On the occurrence of the fireworm *Eurythoe complanata* complex (Annelida, Amphinomidae) in the Mediterranean Sea with an updated revision of the alien Mediterranean amphinomids

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Abstract
The presence of two species within the *Eurythoe complanata* complex in the Mediterranean Sea is reported, as well as their geographical distributions. One species, *Eurythoe laevisetis*, occurs in the eastern and central Mediterranean, likely constituting the first historical introduction to the Mediterranean Sea and the other, *Eurythoe complanata*, in both eastern and Levantine basins. Brief notes on their taxonomy are also provided and their potential pathways for introduction to the Mediterranean are discussed. A simplified key to the Mediterranean amphinomid genera and species of *Eurythoe* and *Linopherus* is presented plus an updated revision of the alien amphinomid species reported previously from the Mediterranean Sea. A total of five exotic species have been included; information on their location, habitat, date of introduction and other relevant features is also provided.

Keywords
Alien polychaetes, cryptic species, Gibraltar Strait, Lessepsian migrant

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Introduction

Introductions of alien species are threatening the economic and ecological well-being of marine ecosystems worldwide. The impacts of alien species on their new environments include alterations of established food webs, importation of new diseases or parasites, competition with native species for food and space, and even changing gene pools (Occhipinti-Ambrogi et al. 2011; Cosentino and Giacobbe 2011; Arias et al. 2013a, 2013b; Çinar 2013). Invaders are able to modify the receiving ecosystems, re-structuring the ecological relations within communities, altering evolutionary processes and causing dramatic changes in native populations. Over 80% of alien polychaete species recorded to date in the Mediterranean Sea come from the Red Sea and the Indo-Pacific (Çinar 2013), presumably reaching the Mediterranean through the Suez Canal and being considered as Lesseptian migrants or Erythrean species (Por 1978). The remaining ~20% originate from the Atlantic Ocean and were introduced to this region mainly via “shipping” (Çinar 2013). In recent decades, the rate of polychaete invasions has exponentially increased and currently in the Mediterranean Sea the number of alien polychaete species is roughly 100 (Zenetos et al. 2012; Çinar 2013).

Amphinomidae is a well-known family of polychaetes that is globally distributed, reaching its highest diversity in shallow tropical and subtropical waters (Kudenov 1995) and occurring at all depths, including abyssal areas (Kudenov 1993). Large tropical species of amphinomids are normally colourful and commonly referred as “fireworms” with hollow calcareous harpoon-type chaetae containing complanine, a trimethylamine compound that cause intense irritation on skin after penetrating the skin of anyone handling them roughly (Kudenov 1993, 1995; Nakamura et al. 2008). The parapodia are biramous with dense bundles of chaetae. The notopodium bears a single true dorsal cirrus (lateral cirrus) and some species may have a second accessory dorsal cirrus (branchial cirrus). The neuropodium has a single ventral cirrus. Besides having calcareous instead of chitinous chaetae, as present in other polychaetes, most amphinomids and other members of the Amphinomida have well-developed nuchal organs known as caruncles, which extend back mid-dorsally for several segments (Kudenov 1995, Rouse and Pleijel 2001).

Shallow water forms play an important ecological role mainly in rocky and coral reef environments, where species such as *Hermodice carunculata* (Pallas, 1766) are major predators of both soft corals (Alcyonacea) and hard corals (Scleractinia) (Ott and Lewis 1972, Vreeland and Lasker 1989). Furthermore, *H. caranculata* is known to act as reservoir and vector of pathogens associated with coral bleaching (Sussman et al. 2003). Another common shallow-water species is *Eurythoe complanata* (Pallas, 1766), which has been traditionally considered as having a wide circumtropical distribution. Nevertheless, recently it was demonstrated that *E. complanata* is actually a species complex. The phylogeographic analysis performed by Barroso et al. (2010) identified three closely related species forming a species complex: two species (one from eastern Pacific and the other from the Atlantic) are morphologically identical and fit the description
of *E. complanata*; and the third one, slightly morphologically different from the others, corresponds to the species *E. laevisetis*. Thereby, we are here proposing the term ‘morphospecies’ to refer to *E. complanata* and *E. laevisetis*, a concept that will be explored in the discussion below. Recently *E. cf. complanata* was also reported from the eastern and central Mediterranean (Barroso et al. 2010, Arias et al. 2013a respectively) but its presence in the Mediterranean Sea was questioned (Zenetos et al. 2010, 2012). Therefore, in order to elucidate the current status of this species complex in the Mediterranean and update its taxonomy, specimens previously identified as *E. complanata* collected from the central and eastern Mediterranean were morphologically re-examined, taking into account the new data for this species complex. Additionally, an updated key to currently known genera and five alien species in Mediterranean Amphinomidae is included.

