

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

Andrés Arias<sup>1</sup>, Rômulo Barroso<sup>2,3</sup>, Nuria Anadón<sup>1</sup>, Paulo C. Paiva<sup>4</sup>

**1** Departamento de Biología de Organismos y Sistemas (Zoología), Universidad de Oviedo, Oviedo 33071, Spain **2** Pontificia Universidade Católica do Rio de Janeiro, Rio de Janeiro, Brazil **3** Museu de Zoologia da Unicamp, Campinas, SP, Brazil **4** Departamento de Zoologia, Instituto de Biologia, Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro, RJ, Brasil

Corresponding author: Andrés Arias (ariasandres.uo@uniovi.es)

---

Academic editor: C. Glasby | Received 17 June 2013 | Accepted 19 September 2013 | Published 30 September 2013

---

**Citation:** Arias A, Barroso R, Anadón N, Paiva PC (2013) On the occurrence of the fireworm *Eurythoe complanata* complex (Annelida, Amphinomidae) in the Mediterranean Sea with an updated revision of the alien Mediterranean amphinomids. ZooKeys 337: 19–33. doi: 10.3897/zookeys.337.5811

---

## 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

## 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, restructuring 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 Lessepsian 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. carunculata* 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

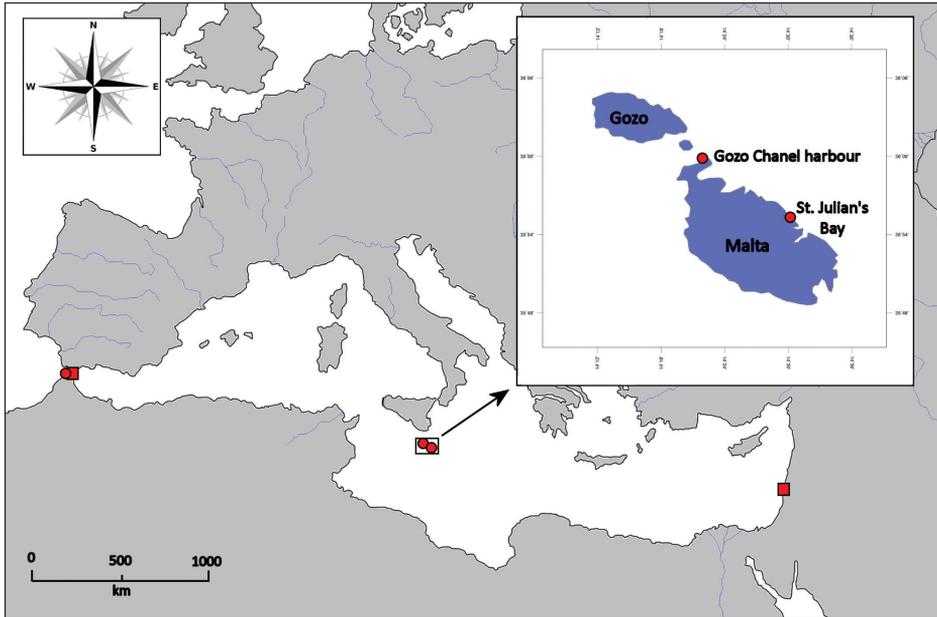
of *E. complanata*; and the third one, slightly morphologically different from the others, corresponds to the species *E. laevisetis*. Thereby, we are here proposing the term ‘morphospecies’ to refer to *E. complanata* and *E. laevisetis*, a concept that will be explored in the discussion below. Recently *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<sub>2</sub> 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 MNCN), 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: IBUFRJ 0545; *Eurythoe cf. laevisetis*: Sal Island (Cape Verde): BOS-Amp1; Gran Canary (Canary Islands): BOS-Amp2; *Eurythoe complanata*: Bocas del Toro, Panamá (Caribbean): IBUFRJ 0542. Red Sea (unknown locality): BMNH 1923.3.20.8.



**Figure 1.** Current distribution of *Eurythoe laevisetis* (red circles) and *Eurythoe complanata* (red squares) along the Mediterranean Sea.

## Abbreviations

<b>BMNH</b>	The Natural History Museum, London, U.K.
<b>BOS</b>	Biology of Organisms and Systems, University of Oviedo, Spain
<b>IBUFRJ</b>	Instituto de Biologia, Universidade Federal do Rio de Janeiro, Brazil
<b>MNCN</b>	Museo Nacional de Ciencias Naturales, Madrid, Spain

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.

