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

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

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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 (Faucauld, 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 crustaceaenus)" 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 (Giandrange 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 considered cryptogenic. If the definition of NIS was restricted only to the species whose native range and spatial-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 check-list 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 tax-
onemy 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 Antarctic (Table 1).

Results

Alien species

Family Amphipodidae Lamarck, 1818
Linoperus canariensis Langerhans, 1881
= Linoperus acarunculatus (Monro, 1937) sensu Ben-Eliahu, 1976

Material examined. Castellamare 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 Gulf of Castellamare (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; Faustel, 1927; Faustel, 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 (50.3402° N, 17.2387° E), 15 m, 02/2018: 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 (Çınar & Ergen, 2007), where it reaches densities that vary from 10 to 70 ind/m². However, Çınar & Ergen (2007) suggested that past records (from 1989), wrongly assigned to Chaetozone setosa McIntosh, 1911, reached densities of 430 ind/m². Grossi et al. (2017) recorded the same species in muddy and sandy bottoms along the Adriatic coast, with densities of 30 ind/m² in north Adriatic and 500 ind/m² in the harbour of Bar. 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 Faustel (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.
| 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**               |                         |                        |                        |                                  |                                 |                   |                   |                      |                      |           |
| Rhynchonereilla petersi     | E Atlantic              | (abs.)                 | A                      | (abs.)                           | (abs.)                          | (abs.)             | (abs.)            | (abs.)               | (abs.)               | E (nat.)  |
| **Ampharetidae**            |                         |                        |                        |                                  |                                 |                   |                   |                      |                      |           |
| Isolda pulchella            | W Atlantic              | (abs.)                 | A                      | A                                | A                               | (abs.)             | (abs.)            | A                    | Q                    |           |
| **Amphinomidae**            |                         |                        |                        |                                  |                                 |                   |                   |                      |                      |           |
| Eurythoe complanata         | W Atlantic              | (abs.)                 | E (nat.)               | A                                | (abs.)                          | A                 | C                | E (mis.)             | Q                    |           |
| Linopogus canariensis       | E Atlantic              | A                      | (abs.)                 | A                                | A                               | A                 | A                | A                    | A                    |           |
| Notopygos crinita           | W Atlantic              | (abs.)                 | A                      | A                                | A                               | (abs.)             | A                | (abs.)               | E (mis.)             | Q         |
| 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              | (abs.)                 | A                      | A                                | A                               | C                 | (abs.)            | (abs.)               | Q                    | Q         |
| Neopseudocapitella brasilienis | W Atlantic            | A                      | A                      | A                                | A                               | (abs.)             | (abs.)            | A                    | Q                    |           |
| Notomastus aberans          | Indian                  | (abs.)                 | A                      | A                                | A                               | A                 | A                | A                    | A                    |           |
| **Cirratulidae**            |                         |                        |                        |                                  |                                 |                   |                   |                      |                      |           |
| Chaetogona corona           | E Pacific               | (abs.)                 | (abs.)                 | (abs.)                           | (abs.)                          | (abs.)             | A                 | A                    | C                    | A         |
| Kirkegaardia dorsobranchialis | E Atlantic            | (abs.)                 | 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                               | A                 | A                | A                    | A                    | A         |
| Ophryotrocha japonica       | W Pacific               | A                      | A                      | A                                | A                               | A                 | A                | A                    | A                    | A         |
| Protodorvillea egena        | E Atlantic              | (abs.)                 | A                      | A                                | A                               | (abs.)             | (abs.)            | A                    | Q                    | Q         |

