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Abstract: Except for the noticeable investigations carried out in 1928 by Karl Zelinka in the Gulf of Naples and Gulf of Trieste, research on the Italian kinorhynch fauna has been rather erratic in space and time. According to the current checklist of the Italian marine biota, 48 species of Kinorhyncha were reported up to 2008 along the Italian coastlines. However, 31 of them are considered *nomina dubia* and hence of doubtful utility. Here we point out those taxa and provide new information based on recent publications and on novel investigations carried out in selected areas of the Adriatic Sea (3 localities), Ligurian Sea (4), Tyrrhenian Sea (8), and Ionian Sea (1). New data derives from qualitative as well as from quantitative samples. The analysis of the new samples yielded 6 families, 9 genera, and 29 species, of which only 14 were previously recorded from peninsular waters. In summary, we recorded one new genus and two new species for Italy, together with 13 additional species that appear new to science. Particularly interesting is the finding of two new species belonging to rare genus *Condyloderes*, as it represents the first records of this taxon in the Mediterranean Sea. The most speciose genus is *Echinoderes*, followed by *Pycnophyes* with 10 and 8 species, respectively. The former genus includes the taxon showing the highest abundance, *E. capitatus*, with recorded densities up to 184 ind./10 cm<sup>2</sup>, while the latter includes the most common species *P. communis*, found in 7 out of the 16 new investigated localities. New faunistic information prompted the revision of the checklist, which in the new version includes 36 species in 9 genera and 6 families. Old and new data were utilized for a preliminary discussion on the geographic distribution of the recorded fauna, from which it appeared that five species only can be considered ubiquitous in the four Italian sea basins, whereas the others taxa appear to be restricted to one or two seas. However, many sectors of the Italian coastline remain unexplored. Besides those areas (e.g., mid Tyrrhenian and Ionian coasts), future research should be focused on peculiar habitats, such as submarine caves, lagoons, and coarse biogenic sediments, as many species and species records come from these neglected biotopes, often representing biodiversity hotspots.

# Kinorhyncha from Italy, a revision of the current checklist and an account of the recent investigations

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## Abstract

Except for the noticeable investigations carried out in 1928 by Karl Zelinka in the Gulf of Naples and Gulf of Trieste, research on the Italian kinorhynch fauna has been rather erratic in space and time. According to the current checklist of the Italian marine biota, 48 species of Kinorhyncha were reported up to 2008 along the Italian coastlines. However, 31 of them are considered *nomina dubia* and hence of doubtful utility. Here we point out those taxa and provide new information based on recent publications and on novel investigations carried out in selected areas of the Adriatic Sea (3 localities), Ligurian Sea (4), Tyrrhenian Sea (8), and Ionian Sea (1). New data derives from qualitative as well as from quantitative samples. The analysis of the new samples yielded 6 families, 9 genera, and 29 species, of which only 14 were previously recorded from peninsular waters. In summary, we recorded one new genus and two new species for Italy, together with 13 additional species that appear new to science. Particularly interesting is the finding of two new species belonging to rare genus *Condyloderes*, as it represents the first records of this taxon in the Mediterranean Sea. The most speciose genus is *Echinoderes*, followed by *Pycnophyes* with 10 and 8 species, respectively. The former genus includes the taxon showing the highest abundance, *E. capitatus*, with recorded densities up to 184 ind./10 cm<sup>2</sup>, while the latter includes the most common species *P. communis*, found in 7 out of the 16 new investigated localities. New faunistic information prompted the revision of the checklist, which in the new version includes 36 species in 9 genera and 6 families. Old and new data were utilized for a preliminary discussion on the geographic

1 distribution of the recorded fauna, from which it appeared that five species only can be considered  
2 ubiquitous in the four Italian sea basins, whereas the others taxa appear to be restricted to one or two  
3 seas. However, many sectors of the Italian coastline remain unexplored. Besides those areas (e.g.,  
4 mid Tyrrhenian and Ionian coasts), future research should be focused on peculiar habitats, such as  
5 submarine caves, lagoons, and coarse biogenic sediments, as many species and species records come  
6 from these neglected biotopes, often representing biodiversity hotspots.  
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## 10 11 12 **1. Introduction**