## 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. complanata*, *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
<i>Eurythoe complanata</i> (Pallas, 1766)	Atlit (Israel)	1937	Eastern	intertidal reefs of <i>Dendropoma</i> spp	Occurring together with another amphinomid <i>Linopherus acarunculatus</i>	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 <i>Eurythoe laevisetis</i>	Current work
	Isabel III Island Gibraltar Strait (Spain)	July 1993	Western	On rocks, 3–6 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
<i>Eurythoe laevisetis</i> Fauvel, 1914	Isabel II Island Gibraltar Strait (Spain)	September 1992	Western	On rocks, 3–6 m depth	Occurring sympatrically with <i>Eurythoe complanata</i>	Current work
	Isabel III 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 <i>Brachiomma bairdi</i>	Current work
	Lebanon	1966	Eastern	Shallow waters	Referred to as <i>Pseudeurythoe acarunculata</i> Monro, 1937. Çinar (2009) suggest that these records could be <i>L. canariensis</i> Langerhans, 1881	Laubier 1966
<i>Linopherus acarunculatus</i> (Monro, 1937)	Gulf of Eilat (Israel)	1976	Eastern	Intertidal reefs of <i>Dendropoma</i> spp		Ben-Eliahu 1976
	Kemer (Turkey)	July, 1993	Eastern	5 m depth on algae		Çinar 2009
<i>Linopherus canariensis</i> Langerhans, 1881	Cyprus	May 1997	Eastern	35 m depth on sandy substrate	Associated with <i>Brachiomma lanceolatum</i>	Ergen and Çinar 1997
	Antalya Bay (Turkey)	1997	Eastern		Referred to as <i>Pseudeurythoe acarunculata</i> Monro, 1937	Çinar 2005
	Cyprus	2005	Eastern			

Species	Locality	Year	Mediterranean area	Habitat	Others features	Reference
<i>Notopygos crinita</i> Grube, 1855	Turkey	September-October 2005	Eastern	On rocks between 0.1–5 m Mainly in <i>C. officinalis</i> substrate		Cinar 2009
	Italy	2005	Central			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 / m <sup>2</sup>	Cosentino and Giacobbe 2011
	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](http://species-id.net/wiki/Eurythoe_laevisetis)

Fig. 2A–F

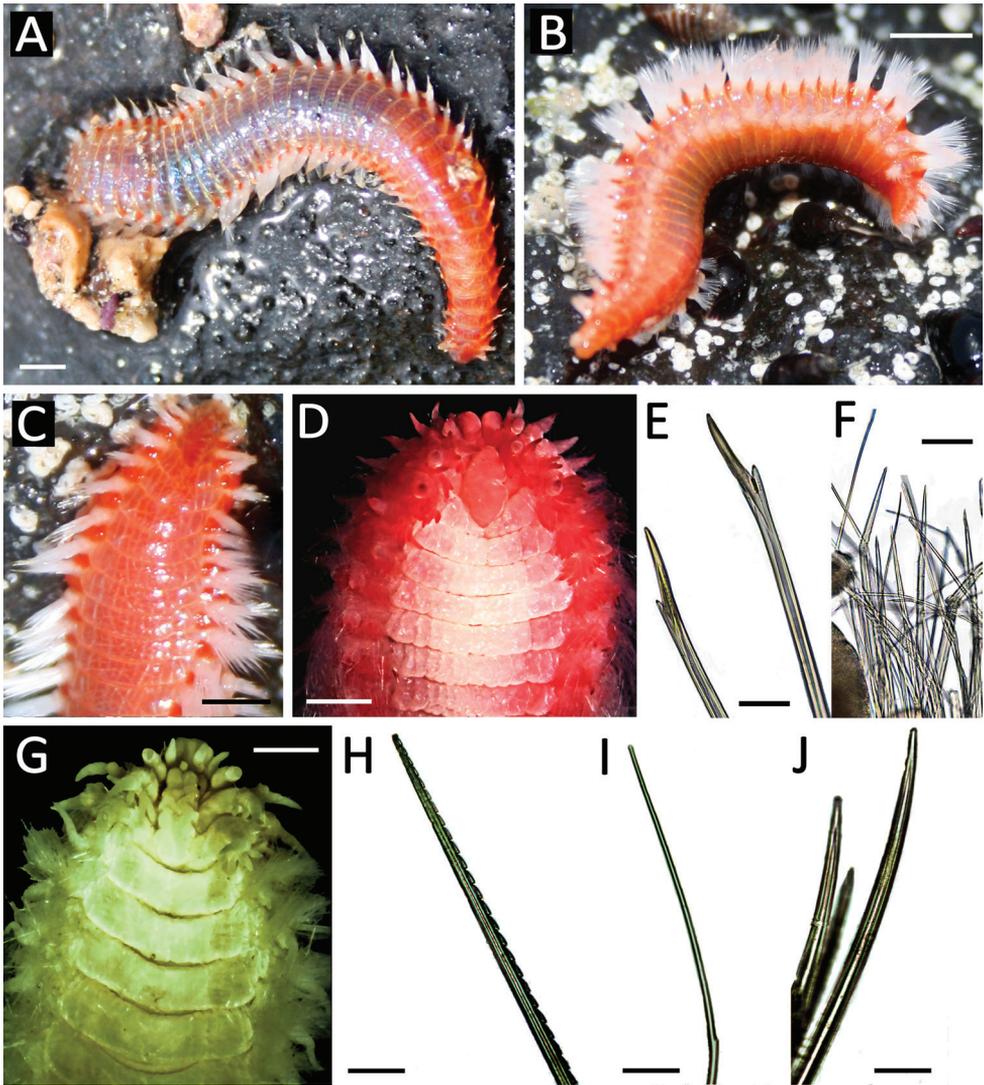
*Eurythoe laevisetis* Fauvel, 1914: 116, pl VIII fig. 28-30, 33-37. Type locality: São Tomé Island, Gulf of Guinea.

