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Research Article

Four new alien species on the coasts of Greece (Eastern Mediterranean)

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Abstract

This study reports four alien polychaete species new to the marine fauna of Greece, four of which are aliens. These species are -*Pseudopolydora paucibranchiata* (family Spionidae), *Paraprionospio coora* (family Spionidae), *Marphysa disjuncta* (family Eunicidae), and *Chaetozone corona* (family Cirratulidae). Another species of *Chaetozone,* though not an alien one, *Chaetozone gibber* is reported here from Greek waters. All of them have been currently reported from the coasts of Turkey (Aegean or Levantine Seas). *Pseudopolydora paucibranchiata* and *Marphysa disjuncta,* probably introduced to the region through ballast waters, seem to be well established in the Mediterranean Sea. *Chaetozone corona* and *Paraprionospio coora* were considered to be cryptogenic. *Pseudolydora paucibranchiata* was found in great densities in a very disturbed site, confirming the opportunistic character of this species. *Chaetozone corona* and *Chaetozone gibber* showed a wider distribution pattern, though their abundance increased in disturbed sites. *Marphysa disjuncta* was found in disturbed as well as in undisturbed sites along the coasts of Greece and *Paraprionospio coora* is characteristic of moderate to higher depth zones. These new findings increase the number of polychaete species from the Hellenic Seas to 777 species and the number of alien species to 33.

Keywords: Alien species; Polychaeta; Eastern Mediterranean; Hellenic Seas.

Introduction

The wave of non-indigenous species recordings in the Mediterranean Sea has triggered, through the re-examination of specimens previously considered as unidentified or assigned to a higher level taxonomic classification, the offering of new evidence on the taxonomic status of some taxa. In addition, the level of taxonomic awareness has increased in relation to the spotting of non-indigenous (for the

Mediterranean) species in the Hellenic seas.

For example the presence of *Chaetozone* species with eyes in the area of the Hellenic seas area was first noticed by SIMBOURA (1996) who assigned them under the species names *Chaetozone* sp. A and *Chaetozone* sp. B [described and drawn by SIMBOURA (1996)]. According to current knowledge of the genus *Chaetozone,* specimens of *Chaetozone* sp. A, which were first reported from the Saronikos Gulf (Table 1) probably belong to *Chaetozone gibber* Woodham & Chambers, 1994 (Fig.1) and specimens of *Chaetozone* sp. B, which were first reported from the Zakynthos island, probably belong to *Chaetozone corona* Berkeley & Berkeley, 1941 (Fig. 1). Only *Chaetozone corona* has an alien status as *C. gibber* was originally described from the coasts of the UK and the Mediterranean coast of France (Banyuls Sur Mer). These species were mostly found in large numbers in polluted or semi-polluted areas of Greece such as the Saronikos Gulf, Elefsis Bay, the Amvrakikos Gulf, the Geras Gulf etc. SIMBOURA & ZENETOS, 2002 assigned the complex *Chaetozone* spp. with the score 3 (first order opportunist species) pertaining to the scoring list of the Bentix index (http://bentix.ath.hcmr.gr).

ÇINAR & ERGEN (2007) also noticed that *Chaetozone setosa* Malmgren, 1867 was previously confused with *C. corona* (or *C. gibber* according to this study) in the Mediterranean Sea. Indeed, high densities of the *Chaetozone* species (*Chaetozone corona* and *C. gibber*) in the Hellenic Seas is related to semi-polluted or polluted conditions.This work aims, to report cases of non-indigenous species that were previously spotted but remained not fully identified, or cases of species that are reported from the Turkish coasts and were co-currently identified as well in the Hellenic seas. Table 1 shows the list of new species reported in this work from the Hellenic seas with reference to the earliest dates and the areas of their finding, taking also into account the suspected miss-identifications. This evidence is necessary in order to have a record of their history of dispersion in relation to other geographical areas, or evaluate their status (cryptogenic or alien). Based on this evidence and their distributional range, a hint for their history and status of establishment is also given (Table 1).