**Methods**

Field collections were made along the Maltese Islands, Central Mediterranean, on hard substrata from the shallow subtidal rocky areas at Ċirkewwa Harbour (35°59’N, 14°19’E) and St. Julian’s Bay (35°55’N, 14°29’E) in March 2011 (Figure 1). Large specimens were randomly removed by a swift hand motion. Small specimens were collected using grabs and screened using a 1 mm mesh sieve. The worms were removed from the residue under a stereomicroscope. Then, all specimens were relaxed in MgCl$_2$ isotonic with seawater, fixed in 10% formaldehyde solution, rinsed in fresh water and finally transferred to 70% ethanol. Photographs were taken using a stereomicroscope Nikon SMZ-1000 equipped with a digital camera; before photography, specimens were stained with lithic carmine solution. Lithic carmine staining increased the contrast of some morphological structures, such as caruncle, branchiae, parapodial lobes and cirri. Glycerol slides of parapodial sections, examined under a compound light microscope Leica DM 2500, were used for the detailed examination of chaetal morphology and distribution.

The examined material was deposited at the Invertebrate Collection of the Department of Biology of Organisms and Systems (BOS) of University of Oviedo. Detailed location data is given below in the ‘Material examined’ sections of the respective species. The number of specimens in each sample is given in parentheses after the museum abbreviation and registration number. Furthermore, preserved specimens identified as *E. complanata* from the Gibraltar Strait, eastern Mediterranean (deposited in the MNHN), and the coasts of Atlit, Israel (deposited in the BMNH), were re-examined.

Additionally, comparative material was also studied: *Eurythoe laevisetis* Fauvel, 1914: São Tomé Island: IBUF RJ 0545; *Eurythoe cf. laevisetis*: Sal Island (Cape Verde): BOS-Amp1; Gran Canary (Canary Islands): BOS-Amp2; *Eurythoe complanata*: Bocas del Toro, Panamá (Caribbean): IBUF RJ 0542. Red Sea (unknown locality): BMNH 1923.3.20.8.
An updated check-list of the alien amphinomid species is provided based on an exhaustive review of the species records in the literature. The species data were mainly extracted from the regional reviews on alien species and compilations of polychaete species. We have also included data on their ecology, distribution and other relevant features.

**Abbreviations**

- **BMNH**: The Natural History Museum, London, U.K.
- **BOS**: Biology of Organisms and Systems, University of Oviedo, Spain
- **IBUFRJ**: Instituto de Biologa, Universidade Federal do Rio de Janeiro, Brazil
- **MNCN**: Museo Nacional de Ciencias Naturales, Madrid, Spain

**Results**

The revision of the literature along with our results (observations on 28 Mediterranean specimens belonging to *E. complanata* complex) revealed that five amphinomid species belonging to three genera were determined to be alien species in the Mediterranean Sea: *E. laevisetis*, *E. complanta*, *Linopherus acarunculatus* (Monro, 1937), *Linopherus canariensis* Langerhans, 1881 and *Notopygos crinita* Grube, 1855. The diagnostic differences between these species are summarised in the key provided. Furthermore, information about location, habitat, date of introduction and other relevant features are provided in Table 1.
**Table 1.** Summary of current knowledge on exotic Mediterranean Amphinomidae.