**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 capillary notochaeta **J** notoacicular spines.

***Eurythoe complanata* (Pallas, 1766)**

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

Fig. 2G–J

*Aphrodita complanata* Pallas, 1766: 109, pl. 8, fig. 19–26. Type locality: Antigua Island, Caribbean Sea.

- 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 alcyonaria* 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). Notoacacula 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 abbranchiate chaetigers; in branchiate chaetigers, one dorsal cirri per notopodium; bipinnate branchiae ..... *Chloeia*
- Dorsal accessory (branchial) cirri plus dorsal cirri on all chaetigers; palmate branchiae ..... *Notopygos*
- 4 First chaetiger dorsally continuous, complete ..... 5
- First chaetiger dorsally discontinuous, not complete ..... 7
- 5 Hooks present in the first chaetiger; caruncle round ..... *Paramphinome*
- Hooks not present in the first chaetiger ..... 6
- 6 Branchiae limited to anterior segments ..... *Linopherus* 10
- Branchiae on all segments after the chaetiger 2 or 3 ..... *Amphinome*
- 7 Caruncle large and conspicuous, extending beyond one chaetiger posteriorly ... 8
- Caruncle small and inconspicuous, not extending beyond one chaetiger posteriorly ..... *Cryptonome*
- 8 Caruncle without a median lobe, with folds obliquely arranged .... *Hermodice*
- Caruncle with a smooth median lobe ..... 9
- 9 Caruncle not sinusoidal ..... *Eurythoe* 11
- Caruncle sinusoidal ..... *Pareurythoe*
- 10 First branchiae present on chaetiger 3 ..... *L. canariensis*
- First branchiae present on chaetiger 4 ..... *L. acarunculatus*
- 11 Three types of notochaetae present: spurred capillary, notoacicular spine and harpoon ..... *E. complanata*
- Two types of notochaetae present: spurred capillary and notochaetal spine; harpoon absen ..... *E. laevisetis*

## 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 (Kudenov 1995, Cosentino and Giacobbe 2011). Four amphinomid species are currently considered to be established in the Mediterranean Sea: *E. laevisetis*, *E. complanata*, *L. canariensis* and *L. acarunculatus* (Table 1). *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 *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/m<sup>2</sup> (Cosentino and Giacobbe 2011).

The use of the term ‘morphospecies’ for referring to *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 notochoetae. 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 notochoetae (Barroso et al. 2010). After the examination of the *E. laevisetis* specimens (without harpoon notochoetae) 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 notochoetae, 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 notochoetae 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 amphinomids 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 *Branchiommma bairdi* (McIntosh, 1885), which is associated with *E. laevisetis* in Maltese Islands (Arias et al. 2013a) and for other conspicuous amphinomids, 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 Lessepsian 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.

## Acknowledgements

We are grateful to C. Glasby, J. Kudenov and one anonymous reviewer for valuable comments and suggestions that greatly improved the manuscript. The first author (AA)

is supported by a Severo Ochoa fellowship from the FICYT Foundation (Principado de Asturias, Spain). CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) provided support to RB. CNPq and FAPERJ (Fundação Carlos Chagas Filho de Apoio à Pesquisa do Estado do Rio de Janeiro) provided financial support to PCP.

## 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 *Branchiomma 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 lineata* (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, Kudenov 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
- Çinar 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.
- Çinar 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

- Çınar 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
- Çınar 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, Polynoidae, Amphinomidae, Eunicidae and Lysaretidae. *Bulletin of Marine Science* 16: 485–555.
- Ergen Z, Çınar 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 Muséum 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 Etrangers publiés par L'Académie 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 für 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 släkten och arter af Annelider. *Öfversigt af Königlich Vetenskapsakademiens förhandlingar, Stockholm* 14(1): 11–14.
- Kinberg JGH (1867) Om regeneration af hufvudet och de främre segmenterna hos en Annulat. *Öfversigt af Königlich Vetenskapsakademiens förhandlingar, Stockholm* 24(2): 53–57.
- Kudenov JD (1974) The reproductive biology of *Eurythoe complanata* (Pallas, 1766) (Polychaeta: Amphinomidae). PhD thesis, University of Arizona, Arizona, United States of America, 204 pp.
- Kudenov JD (1993) Amphinomidae and Euphrosinidae (Annelida: Polychaeta) principally from Antarctica, the Southern Ocean, and Subantarctic regions. *Antarctic Research Series* 58: 93–150. doi: 10.1029/AR058p0093
- Kudenov 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, 672pp.

- 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, Froglija 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*. Hagae 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, Çinar ME, Garcia Raso JE, Bianchi CN, Morri C, Azzurro E, Bilecenoglu M, Froglija C, Siokou I, Violanti D, Sfriso A, San Martin G, Giangrande A, Katağan T, Ballesteros E, Ramos-Esplá A, Mastrototaro F, Ocaña O, Zingone A, Gambi MC, Streftaris 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, Çinar ME, Almogi Labin A, Ates AS, Azzurro 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, Streftaris 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