Results

Family: Cirratulidae Carus,1863

Chaetozone corona Berkeley & Berkeley, 1941

Material examined

Chaetozone corona was found on sandy mud (semi-polluted area) and *Posidonia oceanica* between 2.5 and 50 m depth in Izmir Bay and its vicinity (ÇINAR & ERGEN, 2007) while it was currently found in polluted and semi-polluted areas of Elefsis Bay and the Saronikos Gulf on sandy mud and muddy sand between 20 and 90 m depth, in Greece. SIMBOURA (1996) reported it (as *Chaetozone* sp. B) first from samples dating back to 1982 from Zakynthos Island (Ionian Sea) on sand at 5 m depth (Table 1). SIMBOURA (1996) also reported it in other areas of the Greek coasts such as the N. Evvoikos Gulf, the Thermaikos Gulf, the Kyklades and Crete, showing its wide distribution in sandy, muddy or mixed sediments at a wide depth range in disturbed and undisturbed sites. However, its density seems to increase in semi-polluted or polluted areas, showing the opportunistic character of the species.

Table 1
Date and area of earliest record of these alien species in Greek waters.

Species	Status of establishment/origin	Year of first sighting	Area of first sighting	First cited by	Other areas of occurence	Habitat & depth range of occurence	Frequency & abundance of occurrence
Chaetozone corona	cryptogenic	1982	Zakynthos island	SIMBOURA (1996) as *Chaetozone* sp.B	Crete, Elefsis Gulf, Evvoikos, Kyklades, Kalymnos isl., Saronikos, Thermaikos	Sandy mud, muddy sand, sand, biogenic detritus 5-90 m	Frequent. Fairly abundant in disturbed areas.
Marphysa disjuncta	established alien	1983	N. Evvoikos Gulf	IOFR, 1985 as *M. kinbergi*	N. Evvoikos, Santorini isl., Saronikos	Muddy sand, mud, gravel 60-316 m	Frequent and fairly abundant
Pseudolydora paucibranchiata	established alien	2005	Larymna Bay	PANAGOULIA (2009) as *P. antennata*	Elefsis Gulf, Geras Gulf	Sandy mud, mud, Zostera 3-33 m	Fairly frequent and very abundant in disturbed areas
Paraprionospio coora	cryptogenic	1983	Geras Gulf	DIAPOULIS & BOGDANOS, 1983 as *P. pinnata*	Saronikos Gulf	Muddy sand, 20-70 m	Frequent and fairly abundant in moderate to higher depth zones

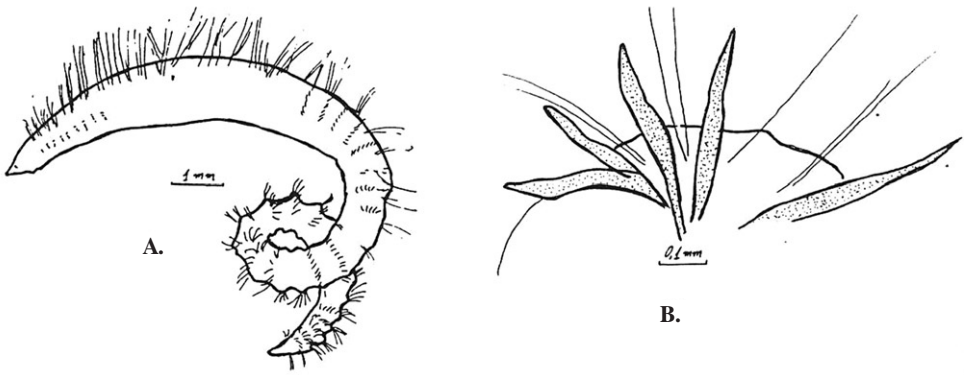

Fig. 1: *Chaetozone corona* **A.** Whole body, **B.** Notopodium of posterior parapodium [after SIMBOURA (1996) identified as *Chaetozone* sp. B (fig.2)].