| Species | Locality | Year | Mediterranean area | Habitat | Others features | Reference |
|---------|----------|------|--------------------|---------|----------------|-----------|
| **Eurythoe complanata**<br>(Pallas, 1766) | Atlit (Israel) | 1937 | Eastern | intertidal reefs of *Dendropoma* spp | Occurring together with another amphinomid *Linopherus acarunculatus* | Monro 1937 Current work |
| | Gulf of Eilat (Israel) | 1976 | Eastern | On rocks, 3–6 m depth | | Ben-Eliahu 1976 |
| | Isabel II Island Gibraltar Strait (Spain) | September 1992 | Western | On rocks, 3–6 m depth | Occurring sympatrically with *Eurythoe laevisetis* | Current work |
| | Isabel II Island Gibraltar Strait (Spain) | July 1993 | Western | On rocks, 3 m depth | | Current work |
| | Congreso Island Gibraltar Strait (Spain) | July 1993 | Western | On rocks, 3 m depth | | Current work |
| | Chafarinas Islands Gibraltar Strait (Spain) | 1995 | Western | Rocky substrate | | López 1995 |
| **Eurythoe laevisetis**<br>Fauvel, 1914 | Isabel II Island Gibraltar Strait (Spain) | September 1992 | Western | On rocks, 3–6 m depth | Occurring sympatrically with *Eurythoe complanata* | Current work |
| | Isabel II Island Gibraltar Strait (Spain) | July 1993 | Western | On rocks, 3–6 m depth | | Current work |
| | Gozo Harbour (Malta) | March 2011 | Central | Rocky bottom 0.5–1 m depth | Associated with the invasive *Branchiomma bairdi* | Current work |
| **Linopherus acarunculatus**<br>(Monro, 1937) | Lebanon | 1966 | Eastern | Shallow waters | Referred to as *Pseudeurythoe acarunculata* Monro, 1937. Çinar (2009) suggest that these records could be *L. canariensis* Langerhans, 1881 | Laubier 1966 Ben-Eliahu 1976 |
| | Gulf of Elat (Israel) | 1976 | Eastern | Intertidal reefs of *Dendropoma* spp | | |
| **Linopherus canariensis**<br>Langerhans, 1881 | Kemer (Turkey) | July, 1993 | Eastern | 5 m depth on algae | | Çinar 2009 |
| | Cyprus | May 1997 | Eastern | 35 m depth on sandy substrate | Associated with *Brachiomma lanceolatum* | Ergen and Çinar 1997 |
| | Antalya Bay (Turkey) | 1997 | Eastern | | Referred to as *Pseudeurythoe acarunculata* Monro, 1937 | Çinar 2005 |
| | Cyprus | 2005 | Eastern | | | |
| Species                        | Locality              | Year            | Mediterranean area | Habitat                                                                 | Others features                                                                 | Reference                      |
|-------------------------------|-----------------------|-----------------|--------------------|---------------------------------------------------------------------------|---------------------------------------------------------------------------------|--------------------------------|
| Turkey                        | September-October 2005| Eastern         | On rocks between 0.1–5 m Mainly in C. officinalis substrate |                                                                                   |                                                                                 | Çinar 2009                     |
| Italy                         | 2005                  | Central         | Artificial modules with a neighboring sandy bottom, 1.2 m depth | Showed an invasive behaviour, reaching densities of 41.86 ind / m²             |                                                                                 | Occhipinti-Ambrogi et al. 2011 |
| Lake of Faro (Italy)          | May 2008              | Central         | Artificial modules with a neighboring sandy bottom, 1.2 m depth | Showed an invasive behaviour, reaching densities of 41.86 ind / m²             |                                                                                 | Cosentino and Giacobbe 2011    |
| *Notopygos crinita* Grube, 1855| Italy                 | 1983            | Central            | Currently this species is considered as not established in the Mediterranean (Zenetos et al. 2010; Occhipinti-Ambrogi 2011) |                                                                                 | Zenetos et al. 2010            |
Family Amphinomidae Lamarck, 1818

Genus *Eurythoe* Kinberg, 1857

**Type species.** *Eurythoe capensis* Kinberg, 1857, subsequent designation: *Eurythoe complanata* (Pallas, 1766).

*Eurythoe laevisetis* Fauvel, 1914
http://species-id.net/wiki/Eurythoe_laevisetis
Fig. 2A–F

*Eurythoe laevisetis* Fauvel, 1914: 116, pl VIII fig. 28-30, 33-37. Type locality: São Tomé Island, Gulf of Guinea.

**Material examined.** *Eurythoe cf. complanata*: Gozo Harbour (Malta), 35°50’N, 14°35’E (Mar. 2011): BOS-Amp3 (2 specimens), BOS-Amp4 (9 specimens).

*Eurythoe complanata*: Isabel II Island (Chafarinas Islands, Spain), 35°11’N, 2°26’W (Sep. 1992): MNCN 16.01/3340 (1 specimen); (Jul. 1993) MNCN 16.01/33394 (1 specimen).

**Diagnosis and description.** Body depressed elongated, rectangular in cross section. Specimens from Malta ranged in length from 14 to 52 mm with a mean of 39 mm (N=11, SD=12.09). Live specimens have a uniform orange-pinkish colour (Fig. 2A–C), on which the gills and a bright red caruncle stand out, and white chaeta fascicles forming two longitudinal bands along the body (Fig 2A, B). Prostomium rounded with 2 pairs of inconspicuous eyes arranged in a square and three antennae, two lateral ones in an anterior position and one slightly behind the others. The anterior end has a bilobed prebuccal lobe where are inserted a pair of cirriform palps (Fig. 2D). The caruncle is elongated and extends until the third chaetiger (Fig. 2C, D). Each segment is provided with a pair of arborescent gills that are present from the second chaetiger to the posterior region (Fig. 2C, D). Biramous parapodia with digitiform dorsal and ventral cirri, similar in size. Notochaetae of two types: very fine with a small spur that continues in a capillary-like thorn; and thicker with a marked spur (spurred capillary notochaeta) (Fig. 2F). The neurochaetae are spur-type and thick, slightly denticulate on juveniles (Fig. 2E).

**Remarks.** Several Maltese specimens present evidence of regeneration of the anterior and posterior end. All preserved specimens have whitish colour and lack the characteristic harpoon notochaetae. The two pairs of eyes are extremely inconspicuous, the anteriormost being similar in size to the posterior one. Specimens from Malta and Chafarinas Islands were morphologically identical to the Atlantic *E. laevisetis* from the Canary Islands and Cape Verde and *E. laevisetis* from São Tomé Island.
**Figure 2.** *Eurythoe laevisetis* from Malta. 