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17 The number of new kinorhynch taxa is growing at a fast pace. Especially during the last two  
18 decades the effort by groups of international researchers, backed by new microscopical techniques,  
19 has led to the discovery and description of several new species and particular interesting new higher  
20 taxa. One hundred and seven species, almost half of those currently known, have been described in  
21 the timespan 1995-2015. New records come from different areas of the World, and often relevant  
22 discoveries are from previously neglected geographic regions (e.g., Dal Zotto et al., 2013; Sánchez  
23 et al., 2014; Sørensen and Thormar, 2010; Sørensen et al., 2000).  
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30 A modern approach to the taxonomy of the kinorhynchs is changing also the long-standing  
31 thoughts about the in-group relationships of the traditional higher taxa. This is best testified by the  
32 recent inclusive revision of the systematics of the Kinorhyncha based on a phylogenetic approach  
33 (Sørensen et al., 2015). As for September 2015, the phylum comprises more than 220 species and  
34 23 genera, whose geographic distribution appears to be largely patchy. This fact likely reflects more  
35 the limited number of investigated areas and the relatively low number of taxonomists with  
36 expertise on Kinorhyncha rather a real biogeographical phenomenon. The most species rich genera  
37 (*Echinoderes*, *Pycnophyes*, and *Kinorhynchus*) exhibit a cosmopolitan distribution (*sensu* Sterrer,  
38 1973), while the genera characterized by a low number of species have been reported solely from  
39 one or two ecoregions (see Neuhaus, 2013). Nevertheless, new studies point out that taxa apparently  
40 endemic to a given region often reveal a wider distribution. Paradigmatic in this regard is the recent  
41 discovery of *Sphenoderes* in Korean waters (Sørensen et al., 2010a) after its original report from  
42 India (Higgins, 1969). A further clue of the cosmopolitan nature of most genera derives from the  
43 genus *Meristoderes* recently described from the Mediterranean sea and the Salomon islands  
44 (Herranz et al., 2012) and subsequently found also in Florida (Herranz and Pardos, 2013) and Korea  
45 (Sørensen et al., 2013). Similar considerations may apply to *Antygomonas*, *Campyloderes*,  
46 *Condyloderes*, *Zelinkaderes*, and *Dracoderes* (see Neuhaus, 2013; Neuhaus and Sørensen, 2013,  
47 and references therein). Furthermore, a survey of poorly studied habitats in relatively well studied  
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1 areas may reveal the copious presence of taxa reported as rare in the original type localities. For  
2 instance, the genus *Antygomonas* originally described based on a single male specimen found in  
3 medium sand in the upper Adriatic Sea (Nebelsick, 1990), has been recently reported to be  
4 abundant in coralline sand in the Ionian sea (Sørensen et al., 2009) and in coarse sand in US waters  
5 (Herranz et al., 2014; Sørensen, 2007).  
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9 Based on the number of species, the Italian kinorhynch fauna appears as one of the best  
10 known in the World. However, investigations have been rather erratic in space and time. The 2008  
11 checklist of the Italian marine species includes 48 species, in six genera and five families  
12 representative of both the traditional (see below) orders Cycloragida and Homaloragida (Sandulli  
13 and de Zio Grimaldi, 2008). As requested by Italian marine checklist project (see Relini and La  
14 Posta, 2005), the distribution of the species according to 9 marine biogeographic zones (BZ) (see  
15 Fig. 1) was provided. In the case of the Kinorhyncha, species presence and distribution records  
16 come almost entirely from the seminal works carried out in the Gulf of Naples (BZ 3) and Gulf of  
17 Trieste (BZ 9) by Zelinka (1928), comprehensive of few previous records, e.g., *Echinoderes*  
18 *dujardinii* found in the Gulf of Salerno (Metschnikoff, 1865), at Ischia Island (Panceri, 1878), and  
19 near Brindisi (Schepotieff, 1907), the latter one falling within the BZ 7.  
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29 While the effort of compiling such a checklist is acknowledged, it should be stressed out that  
30 several of the reported species are considered *nomina dubia* (i.e., a doubtful application).  
31 Consequently the checklist itself is misleading or of a little help in frameworks that see these kind  
32 of lists as a useful tool in, e.g., the process of species identification or metadata analyses focusing  
33 on global patterns. Incorrect checklists are especially misleading when these kind of analyses are  
34 carried out by personnel not specifically trained in the taxonomy of the involved groups. The aim of  
35 the present work is to revise the 2008 checklist, providing: i) indication of the problematic taxa, ii)  
36 update it with additional records from articles published meanwhile and iii) expand the taxonomic  
37 spectrum by adding of new taxa and/or enlarge the geographic range of previously reported species  
38 with unpublished data from our own research carried out mostly in previously unexplored areas. As  
39 for the latter, a full set of information circumstantiating the finds is provided. For the purposes of  
40 this work, among the new information is also to include yet unpublished recordings of the Italian  
41 species from which genetic sequences were used for the phylogenetic study of Dal Zotto et al.  
42 (2013, Table 1).  
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## 54 55 56 **2. Material and methods** 57 58 59 60 61 62 63 64 65

1 Identification of the problematic taxa in the available checklist by Sandulli and de Zio  
2 Grimaldi (2008) has been performed by comparing the reported taxa with information present in  
3 comprehensive papers such as e.g., Adrianov and Malakhov (1999), Higgins (1983), Neuhaus  
4 (2013), and authoritative electronic repositories such as the World Register of Marine Species  
5 (<http://www.marinespecies.org/aphia.php?p=taxdetails&id=101060>, accessed on 25 July 2015). The  
6 high ranking systematization, phylum to families, used in the emended checklist follows that of  
7 Sørensen et al. (2015).  
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Published information on kinorhynch species found along the Italian coasts after the publication of the 2008 checklist derives from: Dal Zotto (2015), Dal Zotto and Todaro (2009), Herranz et al. (2012), Sánchez (2015), and Sørensen et al. (2009). While browsing the ‘grey’ literature on Italian marine fauna, we came across the neglected paper by Mari and Morselli (1987), who reported two species of Kinorhyncha from the Laguna Veneta, so we decided to include these records in the new version of the checklist.

New, unpublished information were obtained by us from qualitative as well as quantitative samples. Qualitative samples from eleven localities (loc. 1, 2, and 4: BZ 1; loc. 5, 6, 7, 8, 9, and 10 – BZ 2; loc. 13 – BZ 6; loc. 16 – BZ 9; Figure 1) were collected manually by skin or SCUBA diving using 500 ml plastic jars (see Todaro et al., 2015). Quantitative samples from five different areas (loc. 3 – BZ 1; loc. 11 and 12 – BZ 3; loc. 14, 15 – BZ 9; Figure 1) were collected as three-four replicate cores (3.4 cm in diameter x 5 cm in height) obtained directly by SCUBA diving or through subsampling the material collected by a Van Veen grab. A list with the names of the sampled localities, together with information on depth, sediment type (according to Giere et al., 1988) and sampling date is provided in Table 1.