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     | Q                      | A                      | A                                 | A                               | A                 | A                 | (abs.)               | (abs.)                 | A         |
| Lysidice collaris       | Indian     | (abs.)                 | A                      | A                                 | A                               | A                 | A                 | (abs.)               | (abs.)                 | A         |
| Lysidice hebes          | W Atlantic | (abs.)                 | (abs.)                 | (abs.)                            | (abs.)                          | (abs.)            | (abs.)            | (abs.)               | (abs.)                 | E (mis.) |
| Fabricidae              |            |                        |                        |                                   |                                 |                   |                   |                      |                        |           |
| Fabriciola ghardaqa     | Indian     | A                      | A                      | A                                 | A                               | A                 | A                 | (abs.)               | (abs.)                 | A         |
| Novafabricia infratonga | W Atlantic | (abs.)                 | A                      | A                                 | A                               | A                 | A                 | (abs.)               | (abs.)                 | A         |
| Flabelligeridae         |            |                        |                        |                                   |                                 |                   |                   |                      |                        |           |
| Diplocirrus hirsutus    | E Atlantic | (abs.)                 | (abs.)                 | (abs.)                            | (abs.)                          | Q                 | (abs.)            | (abs.)               | (abs.)                 | Q         |
| Glyceridae              |            |                        |                        |                                   |                                 |                   |                   |                      |                        |           |
| Glyceria capitata       | E Atlantic | (abs.)                 | (abs.)                 | (abs.)                            | (abs.)                          | Q                 | (abs.)            | A (loc.)             | E (mis.)               |           |
| Hesionidae              |            |                        |                        |                                   |                                 |                   |                   |                      |                        |           |
| Leocrates chinensis     | W Pacific  | (abs.)                 | E (nat.)               | Q                                 | (abs.)                          | (abs.)            | (abs.)            | (abs.)               | (abs.)                 | Q         |
| Podarkeopsis capensis   | E Atlantic | (abs.)                 | E (nat.)               | A                                 | (abs.)                          | (abs.)            | (abs.)            | A                    | A                     | Q         |
| Lumbrineridae           |            |                        |                        |                                   |                                 |                   |                   |                      |                        |           |
| Abyssoninae hibernica   | E Atlantic | (abs.)                 | (abs.)                 | (abs.)                            | (abs.)                          | Q                 | (abs.)            | (abs.)               | (abs.)                 | E (nat.) |
| Gallanderonis ibérica    | E Atlantic | (abs.)                 | (abs.)                 | (abs.)                            | (abs.)                          | Q                 | (abs.)            | (abs.)               | (abs.)                 | E (nat.) |
| Lumbrinerides acutiformis | W Pacific | (abs.)                 | A                      | A                                 | A                               | A                 | A                 | (abs.)               | (abs.)                 | Q         |
| Lumbrinerides neogesae  | E Atlantic | A                      | A                      | A                                 | A                               | A                 | A                 | (abs.)               | A                     | Q         |
| Lumbrineris acutifrons  | E Atlantic | (abs.)                 | (abs.)                 | (abs.)                            | (abs.)                          | A                 | (abs.)            | A (mis.)             | E (mis.)               |           |
| Lumbrineris perkinsi    | W Atlantic | A                      | A                      | A                                 | A                               | A                 | A                 | (abs.)               | (abs.)                 | Q         |
| Lumbrineris pinaster    | E Atlantic | (abs.)                 | (abs.)                 | (abs.)                            | (abs.)                          | Q                 | (abs.)            | (abs.)               | (abs.)                 | E (nat.) |