**A** live specimen, general view  
**B** live specimen, lateral view  
**C** live specimen anterior end, dorsal view  
**D** detailed view of anterior end, dorsal view  
**E** neurochaetae  
**F** spurred capillary notochaetae.  

*Eurythoe complanata* from Israel  

**G** detailed anterior end, dorsal view  
**H** harpoon notochaeta  
**I** notopodial spurred capillar notochaeta  
**J** notoacicular spines.

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**Eurythoe complanata** (Pallas, 1766)  

[http://species-id.net/wiki/Eurythoe_complanata](http://species-id.net/wiki/Eurythoe_complanata)  

Fig. 2G–J

**Aphroditia complanata** Pallas, 1766: 109, pl. 8, fig. 19-26. Type locality: Antigua Island, Caribbean Sea.
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Eurythoe brasiliensis Hansen, 1882: 4, fig. 5-9.
Lycaretus neocephalicus Kinberg, 1867: 55-56.
Eurythoe kamechameha Kinberg, 1857: 14; 1910,36, pl. 12, fig. 13.
Eurythoe pacifica Kinberg, 1857: 14; 1910: 36, pl. 12, fig. 11.
Eurythoe indica Kinberg, 1867: 90.
Eurythoe alboseta Kinberg, 1857: 90.
Eurythoe ehlersi Kinberg, 1867: 90.
Eurythoe havaiva Kinberg 1867: 90.
Eurythoe corallina Kinberg 1857:14; 1910:36, pl. 12, fig. 12.
Eurythoe alysonaria Gravier, 1902: 83, fig. 38, b-m.

Material examined. Eurythoe complanata: Isabel II Island (Chafarinas Islands, Spain), 35°11'N, 2°26'W (Sep. 1992): MNCN 16.01/3337 (2 specimens), MNCN 16.01/3338 (2 specimens), MNCN 16.01/3340 (1 specimen); Congreso Island (Chafarinas Islands, Spain), 35°11'N, 2°26'W (Jul. 1993): MNCN 16.01/3336 (1 specimen); Isabel II Island (Chafarinas Islands, Spain), 35°11'N, 2°26'W: MNCN 16.01/33394 (2 specimens). Atlit (Israel), 32°41'N, 34°56'E (1937): BMNH 1937.4.7.1-5 (7 specimens).

Diagnosis and description. Israeli specimens ranged from 20 to 45 mm in length with a mean of 31 mm (N=7, SD=9.77). Prostomium rounded with 2 pairs of eyes arranged in a square, the first being larger (Fig. 2G), and with three antennae, lateral ones in an anterior position and the single one slightly posterior. Anterior end with a bilobed prebuccal lobe, carrying a pair of cirriform palps. The caruncle is elongated and extends until the third chaetiger (Fig. 2G). Each segment is provided with a pair of arborescent branchiae that are present from the second chaetiger to the posterior end. Biramous parapodia with dorsal and ventral cirri digitiform, similar in size. Notochaetae of three types: harpoon-like (Fig. 2H); spurred capillaries with small spurs (Fig. 2I) and thicker smooth notochaetal spines (Fig. 2J). Notoacicula are very small, hastate, limited in number and always form an arc immediately in front of the dorsal cirrus. Neurochaetae are bifurcate, with prongs of different lengths.

Remarks. One specimen regenerating the posterior end. Pairs of eyes inconspicuous in some specimens, but always with the anterior pair larger than posterior pair. Specimens from Chafarinas Islands had a mean size of 37 mm (N= 8, SD = 7.24). All preserved specimens had a brownish colour.

Key to genera of Amphinomidae and species of Eurythoe and Linopherus of the Mediterranean Sea (modified from Borda et al. 2012)