Regarding the qualitative samples, specimens were extracted using the narcotization-decantation technique with 7% MgCl<sub>2</sub> solution (Pfannkuche and Thiel, 1988). Kinorhynchs were removed with a micropipette, mounted on slides and observed *in vivo* with Nomarski optics using a Nikon, Eclipse 90i microscope. During observation specimens were photographed using a DS-5M digital camera and measured using the ACT-2U v.4 Nikon software. After observation, most of the surveyed specimens were removed from the slide and stored in formalin for future check. Some specimens were transferred to vials containing 95% ethanol and kept at -20°C for forthcoming molecular analyses.

Quantitative samples were treated as follows. The fauna was narcotized using a 7% magnesium chloride solution, fixed on site with a 10% buffered formalin solution pre-stained with rose Bengal and stored for later checking (Todaro et al., 2006). In the laboratory, each sample was filtered using two sieves, 1 and 0.045 mm, respectively, laid one upon the other and fauna extracted

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trice from the finer fraction using the silica gel gradient centrifugation technique (LUDOX AM,  $d = 1.210$ ; Pfannkuche and Thiel 1988; Todaro et al., 2001).

Kinorhynchs were isolated and transferred to HS slides and identified like the specimens from qualitative samples. Additional animals from both qualitative and quantitative samples were prepared for SEM. Specimens for SEM were formalin-fixed, dehydrated through a graded ethanol series, critical point dried using carbon dioxide with a CPD 010-Balzer, mounted on aluminum stubs, sputter-coated with Au/Pd (Sputter Coater E24, Balzer) and observed with a Philips XL 40 scanning electron microscope. Measurements were obtained from both living and fixed animals using ACT-2U software.

### 3. Results and discussion

#### 3.1. Revision of the current checklist

The available checklist of the Italian kinorhynchs includes 48 species, , allocated to six genera, and five families (Sandulli and de Zio Grimaldi, 2008). Most of the species reported in the list were described by Karl Zelinka based on fauna collected in the gulfs of Naples and Trieste (Zelinka, 1928). However, subsequent authors (notably, Adrianov and Malakhov, 1999 and Higgins, 1983), have pointed out that many species described by Zelinka (1928) should be considered as *nomina dubia* because their description was based on juvenile specimens. It should be stressed that the description of a new species of kinorhynchs is usually based on adult specimens and that the morphology of the juveniles stages of most species is unknown or undescribed. In this context, it is worth mentioning that kinorhynch juveniles exhibit morphological traits that may differ from those characterizing the adult stages (male or female; see e.g., Neuhaus, 1995; Sørensen et al., 2010b), and that juveniles of different species may appear morphologically very similar. Consequently, it is virtually impossible to say if the juveniles described by Zelinka (1928) belong to good species or juveniles of already known species (very likely). Hence, the indication of *nomina dubia* for those species appears appropriate. The doubtful application of these names is probably the reason why none of the species erected by Zelinka (1928) based on juvenile stages has been considered in recent taxonomic works.

With regard to the species listed in the current checklist, 29 taxa are considered *nomina dubia* by Higgins (1983) and/or, Adrianov and Malakhov (1999) and also by the Neuhaus (2013); these are: *Echinoderes erinaceus* (Zelinka, 1928) (original name: *Habroderes erinaceus*); *Echinoderes erucus* Panceri, 1878 (reported as *Echinoderes erucus* Zelinka, 1928; original name: *E.*

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2 *eruca*); *Echinoderes ferox* (Zelinka, 1928) (original name: *Habroderella ferox*); *Echinoderes*  
3 *gracilis* Zelinka, 1928 (original name: *Hapaloderes gracilis*); *Echinoderes hyalinus* (Zelinka, 1928)  
4 (original name: *Habroderella hyalina*); *Echinoderes meridionalis* Panceri, 1878; *Echinoderes*  
5 *minax* (Zelinka, 1928) (original name: *Habroderes minax*); *Echinoderes minimus* (Zelinka, 1928)  
6 (original name: *Hapaloderes minimus*); *Echinoderes minutus* Panceri, 1878; *Echinoderes*  
7 *monocercus* Claparède, 1863; *Echinoderes pallidus* (Zelinka, 1928) (original name: *Centropsis*  
8 *pallida*); *Echinoderes parallelus* (Zelinka, 1928) (original name: *Centropsis parallela*);  
9 *Echinoderes pulchellus* (Zelinka, 1928) (original name: *Centropsis pulchella*); *Echinoderes pusillus*  
10 (Zelinka, 1928) (original name: *Centropsis pusilla*); *Echinoderes rosaceus* (Zelinka, 1928)  
11 (reported as *E. rosaceus* Remane, 1936; original name: *Centropsis rosacea*); *Echinoderes spinosus*  
12 Panceri, 1878; *Echinoderes splendidus* (Zelinka, 1928) (original name: *Habroderes splendidus*);  
13 *Echinoderes trispinosus* (Zelinka, 1928) (original name: *Habroderella trispinosa*); *Pycnophyes*  
14 *biserratus* (Zelinka, 1928) (original name: *Centrophyes biserratus*); *Pycnophyes conspicuus*  
15 (Zelinka, 1928) (original name: *Hyalophyes conspicuus*); *Pycnophyes curvatus* (Zelinka, 1928)  
16 (original name: *Centroderes curvatus*); *Pycnophyes denticulatus* (Zelinka, 1928) (original name:  
17 *Centrophyes denticulatus*); *Pycnophyes diffusus* (Zelinka, 1928) (reported as *P. diffusus*; original  
18 name: *Centrophyes diffusus*); *Pycnophyes longihastatus* (Zelinka, 1928) (original name:  
19 *Centrophyes longihastatus*); *Pycnophyes moderatus* (Zelinka, 1928) (original name: *Centrophyes*  
20 *moderatus*); *Pycnophyes rectilineatus* (Zelinka, 1928) (original name: *Centrophyes rectilineatus*);  
21 *Pycnophyes solidus* (Zelinka, 1928) (original name: *Hyalophyes solidus*); *Pycnophyes tenuis*  
22 (Zelinka, 1928) (original name: *Centrophyes tenuis*); *Pycnophyes validus* (Zelinka, 1928) (original  
23 name: *Centrophyes validus*).