**Maldanidae**

Table 1 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 |
| Nereidae | | | | | | | | | | |
| Neanthes argulhana | E Atlantic | (abs.) | (abs.) | A | A | A | (abs.) | (abs.) | (abs.) | A |
| Nereis jacksoni | W Pacific | (abs.) | E (nat.) | A | (abs.) | (abs.) | A | A | A | A |
| *Nereis persica | Indian | A | (abs.) | A | (abs.) | A | (abs.) | A | (abs.) | A |
| Platynereis cf. australis | W Pacific | Q | A | A | A | A | A | A | A | Q |
| Pseudonereis anomala | Indian | A | (abs.) | A | (abs.) | (abs.) | (abs.) | A | A | A |
| Oenidae | | | | | | | | | | |
| Oenone cf. fulgida | Indian | A | E (nat.) | A | (abs.) | (abs.) | (abs.) | (abs.) | A | Q |
| Ouphidae | | | | | | | | | | |
| Diopatra hygeriana | 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.) | (abs.) | A | A | A |
| Paragonidae | | | | | | | | | | |
| Levinnienia demiri | Mediterranean | (abs.) | (abs.) | (abs.) | (abs.) | Q | (abs.) | (abs.) | (abs.) | E (nat.) |
| Paraonis fragilis | W Atlantic | (abs.) | (abs.) | (abs.) | (abs.) | (abs.) | (abs.) | (abs.) | C |
| Pilargidae | | | | | | | | | | |
| Sigambra parva | Indian | (abs.) | (abs.) | A | (abs.) | Q | (abs.) | (abs.) | A | Q |
| Phylophoridae | | | | | | | | | | |
| 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 |
|--------------------------------|-----------------|-------------------------|------------------------|----------------------------------|-------------------------------|-------------------|------------------|----------------------|----------------------|-----------|
| *Amphicoelina pectinata*       | W Pacific       | A                       | A                      | A                                | A                             | A (abs.)          | A (abs.)         | A (abs.)             | A (abs.)             | Q         |
| *Bispira polyomma*             | Unknown         | (abs.)                  | (abs.)                 | (abs.)                           | (abs.)                        | (abs.)            | (abs.)          | A (abs.)             | A (abs.)             | A         |
| *Branchiomma haiti*            | W Atlantic      | (abs.)                  | (abs.)                 | A                                | (abs.)                        | (abs.)            | (abs.)          | A (abs.)             | A (abs.)             | A         |
| *Branchiomma boholense*        | W Pacific       | (abs.)                  | (abs.)                 | (abs.)                           | (abs.)                        | (abs.)            | (abs.)          | A (abs.)             | A (abs.)             | A         |
| *Branchiomma lactuca*          | Indian          | A                       | A                      | A                                | A                             | A                 | A (abs.)        | A (abs.)             | A (abs.)             | A         |
| *Deslemona ornata*             | Indian          | A                       | A                      | A                                | A                             | A                 | A (abs.)        | A (abs.)             | A (abs.)             | A         |
| *Acromegalomma claparedei*     | Indian          | (abs.)                  | A                      | A                                | A                             | A                 | A (abs.)        | A (abs.)             | A (abs.)             | A         |
| *Acromegalomma vesiculosum*    | E Atlantic      | (abs.)                  | (abs.)                 | (abs.)                           | (abs.)                        | A                 | A (abs.)        | Q (abs.)             | (abs.)               | E (mis.) |
| **Scalibregmatidae**           |                 |                         |                        |                                  |                               |                   |                  |                      |                      |           |
| *Hyboscolex longiseta*         | Indian          | (abs.)                  | A                      | Q                                | A                             | A                 | A (abs.)        | Q                    | Q                    |           |
| **Serpulidae**                 |                 |                         |                        |                                  |                               |                   |                  |                      |                      |           |
| *Ficopomatus enigmaticus*      | W Pacific       | A                       | A                      | A                                | (abs.)                        | A                 | A (abs.)        | A (abs.)             | A (abs.)             | A         |
| *Hydroides draconus*           | Mediterranean   | C                       | A                      | A                                | (abs.)                        | A                 | (abs.)          | (abs.)               | A (E nat.)           |           |
| *Hydroides dirampha*           | Unknown         | C                       | A                      | A                                | (abs.)                        | A                 | A (abs.)        | C                    | A                    |           |
| *Hydroides elegans*            | Unknown         | C                       | A                      | A                                | (abs.)                        | A                 | A (abs.)        | C                    | A                    |           |
| *Hydroides cf. inornata*       | Indian          | A                       | (abs.)                 | A                                | (abs.)                        | A                 | (abs.)          | (abs.)               | Q (abs.)             |           |
| *Hydroides sanctaecrucis*      | W Atlantic      | (abs.)                  | (abs.)                 | (abs.)                           | (abs.)                        | A                 | (abs.)          | A (abs.)             | E (mis.)             |           |
| *Pileolari berkeleyana*        | E Pacific       | A                       | A                      | A                                | A                             | A                 | A (abs.)        | A                    | A                    |           |
| *Spirorbis tetraceros s.l.*    | Unknown         | A                       | (abs.)                 | A                                | (abs.)                        | A                 | A (abs.)        | A                    | A                    |           |