1 Caruncle absent ..........................................................................................Hipponoa
– Caruncle present, variably developed ..........................................................2
2 Oval body ........................................................................................................3
– Elongated body; subcylindrical or quadrangular cross section ..................4
3 Dorsal accessory (branchial) cirri plus dorsal cirri on anteriormost abranchi-ate chaetigers; in branchiate chaetigers, one dorsal cirri per notopodium; bipinnate branchiae ................................................................. \textit{Chloeia} \\
\textendash Dorsal accessory (branchial) cirri plus dorsal cirri on all chaetigers; palmate branchiae ................................................................. \textit{Notopygos} \\
4 First chaetiger dorsally continuous, complete ........................................... 5 \\
\textendash First chaetiger dorsally discontinuous, not complete ...................... 7 \\
5 Hooks present in the first chaetiger; caruncle round ............................... \textit{Paramphinome} \\
\textendash Hooks not present in the first chaetiger ............................................ 6 \\
6 Branchiae limited to anterior segments ................................................. \textit{Linopherus} 10 \\
\textendash Branchiae on all segments after the chaetiger 2 or 3 .......................... \textit{Amphinome} \\
7 Caruncle large and conspicuous, extending beyond one chaetiger posteriorly ... 8 \\
\textendash Caruncle small and inconspicuous, not extending beyond one chaetiger pos-teriorly ...................................................................................... \textit{Cryptonome} \\
8 Caruncle without a median lobe, with folds obliquely arranged ................ \textit{Hermodice} \\
\textendash Caruncle with a smooth median lobe .............................................. 9 \\
9 Caruncle not sinusoidal ........................................................................ \textit{Eurythoe} 11 \\
\textendash Caruncle sinusoidal ...................................................................... \textit{Pareurythoe} \\
10 First branchiae present on chaetiger 3 ................................................ \textit{L. canariensis} \\
\textendash First branchiae present on chaetiger 4 ........................................ \textit{L. acarunculatus} \\
11 Three types of notochaetae present: spurred capillary, notoacicular spine and harpoon ................................................................. \textit{E. complanata} \\
\textendash Two types of notochaetae present: spurred capillary and notochaetal spine; harpoon absen ................................................ \textit{E. laevisetis} \\

\textbf{Discussion} \\

Members of the family Amphinomidae have a number of characteristics that gives the group high invasive potential. They show high biological plasticity and reproductive habits that include both sexual and asexual reproduction; possess a great capacity of regeneration and a large dispersal capability due to their long-term rostraria larvae (Kudênov 1995, Cosentino and Giacobbe 2011). Four amphinomid species are currently considered to be established in the Mediterranean Sea: \textit{E. laevisetis}, \textit{E. complanata}, \textit{L. canariensis} and \textit{L. acarunculatus} (Table 1). \textit{Notopygos crinita} is presumably no longer present in the Mediterranean Sea, having been a case of accidental introduction that failed to establish (Zenetos et al. 2010, 2012, Occhipinti-Ambrogi et al. 2011). However, the recently introduced \textit{L. canariensis} has displayed a highly invasive capacity and great potential for colonization, which are particularly favoured in stressed and degraded habitats where populations reach densities over 42 individuals/m² (Cosentino and Giacobbe 2011).

The use of the term ‘morphospecies’ for referring to \textit{E. complanata} has been proposed as an alternative to overcome the identification difficulties associated with this
species complex, which includes two cryptic species along with *E. laevisetis*. Here, we have an example of two species that are genetically distinct but morphologically identical under the same ‘morph’, named as *E. complanata*. So, the *E. complanata* complex erected by Barroso et al. (2010) is actually formed by two morphospecies, *E. complanata* and *E. laevisetis*. The former includes two cryptic species which occur natively, one in the eastern Pacific and one in the Atlantic.

The *E. complanata* complex represents one more case of species group that is likely to be introduced in the Mediterranean, but which has been underestimated and misidentified. Re-examination of specimens from Malta, Chafarinas Islands and Israel demonstrates the existence of two morphospecies belonging to the *E. complanata* complex in the Mediterranean Sea: *E. laevisetis* in the western and central Mediterranean and *E. complanata* in the western and Levantine basins. Moreover, the Israeli *E. complanata* is not a recently introduced species, but one that had been present since, at least 1937. All examined specimens from Malta and two from Chafarinas Islands belong to the species *E. laevisetis*, characterized by the absence of the harpoon notochaetae. According to Barroso et al. (2010), the ‘Atlantic-island-restricted species’, differentiated by DNA sequences and morphology from *E. complanata* is, actually, *E. laevisetis*. This species was erroneously considered the junior synonym of *E. complanata* by several authors (e.g. Fauvel 1947, Ebbs 1966). According to Fauvel (1914), the main diagnostic feature distinguishing *E. laevisetis* from the related *E. complanata* is its lack of harpoon notochaetae (Barroso et al. 2010). After the examination of the *E. laevisetis* specimens (without harpoon notochaetae) from different localities (Malta, Chafarinas Islands, Canary Islands, Cape Verde and São Tomé Island), we observed that both anteriormost and posterior pairs of prostomial eyes were similar in size in all studied specimens, being always very inconspicuous. By contrast, all examined specimens belonging to *E. complanata* exhibited, besides the characteristic harpoon chaetae, anterior eyes larger than posterior ones.

On the other hand, all examined specimens from Israel and nine from Chafarinas Islands were morphologically identical to *E. complanata* from the Atlantic and Pacific sensu Barroso et al. (2010), including the characteristic harpoon notochaetae, length of caruncle, prostomial appendages, branchial distribution pattern and other types of notopodial and neuropodial chaetae. These specimens differ from *E. laevisetis* by the presence of the harpoon notochaetae and size differences between the two pairs of eyes, with the anterior pair always larger than the posterior ones.