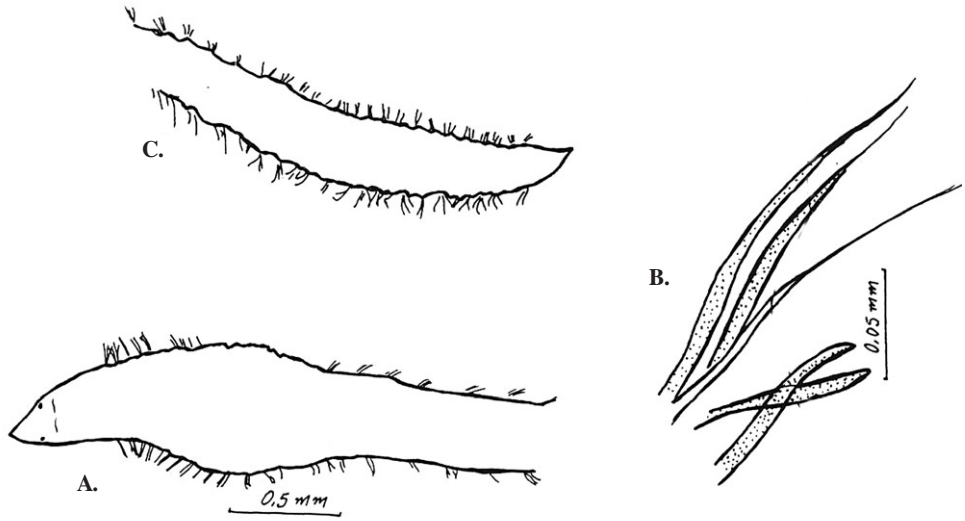

Fig. 2: *Chaetozone gibber.* **A.** Anterior part. **B.** Posterior parapodium. **C.** Posterior part (after SIMBOURA, 1996 identified as *Chaetozone* sp. A).

Taxonomic Remarks

The species is easily distinguished from other species of *Chaetozone* by the presence of a pair of black eyes laterally, pointed prostomium, long capillaries in the anterior regions and the presence of neuropodial acicular spines first appearing on chaetiger 1 (Fig. 1). It differs from other *Chaetozone* species with eyes reported from the Mediterranean, namely *Chaetozone gibber* Woodham & Chambers, 1994 and *Chaetozone carpentieri* McIntosh, 1911 in that *C. corona* bears neuropodial spines from chaetiger 1 and notopodial spines from chaetiger 5 (ÇINAR & ERGEN, 2007); the neuropodial spines in *C. gibber* start from

the 50th segment and the neuropodial spines from the 90th segment to the end of body; *C. carpentieri* has short spines from the 6th segment in notopodia and neuropodia and long spines in notopodia and neuropodia from approximately the 20th segment (CHAMBERS *et al.,* in press).

Distribution: This species was reported from the eastern Pacific, western Atlantic and Mediterranean Sea (Aegean Sea) (ÇINAR & ERGEN, 2007).

The presence of *Chaetozone corona* in the Mediterranean Sea was first reported from Izmir bay and its vicinity by ÇINAR & ERGEN (2007) who postulated that this species might be an alien species introduced into the Mediterranean from the eastern Pacific. They also outlined that its status should remain as cryptogenic (i.e. neither demonstratively native nor introduced) until its real distributional boundary, evidenced by morphological and genetic data, was solved. They also concluded that the species was previously misidentified as *Chaetozone setosa* or assigned to the *Chaetozone* spp. complex of species (SIMBOURA & NICOLAIDOU, 2001; SIMBOURA 1996). However, the presence of *C. corona* in the polluted environments of the Mediterranean, which are more susceptible to bio-invasions than pristine sites, particularly via ballast waters, suggests that it might have been introduced into the Mediterranean from the eastern Pacific.

***Chaetozone gibber* Woodham & Chambers, 1994**

Material examined

Based on currently examined material the species was found together with *Chaetozone corona* in the eutrophicated Elefsis Gulf, an enclosed gulf with organic and industrial pollution and in the inner Saronikos Gulf, an area affected by the treated effluents of the Central Sewage Treatment Plant of the Athens metropolitan area.

Taxonomic remarks

The species is differentiated from the *C. setosa* complex mostly by the presence of eyes and a humpback appearance (WOODHAM & CHAMBERS, 1994).

Its differences from other *Chaetozone* species with eyes reported from the Mediterranean is indicated in the taxonomic remark of *C. corona.*

Distribution: The species was reported from the English Channel and the Mediterranean (Western: the coasts of France and Tunisia; Eastern: the Aegean Sea).

Chaetozone gibber was originally described in the English Channel and the Mediterranean coasts of France (WOODHAM & CHAMBERS, 1994). ÇINAR *et al.* (2004) also reported the presence of *C. gibber* in Ildir Bay (Aegean Sea). Recently, the species has also been reported from the northeast coast of Tunisia (ZAABI *et al.,* 2009). According to the records of SIMBOURA (1996), identified currently with *C. gibber,* it was found in various disturbed and undisturbed Greek sites, such as the Saronikos Gulf, the Evvoikos Gulf, the Lakonikos Gulf and Crete on various sediment types such as sandy mud, muddy sand, mud or biogenic detritus between 15-76 m depth. Among these records the oldest one is from the Saronikos Gulf, dating back to 1989 (Table 1). Based on its distribution, *Chaetozone gibber* is not an alien species.