| *Spirorbis marioni*            | E Pacific       | A                       | A                      | A                                | A                             | A                 | A (abs.)        | A                    | A                    |           |
| **Spinidae**                   |                 |                         |                        |                                  |                               |                   |                  |                      |                      |           |
| *Dispio ucinata*               | E Pacific       | E (nat.)                | A                      | A                                | A                             | A                 | A (abs.)        | (abs.)               | (abs.)               | Q         |
| *Polydora colonia*             | W Atlantic      | (abs.)                  | (abs.)                 | A                                | A                             | A                 | A (abs.)        | (abs.)               | A (abs.)             | Q         |
| *Polydora cornuta*             | W Atlantic      | A                       | (abs.)                 | A                                | A                             | A                 | A (abs.)        | A                    | A                    | A         |
| **Prionospio pulchra**         | W Pacific       | A                       | (abs.)                 | A                                | (abs.)                        | A                 | (abs.)          | (abs.)               | A (abs.)             | Q         |
| **Prionospio pygmaea**         | E Pacific       | A                       | A                      | A                                | A                             | A                 | A (abs.)        | A                    | A (abs.)             | 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.)            | A                     | Q                   |           |
| Pseudopolydora paucibranchiata | W Pacific      | (abs.)                 | (abs.)                 | (abs.)                           | (abs.)                          | (abs.)             | (abs.)            | (abs.)                | (abs.)              | (abs.)    |
| **SYLLIDAE**                    |                |                        |                        |                                  |                                 |                    |                   |                       |                     |           |
| Erinaceusyllis belizensis       | W Atlantic     | (abs.)                 | (abs.)                 | A                                | (abs.)                          | (abs.)             | (abs.)            | A                     | Q                   | Q         |
| Erinaceusyllis serratosettosa   | W Pacific      | (abs.)                 | (abs.)                 | (abs.)                           | (abs.)                          | (abs.)             | (abs.)            | A                     | Q                   |           |
| Streptosyllis arenae            | W Atlantic     | (abs.)                 | (abs.)                 | A                                | (abs.)                          | (abs.)             | (abs.)            | A                     | (abs.)              | (abs.)    |
| Syllis alosae                   | W Atlantic     | A                      | A                      | (abs.)                           | (abs.)                          | (abs.)             | (abs.)            | Q                     | Q                   |           |
| Syllis hyllebergi               | Indian         | (abs.)                 | (abs.)                 | A                                | A                              | A                  | (abs.)            | A                     | (abs.)              |           |
| Syllis pectinans                | W Pacific      | (abs.)                 | (abs.)                 | (abs.)                           | A                              | (abs.)             | (abs.)            | A                     | A                   | A         |
| Trypanosyllis gigantea          | Antarctic      | (abs.)                 | (abs.)                 | (abs.)                           | (abs.)                          | (abs.)             | (abs.)            | (abs.)                | E (mis.)            |           |
| **TEREBELLIDAE**                |                |                        |                        |                                  |                                 |                    |                   |                       |                     |           |
| Loimia medusa                   | Indian         | (abs.)                 | A                      | (abs.)                           | (abs.)                          | (abs.)             | (abs.)            | A                     | Q                   | Q         |
| Parapamphitrite bivrulai        | Arctic         | (abs.)                 | (abs.)                 | (abs.)                           | (abs.)                          | (abs.)             | (abs.)            | (abs.)                | (abs.)              | (abs.)    |
| Pista unibranchia               | Indian         | A                      | A                      | A                                | A                              | A                  | (abs.)            | A                     | (abs.)              |           |
| Pistella kornensis              | E Atlantic     | (abs.)                 | (abs.)                 | (abs.)                           | (abs.)                          | (abs.)             | (abs.)            | (abs.)                | Q                   |           |
| Streblosoma comatus             | E Pacific      | (abs.)                 | A                      | A                                | A                              | (abs.)             | (abs.)            | A                     | (mis.)              |           |
| Streblosoma hesslei             | Indian         | A                      | A                      | (abs.)                           | (abs.)                          | (abs.)             | (abs.)            | (abs.)                | E (mis.)            |           |
| Streblosoma pseudocomatus       | Unknown        | (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        |
**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 peninsula coastline, missing only in Sardinia and Sicily. Intertwining 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.