Kinberg (1857) first described the genus *Eurythoe* in the Mediterranean Sea based on *Eurythoe syriaca* from the Syrian coasts and *Eurythoe hedenborgi* from Dr. Hedenborg’s collection. Later, Monro (1937) reported *E. complanata* for the first time from the Mediterranean, considering *E. syriaca* as its junior synonym. Nevertheless, Hartman (1948) when reviewing the species described by Kinberg considered *E. syriaca* as a valid species. In the same review, as well as in her later world catalogue Hartman (1959) regarded *E. hedenborgi* as a questionable species, even though no justification was provided. More recently, Çinar (2008) described *Eurythoe turcica* from the Levantine coast of Turkey and differentiated this species from the related Indo-Pacific
Eurythoe parvecarunculata Horst, 1912. Nevertheless, Borda et al. (2012) transferred these latter two species to the genus Cryptonome based on a phylogenetic analysis. Therefore, based upon a comprehensive review of the literature descriptions we propose that currently only two species can be validly assigned to the genus Eurythoe in the Mediterranean Sea, E. complanata and E. laevisetis.

The origins, plausible pathways and introduction vectors of these related amphipomids into the Mediterranean may be discerned by focusing on populations of the central (E. laevisetis), western (E. laevisetis and E. complanata) and Levantine (E. complanata) regions. For example, Maltese and Chafarinas populations of E. laevisetis may have originated from Atlantic islands through the Gibraltar Strait. Such a scenario is wholly consistent with arrivals of other Atlantic species of marine invertebrates into the Mediterranean such as the gastropod Marginella glabella (Linnaeus, 1758), which is presently colonizing the coasts of Málaga (SE Spain, western Mediterranean) from the Canary Islands and West Africa (Luque et al. 2012). The Gibraltar Strait was also suggested to be the main pathway of introduction for other polychaetes such as the invasive sabellid Branchiomma bairdi (McIntosh, 1885), which is associated with E. laevisetis in Maltese Islands (Arias et al. 2013a) and for other conspicuous amphipomids, such as H. carunculata. The Mediterranean populations of the latter also seem to have descended from Atlantic ones (Ahrens et al. 2013) as well as L. canariensis populations from the Italian coasts (Cosentino and Giacobbe 2011). Two different plausible hypotheses concerning E. complanata populations must be considered in relation to their present geographical distributions. For example, Israeli populations could be Lessesian migrants due to their proximity to the Suez Canal. On the other hand, E. complanata from the Chafarinas islands and also localized in the Strait of Gibraltar, could be Atlantic migrants from the Canaries or other Atlantic archipelagos. However, multiple routes and times of introduction for all studied populations (Chafarinas, Malta and Israel) seem tenable and cannot be excluded. Further research mainly using molecular markers of Maltese and Israeli populations, as well as Red Sea and Canary Island ones, is needed to give more information concerning their origins and dispersion in the Mediterranean Sea. Finally, it is essential to emphasize that the great dispersive capacity of E. complanata (Barroso et al. 2010) is likely due to the inferred high longevity of its planktotrophic rostraria larvae (Bhaud 1972); additionally, the combination of asexual and sexual reproduction (Kudenov 1974) may promote the invasive potential of this species. Therefore, a detailed monitoring of the dynamics of Maltese and Israeli populations, as well as setting up a current distribution map should be undertaken in order to establish and understand the evolution of E. complanata complex across the Mediterranean Sea.

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References

Ahrens JB, Borda E, Barroso B, Paiva PC, Campbell AM, Wolf A, Nugues MM, Rouse GW, Schulze A (2013) The curious case of *Hermodice carunculata* (Annelida: Amphinomidae): evidence for genetic homogeneity throughout the Atlantic Ocean and adjacent basins. Molecular Ecology 22(8): 2280–2291. doi: 10.1111/mec.12263

Arias A, Giangrande A, Gambi MC, Anadón N (2013a) Biology and new records of the invasive species *Branchionomma bairdi* (Annelida: Sabellidae) in the Mediterranean Sea. Mediterranean Marine Science 14(1): 162–171. doi: 10.12681/mms.363

Arias A, Richter A, Anadón A, Glasby CJ (2013b) Revealing polychaetes invasion patterns: Identification, reproduction and potential risks of the Korean ragworm, *Perinereis lineae* (Treadwell), in the Western Mediterranean. Estuarine, Coastal and Shelf Science 131: 117–128. doi: 10.1016/j.ecss.2013.08.017

Barroso R, Klautau M, Solé-Cava AM, Paiva PC (2010) *Eurythoe complanata* (Polychaeta: Amphinomidae), the ‘cosmopolitan’ fireworm, consists of at least three cryptic species. Marine Biology 157: 69–80. doi: 10.1007/s00227-009-1296-9

Ben-Eliahu MN (1976) Errant polychaete cryptofauna (excluding Syllidae and Nereidae) from rims of similar intertidal vermetid reefs on the Mediterranean coast of Israel and in the Gulf of Elat. Israelite Journal of Zoology 25: 156–177.