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42 How to deal with the species considered *nomina dubia* in the framework of the present work?  
43 According to the International Code of Zoological Nomenclature (ICZN, 1999) the scientific names  
44 remain valid. However, in the Fauna Europaea project (de Jong et al., 2014), species considered  
45 *nomina dubia* have been ignored (i.e., omitted from the database), even though some authors do not  
46 agree with this general rule (see van Helsdingen, 2003). In our opinion the assembly, and the final  
47 goal of a checklist, approaches that of the fauna Europaea project; consequently, we decide not to  
48 include taxa considered *nomina dubia* in this updated version of the checklist (see below).  
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In addition to the *nomina dubia* listed above, two other species listed in the 2008 checklist appear problematic, namely *Centroderes eisigii* Zelinka, 1928 and *Pycnophyes flagellatus* Zelinka,

1928 as they have been considered as junior synonyms of *Centroderes spinosus* (Reinhard, 1881) and *Paracentrophyes quadridentatus* Zelinka, 1928 respectively (see Higgins, 1983; Neuhaus et al., 2013). We agree with the view of the latter authors and, consequently, do not include these species in the emended version of the checklist (see below). As far as the distribution of species is concerned, we could not find the original reference accounting for the presence of *Centroderes spinosus* in the Italian marine biogeographic zone n. 5 (southeast coast of Sicily), consequently we could not confirm the datum reported by Sandulli and de Zio Grimaldi (2008) regarding the presence of this taxon in that marine biogeographic zone. By contrast, two records not included in the 2008 checklist are acknowledged: *Echinoderes dujardinii* (Fam. Echinoderidae) and *Semnoderes armiger* (Fam. Semnoderidae), reported by Mari and Morselli (1987) to be associated with the sponge *Hymeniacidon sanguinea* (Grant, 1826) collected in the southern side of the Laguna Veneta, near Chioggia (BZ 9).

As for the high ranking systematization, Sørensen et al. (2015), based on a phylogenetic approach, proposed the phylum Kinorhyncha to be subdivided in two classes, Allomalorhagida and Cyclorhagida, the latter divided in three orders (Kentrorhagata, Echinorhagata, and Xenosomata). Allomalorhagida currently do not include any taxon of order rank, due the low statistical support at the nodes of interest shown on the phylogenetic trees derived from the analyses (see Sørensen et al. 2015). We accept this solution and consequently in the preparation of the new checklist we transfer: i) the families Antygomonidae, Centroderidae and Semnoderidae and related taxa, traditionally affiliated with the order Cyclorhagida, to the new established order Kentrorhagata (class Cyclorhagida), ii) the family Echinoderidae and related taxa, previously affiliated with the order Cyclorhagida, to order Echinorhagata (class Cyclorhagida), and iii) the families Neocentrophyidae and Pycnophyidae and related taxa, traditionally affiliated with the order Homalorhagida, to the class Allomalorhagida.

### 3.2 Kinorhynch taxa reported from Italy after 2008

Based on the examined literature the following taxa should be added to the list.

Class ALLOMALORHAGIDA Sørensen, Dal Zotto, Rho, Herranz, Sánchez, Pardos and Yamasaki, 2015

Family Pycnophyidae Zelinka, 1896

Genus *Pycnophyes* Zelinka, 1907

*Pycnophyes zelinkaei* Southern, 1914

1 This species was recently found by Sánchez (2015) in muddy sand at 22-53 m depth from the Gulf  
2 of Naples. The species was originally described from Irish coastal waters (Southern, 1914),  
3 subsequently reported from other Atlantic localities (Bamber, 1989; McIntyre, 1962), and more  
4 recently from Gibraltar (Sánchez et al, 2012).  
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7 The presence of this species along the Tyrrhenian coast of Italy points out its broad distribution  
8 within the Mediterranean Sea and along the European coasts.  
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13 Class CYCLORHAGIDA Sørensen, Dal Zotto, Rho, Herranz, Sánchez, Pardos and Yamasaki, 2015  
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16 Order Echinorhagata Sørensen, Dal Zotto, Rho, Herranz, Sánchez, Pardos and Yamasaki, 2015  
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19 Family Echinoderidae Butschli, 1876  
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22 Genus *Meristoderes* Herranz, Thormar, Benito, Sánchez and Pardos, 2012  
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25 *Meristoderes macracanthus* Herranz, Thormar, Benito, Sánchez and Pardos, 2012  
26