**Naineris setosa** Verrill, 1900  
**Material examined.** Livorno port, Tyrrhenian Sea (43.5491° N, 10.2968° E), 1 m, 11/2015: 3 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) (Aztori 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 toler-
Bispira polyomma Faasse & Giangrande, 2012

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* Kroyer, 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.

**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. Marina 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 coast 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. Tortoli Pond, Tyrrhenian Sea (39.9522° N, 9.6825° E), 0.5 m, 05/2016: 10 specimens. Ústica 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 Portoferroa, 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; Martinek 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 (Martinek 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 *Triellaria inopinata* d’Hondt & Ochcipinti-Ambrogi, 1985 (Dyrynda et al., 2000). The first introduction in European waters 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, 10.3578° 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 (42.3908° N, 11.3770° 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]

= *Eupomatus pectinatus* Philippi, 1844

Material examined. Porto Torres, Sea of Sardinia (40.8417° N, 7.6612° E), 1500 m, 09/2009: 1 specimen.

Remarks. Although H. elegans was originally described from Australia (Haswell, 1883), *Hydroides abbreviata* Kroyer 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 bekeleyana** (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 (Lautier, 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*.

**Spirobis 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).

**Spirobis 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 also can 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; Činar et al., 2005; Dağlı & Ergen, 2008; Simboura et al., 2008; Radashevsky & Selifonova, 2013; Bertasi, 2016). Bertasi (2016) reported this species as abundant in 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.

**Syllis hyllebergi** Rathke, 1843  
**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 bowerieri* (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. Piazzola 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; Činar 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 congeners, 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 (Činar et al., 2008; Lipej et al., 2017; present data).

**Cryptogenic species**

Family *Parasponiidae* Cerruti, 1909  
*Paraonis fragilis* (Webster, 1879)  
= *Aricidea fragilis* Webster, 1879  
= *Aricidea jeffreysi* (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 di 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* (Soolowiew, 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 relic 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 Činar (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 Činar (2009). The identification of the Levant Sea specimens as *S. comatus* by Činar (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

*Isolella 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 Amphimedidae** 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 Amphimedidae 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-Lessopian 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.

**Notopygus megalops** McIntosh, 1885

= *Notopygus crinita* Grube, 1855

Remarks. This species was reported in the Mediterranean Sea only by Cantone & Fasari (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-Purra, 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** Augusten, 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 (42.4416° N, 18.5594° E), 5 m, 06/2014: 2 specimens. Casaraccio 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 frigilis* 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 Alface 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 original 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., 2017). More recently it was also collected along the North Adriatic coast (Rulier et al., 2017). The species is often reported for slightly enriched environments (Zavodnik et al., 1985; Capaccioni-Azzati et al., 1992; present data).
Family **Eunicidae** Berthold, 1827

**Leodice antennata** (Savigny in Lamarck, 1818)

**Remarks.** This species has been reported from the Levant Sea as a Lessesian 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 vitata** (Delle Chiave, 1828) (Cantone et al., 1991; Cantone, 1999). Based on personal observations, **E. vitata** 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** (Poutarels, 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 totopotypic 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; 11/2001: 40 specimens; 11/2002: 78 specimens. Varano Lake, Adriatic Sea (41.8747° E, 15.7063° N), 3 m, 11/2014: 7 specimens. Pallassa 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* Lautier, 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 neogaeae* 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 Tyrrenhenian 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-Elihu, 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** Malmeqen, 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 Neridae** Blainville, 1818

*Neanthes agulhana* Day, 1963

**Material examined.** 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 Southern Adriatic 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 again been 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-
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grant, and its occurrence on the Israeli coast might sup-
port this view. However, Mediterranean specimens show
differences from other descriptions of this species; these
differences have been ascribed to the small size of the in-
dividual, 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 (Caselli & Stefanon, 2008). It is most likely a ther-
mophilous 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 *Di-
opatra* in Mediterranean waters has been recently reas-
sessed (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 juve-
niles of an already described *Diopatra* species.

