, 2003; Giangrande *et al.*, 2005; Boero, 2010). Further efforts in polychaete taxonomy will likely allow to settle the status of a large part of the questionable and cryptogenic species, leading to a number of confirmed NIS occurring in Italian marine waters which might be comparable to that of other better known invertebrate taxa.

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