27 A written report of this species from Italian waters (Sardinia) can be found in Herranz et al. (2012);  
28 direct contact with M. Herranz and M. V. Sørensen allowed us to confirm that samples were  
29 collected in September 2010 from La Maddalena Archipelago during a workshop on meiofauna (see  
30 Curini-Galletti et al., 2012). By crossing works by Neuhaus (2013) and Curini-Galletti et al. (2012),  
31 the exact location appears to be Cala Ferrigno, where coarse sandy sediment was collected at 4 m  
32 depth. The species was originally described from the vicinity of Blanes (Gerona, NE Spain), hence  
33 it appears so far to be endemic to the Mediterranean basin.  
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42 Order Kentrorhagata Sørensen, Dal Zotto, Rho, Herranz, Sánchez, Pardos and Yamasaki, 2015  
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45 Family Antygomonidae Adrianov and Malakhov, 1994  
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48 Genus *Antygomonas* Nebelsick, 1990  
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51 *Antygomonas caeciliae* Dal Zotto, 2015  
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53 A relatively high number of specimens (> 20) of this species was found in October 2008 in the  
54 medium-coarse, biogenic sand collected at about 1.5-3.5 m water depth in the Meloria shoals, off of  
55 Leghorn, Tuscany (Dal Zotto, 2015). Prior to its formal description, a short account on the  
56 specimens from the Meloria shoals was provided by Dal Zotto and Todaro (2009). Recently  
57 specimens apparently belonging to this species have been found by us near the type locality, in the  
58 island of Pianosa (BZ 2) in similar sediment and water depth (see below).  
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1 *Antygomonas incommitata* Nebelsick, 1990

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3 Several individuals, juveniles and adults of both sex and of this species were found in coarse  
4 coralline debris mixed with mud, collected at 14 m water depth near Porto Cesareo, Taranto, South  
5 Italy (Sørensen et al., 2009, and personal communication). Strictly speaking, this is the first finding  
6 of the species in Italian waters (BZ 6, see below); however the species was originally described from  
7 the Bay of Vestar (Croatia), which falls within the boundaries of the BZ 9 of the biogeographic  
8 zones of the Italian seas. Consequently, we will include also the Croatian record in the updated  
9 version of the checklist (see below).  
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### 17 3.3. New data

18 A total of 29 species in nine genera and six families of Kinorhyncha were recorded from 16  
19 Italian localities mostly surveyed over the years 2004-2015 during research on meiofaunal organisms  
20 (see e.g., Dal Zotto et al., 2007, 2008; Guidi et al., 2011; Leasi and Todaro, 2010; Marotta et al.,  
21 2005; Todaro et al., 2004, 2006; see also Dal Zotto et al., 2016). Information about localities,  
22 environmental parameters and kinorhynch fauna are summarized in Tables 1-4. Information on each  
23 recorded species follows below.  
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32 Class ALLOMALORHAGIDA Sørensen, Dal Zotto, Rho, Herranz, Sánchez, Pardos and Yamasaki,  
33 2015  
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36 Family Neocentrophyidae Higgins, 1983  
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39 Genus *Paracentrophyes* Higgins, 1983  
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42 *Paracentrophyes quadridentatus* (Zelinka, 1928) (Figure 2)  
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44 We found specimens of this taxon in silty samples collected at 30-50 m depth from the Gulf of  
45 Castellammare (Sicily, loc.11 and 12.). The densities ranged from 1 to 4 ind./10 cm<sup>2</sup>. Previously, in  
46 Italy, the species was known for the Gulf of Naples (Zelinka, 1928). Outside Italy the species  
47 appears to be widespread along the Atlantic and North Sea coasts of Europe (Bamber 1989;  
48 McIntyre, 1962; Nyholm 1947; Sánchez et al., 2012). SEM survey of some of the Sicilian specimens  
49 revealed interesting details (e.g., number and position of sensory spots) useful for intraspecific  
50 comparisons and/or comparisons with the only two other species allocated in this genus.  
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1 During a recent survey, at about 100 m depth, in front of Leghorn (Ligurian Sea, loc. 3), we found a  
2 single female adult specimen of a *Paracentrophyes* whose morphological characters differ from the  
3 original description of *P. quadridentatus* (Zelinka, 1928) in showing, e.g., greater TL (500 vs 370  
4  $\mu\text{m}$ ), longer middorsal spine of segment 11 (75 vs 65  $\mu\text{m}$ ), and longer lateral terminal spines (126 vs  
5 96  $\mu\text{m}$ ). These morphometric features appear similar to those of *P. cf. quadridentatus* reported from  
6 Spain and from the Faroe islands (see Sørensen et al., 2010c).  
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12 Family Pycnophyidae Zelinka, 1896