***Marphysa disjuncta* Hartman, 1961**

Family: Eunicidae Berthold, 1827

Material examined

The specimens from the Aegean Sea

(Greek coast) were examined and compared with the specimens collected from the type locality (California) by Hartman in 1957 (HARTMAN, 1961). On the coasts of Greece (Aegean Sea) it was firstly identified on mud mixed with metalliferous waste (slag) at 80 m depth in the N. Evvoikos Gulf, later on muddy gravel of volcanic material at 316 m depth in the caldera of Santorini Island (Kyklades, Aegean Sea) and on muddy sandy sediments at 60-70 m depth in the Saronikos Gulf. It was also reported at the same depths in the Levantine basin. It is most closely related to the species *Marphysa kinbergi* McIntosh, 1910, which has only compound spinigers on parapodia.

Taxonomic Remarks

Marphysa disjuncta is closely related to *M. kinbergi* but distinguished from it by the number of branchiae which are maximally 20 pairs in *M. kinbergi* and maximally 15 pairs in *M. disjuncta.* In addition, the tip of the shaft of the compound spinigers is smooth in *M. disjuncta* and distinctly serrated in *M. kinbergi.* SIMBOURA & NICOLAIDOU (2001) report *M. kinbergi* from the coasts of Greece, however older material should be re-examined as *M. kinbergi* may not be present in Greece and material may actually refer to *M. disjuncta.* The oldest (samples dating back to 1983 -IOFR, 1985) record of *M. kinbergi* from the coasts of Greece (SIMBOURA & NICOLAIDOU, 2001) corresponds to the same area of metalliferous waste discharge where *M. disjuncta* was currently identified (Table 1).

Distribution: The species was previously reported from the Pacific Ocean, the Levantine Sea and the Aegean Sea.

This is a species described from southern California (Pacific Ocean) by HARTMAN (1961) and was first recorded in the Mediterranean Sea from Fethiye Bay (Levantine Sea, Turkey) by KURT ŞAHIN & ÇINAR (2009). They postulated that it had entered the Mediterranean from the Pacific Ocean through ballast waters. The dispersion of *M. disjuncta* from the Levantine or its direct introduction into the Hellenic Seas through ballast waters is in question and remains to be resolved after more data about its distribution are accumulated.

Family: Spionidae Grube, 1850

***Pseudopolydora paucibranchiata* (Okuda 1937)**

Material examined

In Greece, *Pseudopolydora paucibranchiata* was first (Table 1) reported in Larymna Bay (Evvoikos Gulf, Aegean Sea), an area impacted from the activities of a metallurgical plant processing ferro-nickel mineral ore (PANAGOULIA, 2005). The species was found in on polluted mud, in shallow waters (3-5m depth) reaching very high densities (up to 2160 ind.m^{-2}) and its description perfectly matches that of DAGLI & ÇINAR (2008). In Larymna Bay it is the most dominant species among other pollution-tolerant polychaetes, such as *Prionospio fallax, Protodorvillea kefersteini* or *Lumbrineris gracilis;* density of all three species reached 180 ind.m^{-2}. It was also found occasionally among the endofauna of a *Zostera* meadow in the Geras Gulf (Lesvos island) and in Elefsis Bay (Saronikos Gulf). Another non-indigenous invasive species, belonging to the same family, *Polydora cornuta* was recently reported from the Bosphorus Strait and the Sea of Marmara as well as Elefsis Bay, Greece (KALKAN *et al.,* 2008; SIMBOURA *et al.,* 2008).

Taxonomic remarks

Pseudopolydora paucibranchiata differs from the native species *P. antennata* in that

it has a rounded prostomium without antero-lateral processes; 11-13 pairs of branchiae (more than 20 pairs in *P. antennata*) and hooks with a well-defined constriction on the shaft.

Distribution: This species was previously reported from the Pacific Ocean (western and eastern), the north-eastern Atlantic (European waters) and the Mediterranean Sea (Levantine, Aegean Sea).

In the Mediterranean Sea, this species was firstly reported in the Aegean Sea (Izmir Bay) and the Levant coasts of Turkey by DAGLI & ÇINAR (2008). They postulated that the species was previously erroneously identified as *P. antennata* Claparéde, 1870. *Pseudopolydora paucibranchiata* was originally described from Japan and the Pacific Ocean and its establishment in the Mediterranean area was attributed to ballast waters (DAGLI & ÇINAR, 2008). The competitiveness of this species seems to be low and it can only form dense populations in highly polluted areas (DAGLI & ÇINAR, 2008).