Bhaud M (1972) Identification des larves d’Amphinomidae (Annélides Polychètes) recueillies près de Nosy-Bé (Madagascar) et problèmes biologiques connexes. Cahiers ORSTOM Océanographie 10: 203–216.

Borda E, Kudenoğlu JD, Bienhold C, Rouse GW (2012) Towards a revised Amphinomidae (Annelida, Amphinomida): description and affinities of a new genus and species from the Nile Deep-sea Fan, Mediterranean Sea. Zoologica Scripta 41(3): 307–325. doi: 10.1111/j.1463-6409.2012.00529.x

Cosentino A, Giacobbe S (2011) The new potential invader *Linopherus canariensis* (Polychaeta: Amphinomidae) in a Mediterranean coastal lake: colonization dynamics and morphological remarks. Marine Pollution Bulletin 62: 236–245. doi: 10.1016/j.marpolbul.2010.11.006

Çınar ME (2005) Polychaetes from the coast of northern Cyprus (Eastern Mediterranean Sea), with two new records for the Mediterranean Sea. Cahiers de Biologie Marine 46: 143–161.

Çınar ME (2008) Description of a new fireworm, *Eurythoe turcica* sp. nov. (Polychaeta: Amphinomidae), from the Levantine coast of Turkey (eastern Mediterranean), with re-descriptions of *Eurythoe parvecarunculata* Horst and *Amphinome djiboutiensis* Gravier based on type material. Journal of Natural History 42: 1975–1990. doi: 10.1080/00222930802140194
Çinar ME (2009) Alien polychaete species (Annelida: Polychaeta) on the southern coast of Turkey (Levantine Sea, eastern Mediterranean), with 13 new records for the Mediterranean Sea. Journal of Natural History 43: 2283–2328. doi: 10.1080/00222930903094654
Çinar ME (2013) Alien polychaete species worldwide: current status and their impacts. Journal of the Marine Biological Association of the United Kingdom 93(5): 1257–1278. doi: 10.1017/S0025315412001646
Ebbs NK (1966) The coral-inhabiting polychaetes of the northern Florida reef tract. Part I. Aphroditidae, Polyonidae, Amphinomidae, Eunicidae and Lysaretidae. Bulletin of Marine Science 16: 485–555.
Ergen Z, Çinar ME (1997) Polychaeta of Antalya Bay (Mediterranean coasts of Turkey). Israelite Journal of Zoology 43: 229–241.
Fauvel P (1914) Sur les polychètes rapportées par M. Ch. Gravier de San Tomé. Bulletin du Museum de Paris 14: 66–70.
Fauvel P (1947) Annélides polychètes de Nouvelle-Calédonie et des Iles Gambier Faune de l’Empire français. Office de la Recherche Scientifique Coloniale, Paris, 107 pp.
Gravier C (1902) Contribution à l’étude des Annélides Polychètes de la Mer Rouge. Nouvel Archives du Muséum d’Histoire Naturelle de Paris 4(3): 147–268.
Hansen GA (1882) Recherches sur les annélides recueillies par M. le professeur Édouard van Benedon pendant son voyage au Brésil et à la Plata. Mémoires Couronnes et Mémoires des Savants Étrangers publies par L’Academie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique 44(3): 1–29.
Hartman O (1948) The marine annelids erected by Kinberg with notes on some other types in the Swedish State Museum. Arkiv för Zoologi, Stockholm 42A (1): 1–137.
Hartman O (1959) Catalogue of the polychaetous annelids of the world. I. Errantia. Allan Hancock Foundation Publications (Occasional Paper) 23: 1–628.
Kinberg JGH (1857) Nya slägten och arter af Annelider. Öfversigt af Königlich Vetenskapssakadiemiens förhandlingar, Stockholm 14(1): 11–14.
Kinberg JGH (1867) Om regeneration af hufvudet och de främre segmenterna hos en Annulat. Öfversigt af Königlich Vetenskapssakadiemiens förhandlingar, Stockholm 24(2): 53–57.
Kudenv JD (1974) The reproductive biology of Eurythoe complanata (Pallas, 1766) (Polychaeta: Amphinomidae). PhD thesis, University of Arizona, Arizona, United States of America, 204 pp.
Kudenv JD (1993) Amphinomidae and Euphosinidae (Annelida: Polychaeta) principally from Antarctica, the Southern Ocean, and Subantarctic regions. Antarctic Research Series 58: 93–150. doi: 10.1029/AR058p0093
Kudenv JD (1995) Family Amphinomidae Lamarck, 1818. In: Blake JA, Hilbig B, Scott PH (Eds) Taxonomic Atlas of the Benthic Fauna of the Santa Maria Basin and Western Santa Barbara Channel, Vol. 5: The Annelida. Part 2. Polychaeta: Phyllodocida (Sylliae and Scale-bearing Families), Amphinomida and Eunicida. Santa Barbara Museum, Santa Barbara, 207–215.
Lamarck JB (1818) Histoire naturelle des Animaux sans Vertèbres. Deterville, Paris, 612 pp.
Laubier L (1966) Sur quelques Annélides Polychètes de la région de Beyrouth. Miscellaneous Papers of Natural Sciences of American University of Beirut 5: 1–15.
López E (1995) Anélidos Poliquetos de sustratos duros de las Islas Chafarinas. PhD thesis, Universidad Autónoma de Madrid, Madrid, Spain, 672 pp.
On the occurrence of the fireworm Eurythoe complanata complex...