13 Genus *Kinorhynchus* Sheremetevskij, 1974  
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18 *Kinorhynchus giganteus* Zelinka, 1908  
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20 This species has been found in the Northern Adriatic (Chioggia, loc. 14) and Tyrrhenian Sea (Gulf of  
21 Castellammare, loc. 11 and 12) and also in the Ligurian Sea (Leghorn, loc. 3). *K. giganteus*  
22 population densities were of up to 2 ind./10 cm<sup>2</sup> at Chioggia and Leghorn and up to 7 ind./10 cm<sup>2</sup> in  
23 the Gulf of Castellammare.  
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29 *Kinorhynchus* sp. 1  
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31 Three specimens of this taxon were found in the Upper Adriatic Sea, at Chioggia (loc. 14), in  
32 sediment made of coarse silt collected at 20-29 m water depth where salinity is about 30-32 psu. The  
33 presence of pointed middorsal processes, together with much shorter trunk length, clearly  
34 differentiate this species from *K. giganteus* and from *Kinorhynchus* sp. 2 (see below), the only two  
35 other species belonging to this genus known so far the Mediterranean Sea.  
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42 *Kinorhynchus* sp. 2  
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44 Two specimens of this taxon were found in silty sediment of the Northern Adriatic region, however,  
45 they were collected from the Vallona Lagoon (loc. 15), at 1-3 m depth, where salinity ranges from  
46 18 to 31 psu (ARPAV, 2011-2015). A smaller size, blunt middorsal processes, and presence of  
47 posterolateral indented margins of segment 10 are the main traits that distinguish this species from  
48 the other two congeners known from the Mediterranean Sea.  
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54 Genus *Pycnophyes* Zelinka, 1907  
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58 *Pycnophyes carinatus* Zelinka, 1928  
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1 This species has been found by us in the Gulf of Castellammare (Sicily, loc. 11 and 12), and  
2 previously in the Gulf of Naples by Zelinka (1928). Population densities were of up to 17 ind./10  
3 cm<sup>2</sup>. Recently the species has been reported from the Mediterranean coast of Spain (Sánchez *et al.*,  
4 2012). Some morphological details of our specimens, like the shape of tergal margin and lateral  
5 projections of the segment 1, appear somewhat different from those reported in the original  
6 description by Zelinka (1928) but similar to those reported in the Spanish specimens.  
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12 *Pycnophyes communis* Zelinka, 1908  
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14 We found this species in the Ligurian (loc. 3), Tyrrhenian (loc. 7, 11 and 12), and Northern Adriatic  
15 seas (loc. 14, 15 and 16). Previously it was known from the Gulf of Naples and Trieste (Zelinka,  
16 1928). Recently, this species has been found also in muddy sediment collected at 16 m depth near  
17 Ancona (Adriatic Sea, Southern boundary of the BZ 9; F. Semprucci and M.V. Sørensen, pers.  
18 comm.). *P. communis* appears as one of the most common Italian kinorhynch species, it inhabits  
19 subtidal muddy sediments down to 100 m. In contrast with its ample distribution, populations  
20 density of this taxon appears, at the investigated locations, relatively low, ranging from 1 to 2 ind./10  
21 cm<sup>2</sup>. A bit surprising was the discovery of this species from the Vallona Lagoon where salinity may  
22 be relatively low; however, the reported presence in the Baltic Sea (see Neuhaus 2013) should testify  
23 that *P. communis* is an eurhyaline species. Future study based on molecular markers could clear out  
24 doubts about the present of cryptic species in the currently recognized taxon, as some details of the  
25 specimens from the Vallona Lagoon seem to suggest.  
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38 *Pycnophyes flaveolatus* Zelinka, 1928  
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40 Four specimens resembling *P. flaveolatus* closely were found in the Vallona Lagoon (Northern  
41 Adriatic Sea, loc. 15). Differences with the specimens reported from the Gulfs of Trieste and Naples  
42 by Zelinka (1928) regard, for instance, the lateral terminal spines, which in our specimens are longer  
43 (130 µm vs 80-120 µm). Outside Italy, the species has been found in Germany (Kiel) and Sweden  
44 (west and East coast).  
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51 *Pycnophyes robustus* Zelinka, 1928 (Figure 3)  
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53 The species has been found in the Gulf of Castellammare (Sicily, loc. 11 and 12), showing  
54 population densities ranging from 1 to 3 ind./10 cm<sup>2</sup>. Previously it was known from the Gulfs of  
55 Naples and Trieste (Zelinka, 1928). Our SEM observations show for the first time the presence of  
56 spermatophore on a male specimen (Fig. 3C). Previously, spermatophores in Pycnophyidae were  
57 recorded only on female specimens (see Brown, 1983; Neuhaus and Higgins, 2002; Neuhaus, 2013).  
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1 *Pycnophyes rugosus* Zelinka, 1928

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3 Individuals ascribed to *P. rugosus* were found by us in the Ligurian Sea (Leghorn, loc. 3), even  
4  
5 though some morphological details differ from the original description. For example, the total body  
6  
7 length in our specimens appears longer (680  $\mu\text{m}$  vs 620  $\mu\text{m}$ ) compared to the specimens described  
8  
9 from the Gulf of Naples by Zelinka (1928). *P. rugosus* has so far been collected in Italian waters  
10  
11 only.

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13  
14 *Pycnophyes* sp. 1

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16 This species was found at Chioggia (Upper Adriatic sea, loc. 14); the general appearance approaches  
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18 that of *P. communis*, but in contrast with the latter species our specimens show e.g., longer lateral  
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20 terminal spines (ca. 130  $\mu\text{m}$  vs 70-100  $\mu\text{m}$ ).

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22  
23 *Pycnophyes* sp. 2

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25 Two specimens were collected from the Vallona Lagoon (Upper Adriatic Sea, loc. 15); the general  
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27 appearance is clearly different from that of *Pycnophyes* sp. 1 and approach more *P. robustus*; the  
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29 new species appears to be of a smaller size (trunk length ca. 530  $\mu\text{m}$  vs 570-640  $\mu\text{m}$ ) and to possess  
30  
31 shorter and thinner lateral terminal spines (180  $\mu\text{m}$  vs 210  $\mu\text{m}$ ).