**Longibrachium atlanticum** (Day, 1973)

**Remarks.** This species has been reported in the Medi-
terranean Sea only once (Cantone *et al.*, 1997) and is list-
ed 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 para-
podium 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 Medi-
terranean Sea, and confused with other Onuphidae.

**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. Pi-
ombino, 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 speci-
mens. Mar Grande of Taranto, Ionian Sea (40.4340° N,
17.2387° E), 12 m, 07/2018: 2 specimens.

**Additional material.** *Sigambra tentaculata* (Tread-
well, 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 (45.7463° N, 13.58537° E), 15 m, 10/1995: 6 speci-
mens.

**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 exam-
ned 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 differenc-
es retrieved by Moreira & Parapar (2002), *S. tentacula-
...

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**Fig. 3: Sigambra parva** (Day, 1963) sampled in the port of Li-
vorno, 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 (Ochippinti-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.

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 (Cinar, 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; Cinar, 2006), the identity of this material was questioned by Sun et al. (2017a). At least specimens examined by Cinar (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 uncincta Hartman, 1951

Remarks. According to Surugiu (2016) and Delgado-Blas et al. (2018), Mediterranean and more generally European records of D. uncincta 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; Dağlı & Çinar, 2011). Dağlı & Çinar (2011) suggested that the species might actually correspond to an undescribed *Prionospio* species with several unbranched branchiae (corresponding to the subgenus *Minospio* 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, 10.3143° E), 1 m, 07/2019: 15 specimens; 4 m, 05/2018: 2 specimens. Porto Santo Stefano, Maremma, Tuscany, Tyrrhenian Sea (43.5165° N, 10.3143° E), 2 m, 07/2019: 15 specimens.

**Remarks.** This very small polychaete has been originally described from mangrove environments in Belize. In the Mediterranean Sea it was firstly recorded for 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.
mens; 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 Tyrrenhian 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), Servallo 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 Martín, 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.

**Loimia medusa** Savigny, 1822

= *Axioloxica 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 unibranchiatata* Day, 1963 [lapsus calami in Mohammad, 1980; Činar, 2005; Zenetos et al., 2010; Činar 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 (Činar, 2005; Zaibi et al., 2012; Činar 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; Činar, 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 lecithotrophic, 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

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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

*Rhynchoneurella 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

*Notoppygos 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 GYLCERIDAE** 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 noeliae* Böggemann, Biendhold & 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

*Abyssinonoe 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 mabit* Ramos, 1976 (which in turn most likely should be transferred to *Abyssinonoe* 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 *Abyssoni- noe* 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.

**Levinsenia demiri** Çinar, Dağlı & 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 & Dağlı, 2013). The majority of Mediterranean specimens recorded as *Levinsenia gracilis* (Taubert, 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.

**Hydroides dianthus** (Verrill, 1873)  
**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).

**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 *Acrorhomaloma 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 *Acrorhomaloma*.
mens 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 specimens 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 aequalis* Langerhans, 1879. In agreement with Mikac (2015), we suggest to remove it from Mediterranean checklists.

**Family Terebellidae** Johnston, 1846  
**Strebllosoma 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 *Strebllosoma 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.

**Strebllosoma 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 *Strebllosoma 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 toptotypic 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.](http://epublishing.ekt.gr)
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), A.A.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, Sabella dorvillei 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 toptotypic 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 (Tomikawa 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 huperiana, Issola 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 Irnula 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 Erinacuesyllis sp. and Dioplosyllis cirrosp 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; Hydrodoides dianthus has been recently removed from Mediterranean NIS lists following Sun et al. (2017b), while the record of Hydrodoides sanctaeceacrux for the Lagoon of Venice was based on DNA sequences only (Rech et al., 2018) and the low sequence identity with H. sanctaeacrus, 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
represented by only four species overall, and these were all excluded NIS, with the exception of the Arctic *Parapartimastix 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. 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.*
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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