Luque AA, Barrajon A, Remon JM, Moreno D, Moro L (2012) Marginella glabella (Mollusca: Gastropoda: Marginellidae): a new alien species from tropical West Africa established in southern Mediterranean Spain through a new introduction pathway. Marine Biodiversity Records 5: e17. doi: 10.1017/S1755267212000012

Monro CCA (1937) A note on a collection of Polychaeta from the eastern Mediterranean, with the description of a new species. Annals and Magazine of Natural History, London (ser.10) 17: 82–86.

Nakamura K, Tachikawa Y, Kitamura M, Ohno O, Suganuma M, Uemura D (2008) Complanine, an inflammation-inducing substance isolated from the marine fireworm Eurythoe complanata. Organic & Biomolecular Chemistry 6(12): 2058–60. doi: 10.1039/b803107j

Occhipinti-Ambrogi A, Marchini A, Cantone G, Castelli A, Chimenz C, Cormaci M, Froglia C, Furnari G, Gambi MC, Giaccone G, Giangrande A, Gravili C, Mastrototaro F, Mazziotti C, Orsi-Relini L, Piraino S (2011) Alien species along the Italian coasts: an overview. Biological Invasions 13: 215–237. doi: 10.1007/s10530-010-9803-y

Ott B, Lewis JB (1972) The importance of the gastropod Coralliophila abbreviata (Lamarck) and the polychaete Hermodice carunculata (Pallas) as coral reef predators. Canadian Journal of Zoology 50(12): 1651–1656. doi: 10.1139/z72-217

Pallas PS (1766) Miscellanea zoologica quibus novae imprimis atque obscurae Animalium species describuntur et observationibus iconibusque illustrantur. Haege Comitum, The Hague, 451 pp.

Por FD (1978) Lessepsian migration: the influx of Red Sea biota into the Mediterranean by way of the Suez Canal. Ecological Studies 23: 1–228. doi: 10.1007/978-3-642-66728-2_1

Rouse GW, Pleijel F (2001) Polychaetes. Oxford University Press, Oxford, 354 pp.

Sussman M, Loya Y, Fine M, Rosenberg E (2003) The marine fireworm Hermodice carunculata is a winter reservoir and spring-summer vector for the coral-bleaching pathogen Vibrio shiloi. Environmental Microbiology 5(4): 250–255. doi: 10.1046/j.1462-2920.2003.00424.x

Vreeland HV, Lasker HR (1989) Selective feeding of the polychaete Hermodice carunculata Pallas on Caribbean gorgonians. Journal of Experimental Marine Biology and Ecology 129(3): 265–277. doi: 10.1016/0022-0981(89)90108-1

Zenetos A, Gofas S, Verlaque M, Çınar ME, Garcia Raso JE, Bianchi CN, Morri C, Azzurro E, Bilecenoglu M, Froglia C, Siokou I, Violanti D, Sfriso A, San Martín G, Giangrande A, Katakarg T, Ballesteros E, Ramos-Esplá A, Mastrototaro F, Ocaña O, Zingone A, Gambi MC, Stretaris N (2010) Alien species in the Mediterranean Sea by 2010. A contribution to the application of European Union Marine Strategy Framework Directive (MSFD). Part I. Spatial distribution. Mediterranean Marine Science 11(2): 381–493. doi: 10.12681/mms.87

Zenetos A, Gofas S, Morri C, Rosso A, Violanti D, García Raso JE, Çınar ME, Almogi Labin A, Ates AS, Azzuro E, Ballesteros E, Bianchi CN, Bilecenoglu M, Gambi MC, Giangrande A, Gravili C, Hyams-Kaphzan O, Karachle V, Katsanevakis S, Lipej L, Mastrototaro F, Mineur F, Pancucci-Papadopoulou MA, Ramos Esplá A, Salas C, San Martín G, Sfriso A, Stretaris N, Verlaque M (2012) Alien species in the Mediterranean Sea by 2012. A contribution to the application of European Union’s Marine Strategy Framework Directive (MSFD). Part 2. Introduction trends and pathways. Mediterranean Marine Science 13(2): 328–352. doi: 10.12681/mms.327