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34 *Pycnophyes* sp. 3

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36 Specimens were found in silty sediment collected at about 100 m depth off Leghorn (Ligurian Sea,  
37  
38 loc. 3). The general appearance approaches that of *P. flaveolatus* but in contrast with the latter  
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40 species our specimens show e.g., much longer and stouter lateral terminal spines (ca. 170  $\mu\text{m}$  vs 80-  
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42 120  $\mu\text{m}$ ).

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45 Class CYCLORHAGIDA Sørensen, Dal Zotto, Rho, Herranz, Sánchez, Pardos and Yamasaki, 2015

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48 Order Echinorhagata Sørensen, Dal Zotto, Rho, Herranz, Sánchez, Pardos and Yamasaki, 2015

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51 Family Echinoderidae Bütschli, 1876

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53 Genus *Echinoderes* Clarapède, 1863

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56 *Echinoderes agigens* Băcescu, 1968

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58 We found several adults of *E. agigens* in silty sediment from the Northern Adriatic (Chioggia and  
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60 Cesenatico, loc. 14 and 16). The taxonomic status of this taxon is somewhat controversial. Huys and

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Coomans (1989) consider it as *species inquirenda* but Neuhaus (2013) listed it among the currently recognized species, and as an accepted species it is reported in the WoRMS database (<http://www.marinespecies.org/aphia.php?p=taxdetails&id=101103> accessed on 24 July 2015). We follow the latter author. Hopefully, our specimens will allow a more precise description this taxon including a the report of a certain morphological variability shown by Adriatic animals (e.g., a few recorded specimens lacked some of the lateral spines reported in the original description). This is the first record for the species in the Mediterranean Sea and outside its type locality, the Black Sea (Băcescu, 1968). The finding in the Northern Adriatic Sea can be related to the habitat characteristics, such as the relatively low salinity and other environmental features (sediment, etc.), resulting similar to those reported in the original description. A faunistic similarity between the Northern Adriatic and the Black Seas was observed also for other meiofaunal taxa, such as gastrotrichs (Todaro et al., 2003).

*Echinoderes capitatus* (Zelinka, 1928)

We found the species in the Northern Adriatic Sea (14. Chioggia), the Tyrrhenian Sea (Sicily: 11. Castellammare and 12. Trappeto), and the Ligurian Sea (3. Leghorn). The species was previously reported from the Gulfs of Naples and Trieste (Zelinka, 1928), hence our findings widen its geographic range and make the species one of the most common cyclorhagids along the Italian coastlines. In our samples population densities reached up to 184 ind./10 cm<sup>2</sup> at Castellammare (see Dal Zotto et al., 2016), 153 ind./10 cm<sup>2</sup> at Trappeto, and up to 5 ind./10 cm<sup>2</sup> at Chioggia and Leghorn. We noticed that some specimens from Sicily showed a number of characters in agreement with the original description by Zelinka (1928), and not with the details provided more recently by Nebelsick (1992). For instance, we observed 4 spines on segment 2, lateroventral spines on segments 5 and 8, paradorsal spines on segment 8, two small paradorsal spines on segment 10. In general the number of spines, especially on segment 8, appears to be lower than the one reported by Nebelsick (1992). The discrepancies between the original description by Zelinka (1928) and the redescription by Nebelsick (1992), together with the contrasting information reported by Adrianov and Malakhov (1999), who, for instance, refer to a dorsal spine on segment 4 only in an identification key, but not in the species description, stimulate some hypotheses. Probably the absence of dorsal spines derives from the accidental damaging of specimens (see Pardos et al., 1998). Alternatively, this taxon could either show a very high intraspecific variability, or represent a cluster of cryptic species. Further analyses are needed to resolve the doubts related to the morphology of this species. Molecular data from specimens of Adriatic and Tyrrhenian populations have been collected (see Dal Zotto, 2015)