***Paraprionospio coora* Wilson, 1990**

Material examined

The species was identified from samples on muddy sand at 70m depth in the Saronikos Gulf. The closely similar species *Paraprionospio pinnata* (Ehlers, 1901) has a wide geographical distribution and is reported also from the western and eastern Mediterranean. However, the examination of older benthic material collected from the Aegean Sea and identified as *P. pinnata* revealed that the material actually belonged to *P. coora* (YOKOYAMA *et al.,* 2010). SIMBOURA (1996) reported some specimens of a spionid species closely resembling *P. pinnata,* and assigned them to the genus *Aquilaspio* because of the insertion of the first pair of branchiae on the chaetiger 2. The species, which was described as incomplete, was reported to have only two pairs of branchiae, the second one significantly smaller than the first one, which might show that the first pair of branchiae were missing. The above case shows that old material identified as *P. pinnata* or *Aquilasio* sp. should be re-examined and the occurrence of *P. coora* in the Mediterranean Sea might date more than a decade back. YOKOYAMA *et al.,* (2010) also doubted the existence of *P. pinnata* in the Mediterranean. According to a checklist of the marine polychaete fauna of Greece (SIMBOURA & NICOLAIDOU, 2001), the oldest record of *P. pinnata* in Greek waters was sampled in 1983 in the Geras Gulf (DIAPOULIS & BOGDANOS, 1983) on muddy sand at 20 to 65 m depth (Table 1).

Taxonomic remarks

The examined specimens of *P. coora* agree well with the description of the species by YOKOYAMA *et al.* (2010). The Greek specimens also have a small protuberance on the dorsum near the base of the third branchiae, and 2-3 pairs of apical teeth in neuropodial hooded hooks. *P. coora* mainly differs from *P. pinnata* in that the former species has a small papillae on the posterior margin of the peristomium (absent in *P. pinnata*), and a very long first and second pair of branchiae.

Distribution: This species was previously reported from the Pacific Ocean (Australia, Far East), and the Mediterranean Sea (Spanish coasts, Aegean Sea, Sea of Marmara).

The species was first reported in the Mediterranean Sea by YOKOYAMA *et al.* (2010) who reported it from the Aegean Sea, the Sea of Marmara and the Spanish Mediterranean coast. These authors sug-

gested that this species, like many spionids, might have been introduced into the Mediterranean sea via the ballast waters of ships. However, its alien status cannot be proved, apart from its extensive geographical distribution. Therefore this species could not be considered as cryptogenic, as many reports of *P. pinnata* from the Mediterranean as well as other parts of the world might actually belong to *P. coora.*

Discussion and Conclusions

According to a first complete checklist of polychaetes from the Hellenic Seas (SIMBOURA & NICOLAIDOU, 2001) polychaetes in the area numbered 753. KAMBOUROGLOU & NICOLAIDOU (2003) added the presence of the Red Sea immigrant *Pseudonereis anomala* (Gravier, 1900) in the Hellenic waters, BARNICH & FIEGE (2003) also added the Lessepsian migrant *Paradyt*e cf. *crinoidicola* (Potts, 1910) from Kassos Island to the list. Later, SIMBOURA & ZENETOS (2005) added 13 more species to the list. PANCUCCI *et al.* (2005) updated the list of the marine alien species in Hellenic waters and added a spionid species (*Prionospio pulchra* Imajima, 1990) to the list. SIMBOURA *et al.* (2007) found *Pionosyllis anophthalma* Capaccioni & San Martín, 1989 in a Greek lagoon. SIMBOURA (2008) and SIMBOURA *et al.* (2008) first reported the alien species *Glycinde bonhourei* Gravier, 1904 and *Polydora cornuta* Bosc, 1802, respectively ,on the coasts of Greece.

With the additions of species to the list after 2001, together with five new reports in this study, the total number of polychaetes in the Hellenic area rose to 777. Among them 764 species are reported from the Aegean Sea and 220 of these species are also found in the Ionian Sea. A total of 13 species were only reported from the Ionian Sea (ZENETOS *et al.,* 2010). According to the latest update of aquatic alien species in Greece, the number of marine and estuarine alien polychaete species in Greece is 17 (ZENETOS *et al.,* 2009). However, there are a number of alien polychaete species that have been recorded from the Greek coasts by ARVANITIDIS (2000) and SIMBOURA & NICOLAIDOU (2001) that are missing from the most update lists of alien species from the Hellenic seas (ZENETOS *et al.,* 2009) as they were either excluded during the course of update (Pancucci *et al.* (2005) or not included in the first place. These are the species *Neopseudoleiocapitella brasiliensis, Dispio magnus, Dodecaceria capensis, Leocrates chinensis, Polydora spongicola, Protodorvillea biarticulata, Lumbrineris perkinsi* (ex. *Lumbrineris inflata*), *Capitelethus dispar, Dasybranchus carneus, Scoletoma debilis, Sigambra constricta, Timarete dasylophius.*

With the above 12 records and the reports of four more alien species of this work, the number of aliens in Hellenic coastal and transitional waters (lagoons and estuaries) rises to 33. Among them 25 are found in the Aegean Sea, 3 in the Ionian Sea and its embayments and 5 of them in both Aegean and Ionian Seas. The total number of marine alien polychaete species recorded in the Mediterranean Sea and according to a latest update ZENETOS *et al.* (2005) is 70 species including 34 established, 20 casual and 16 questionable records of alien polychaetes. ZENETOS *et al.* (2008) in a further update of the list added 10 more records of alien polychaete species in the Mediterranean Sea. Most recently ÇINAR (2009) reported 13 more alien species from the southern coast of Turkey (Levantine Sea, eastern Mediterranean) new for the Mediterranean Sea. Therefore, up to 2009

the total number of alien polychaetes reported from the Mediterranean Sea reaches 93 species.

In relation to the total number of alien polychaetes of the Mediterranean Sea (93 species), the alien polychaetes of Greece (33 species) account for a percentage of 36%.

Of course there is a number of cases of polychaete species that there is a certain controversy around their characterization as aliens. It would be worth noting here the case of the terebellid polychaete *Loimia medusa* Savigny, 1818. This species was first reported from the Hellenic seas (Pagassitikos Gulf) in 1976 (BOGDANOS & SATSMADJIS, 1983). It was included in the list of alien species along the Italian coasts (OCCHIPINTI-AMBRODGI *et al.,* 2010) as a lessepsian migrant having arrived via shipping. However, this species has been frequently reported from the Greek coast as well as other parts of the Mediterranean Sea (including the Sea of Marmara). It was also reported from the eastern Atlantic Ocean (Spain, Portugal, Denmark) (CAMPOY, 1982; HARTMANN-SCHRÖDER, 1971). It seems to be a complex of species (HUTCHINGS & GLASBY, 1995). Therefore, this species should be considered as a cosmopolitan species until the taxonomic status of the species is resolved, at least in the Mediterranean Sea. This species is especially abundant in disturbed areas such as the Saronikos Gulf, however it also exists on stones in undisturbed environments (ME Ç INAR pers. comm.). OCCHIPINTI AMBRODGI *et al.* (2010), also reported the scalibregmid *Hyboscolex longiseta* (SCHMARDA, 1861) in Italian waters and considered it to be an alien. However, the report of this species is questionable and no description based on the Mediterranean specimens was given. This species was also reported in the Hellenic seas by FASSARI (1982) off Alexandroupoli on the sand of the mediolittoral and upper infralittoral zones. In this context, the number of alien species may not be accurately estimated and further taxonomic studies may increase the number of alien species, or, on the contrary, reveal cases of cryptogeny. However, in general, the number of alien species is expected to increase due to the spread of alien species (global warming, increase in shipping traffic, spread of aquaculture etc). Also, as a response to the increase in the incidence of alien species there is an increased awareness of taxonomy and an increased production of published works including descriptions of new species. Another important issue arising from this work is that it seems that there is an increasing number of cases of alien species formerly mis-identified with other widely distributed or Atlantic species, e.g. *Paraprionospio* coora with *Paraprionospio pinnata, Chaetozone corona* with *Chaetozone setosa, Marphysa disjuncta* with *Marphysa kinbergi,* and these cases have been reported in the area since the eighties (1980) (table 1). According to a scenario suggested by ÇINAR *et al.* (2005) the rate of alien species' introduction through shipping in the Aegean Sea was already significant over the period 1981-2000 (one species per 15.3 weeks) while it has accelerated between 2001-2005 (ÇINAR, 2009).

These issues also raise the problem of accurate estimation of biodiversity levels in the Mediterranean. Should the taxa that were erroneously included in Mediterranean fauna lists be excluded? How feasible is the re-examination of all older material? What is the possible impact of alien species on native populations if the closely related species did not ever exist? Or if there is an unknown number of cryptogenic species that are the real 'victims' of alien species' introduction?

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