1 and along with other kinorhynchs that are being gathered, they will be analyzed to evaluate intra-  
2 and interpopulation divergences.  
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5 *Echinoderes ferrugineus* Zelinka, 1928  
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7 This species, formerly known for the Adriatic Sea (Slovenia) and the Tyrrhenian Sea (Gulf of  
8 Naples, Zelinka, 1928), was found by us in Northern Adriatic Sea (Chioggia, loc. 14) and in  
9 Southern Tyrrhenian Sea (Sicily: Castellammare, loc. 11, and Trappeto, loc. 12). The densities of *E.*  
10 *ferrugineus* were of 1-3 ind./10 cm<sup>2</sup> at Chioggia, and of up to 81 ind./10 cm<sup>2</sup> in the Sicilian locations.  
11 Some of our specimens differ from the original description by Zelinka (1928), as the lateral spines  
12 on segment 9 are lacking, and the lateral terminal spines appear shorter. It should be stressed that the  
13 original (old) descriptions of some echinoderids can be rather approximate and confusing, as  
14 reported also by Higgins (1982), and this appears to be also the case for *E. ferrugineus* also.  
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23 *Echinoderes gerardi* Higgins, 1978  
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25 Our findings of *E. gerardi* in the southern Tyrrhenian Sea (Sicily: Castellammare, loc. 11, and  
26 Trappeto, loc. 12) represent the first records of the species in Italian waters (see also Dal Zotto et al.,  
27 2016). and the third ever for the taxon as specimens resembling *E. gerardi* have been recently  
28 reported from the Turkish coast (Sönmez et al., 2016). *E. gerardi* reached a maximum population  
29 density of 22 ind./10 cm<sup>2</sup> at Trappeto, and of 4 ind./10 cm<sup>2</sup> at Castellammare. Originally *E. gerardi*  
30 was discovered in the Gulf of Tunis (Tunisia) inside a poriferan (Higgins, 1978), while in our case it  
31 was found in silty sediment. Higgins (1985) suggested that most of the reports of *E. dujardinii* in the  
32 Mediterranean could actually represent misidentifications of *E. gerardi*; if so, our data indicate that  
33 misidentification may plague not only specimens associated with sponges (e.g., Mari and Morselli,  
34 1987) but also sediment dwellers.  
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45 *Echinoderes* sp. 1  
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47 This species has been found at Chioggia (loc. 14) in coarse silt at depths of 20-29 m, together with *E.*  
48 *agigens*, *E. capitatus*, and other species reported above. Size and general morphology resemble that  
49 of *E. setiger*, but the pattern of the lateroventral spines is quite different (e.g., spines on segments 8  
50 and 9 are lacking), and the length of lateral terminal accessory spines is much shorter.  
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56 *Echinoderes* sp. 2  
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58 This echinoderid has been found twice in the Ligurian Sea (Leghorn, loc. 2 and 3). Specimens are  
59 characterized by a combination of dorsal and lateroventral spines that resemble that of *E. dujardinii*,  
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1 but in contrast to the latter species, they exhibit the lateral accessory spines on segment 7 (not 8), and  
2 have much longer middorsal and lateral terminal spines.  
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4  
5 *Echinoderes* sp. 3  
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7 Specimens of this taxon have been found in the Ligurian Sea (Leghorn, loc. 3) in sympatry with the  
8 congeneric *E. capitatus* and *Echinoderes* sp. 2, and with several other species (see Table reported  
9 above). Among other morphological traits, *Echinoderes* sp. 3 bears dorsal spines on segments 5 to 8  
10 and has rather long lateral terminal spines. The sediment in which the species has been found is  
11 made up by fine sand-coarse silt and was collected at 100 m water depth.  
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18 *Echinoderes* sp. 4 (Figure 4)  
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20 Twenty-eight specimens of this echinoderid have been found off Grosseto (Tyrrhenian Sea,  
21 geographic area n. 2). This species, corresponding to *Echinoderes* sp. 5 in Dal Zotto et al. (2013) and  
22 Dal Zotto (2015), shows many characters in common with *E. peterseni*, reported from Disko Island,  
23 Greenland (Higgins and Kristensen, 1988). The Italian specimens differ from the polar species as  
24 they show a small middorsal spine and latero-subdorsal tubes on segment 2, and lack the ventral  
25 spines on the same segment. Furthermore, the lateral terminal spines and the middorsal spines appear  
26 longer in this taxon. Differences between the two species exist also concerning the microhabitats that  
27 hosts them. For instance, the Italian species inhabits coarser and deeper environment than the one  
28 characterizing the type locality of *E. peterseni* (medium sand at 37 m depth vs mud with rocks and  
29 pebbles covered with encrusting algae *Lithothamnium corallina* at 9 m depth). COI data from this  
30 taxon have been gathered (see Dal Zotto 2015) for possible future comparisons at molecular level.  
31 Published phylogenies based on molecular markers, confirm the distinctness of this taxon and of the  
32 two that follow below (Dal Zotto et al. 2013).  
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45 *Echinoderes* sp. 5  
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47 Two specimens of this species, were found in a medium-fine sandy sediment at a 7 m depth from  
48 Budelli Island (Sardinia, loc. 8). It shows some characters resembling *Echinoderes* sp. 4, but differs  
49 in having long middorsal spines on segments 4, 6, and 8, ventral tubes on segment 2, very long  
50 lateral terminal spines (ca. 150  $\mu$ m), and different shape of tergal extensions but, apparently, lacks  
51 the lateral accessory tubes on segment 8. This species is also reported as *E. sp. 6* in Dal Zotto et al.  
52 (2013). In the same sample was found also *Meristoderes macrachantus* (see below).  
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60 *Echinoderes* sp. 6  
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1 This species has been reported from two locations, namely Lo Scollione (Capraia Island, loc. 4) Le  
2 Bombarde (Sardinia, loc 10). In both case the specimens were found in medium sand, but collected  
3 at two different depths, 30 m and 1.5-3 m respectively. In the first case were found 2 specimens,  
4 while in the second 5 specimens were recorded, showing a possible preference for sandy sediments.  
5 One of the traits that characterizes this taxon is the presence of rather long middorsal spines on  
6 segments 5, 6 and 7. This taxon corresponds to *E. sp. 7* in Dal Zotto et al. (2013).  
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12 Genus *Meristoderes* Herranz, Thormar, Benito, Sánchez and Pardos, 2012  
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16 *Meristoderes macracanthus* Herranz, Thormar, Benito, Sánchez and Pardos, 2012 (Figure 5)  
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18 Three specimens of *M. macracanthus* were found in a 500 ml sandy sample collected in 2009 from  
19 the sublittoral (-7 m) of the famous pink beach of Budelli Island (Sardinia, loc. 8). In the same  
20 sample there was also *Echinoderes* sp. 6. As reported above, additional specimens of this taxon have  
21 been collected in 2010 from the same island, as reported by Herranz et al. (2012).  
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25 Three more specimens of *M. macracanthus* have been found in a peculiar habitat: the Nereo Cave  
26 located at about 20 m depth, near Capo Caccia (Sardinia, loc. 9). The reports of kinorhynchs from  
27 troglolobial habitats are very few (e.g., Sørensen et al., 2000). Cave sediments have been considered  
28 biodiversity hotspots for other meiofaunal taxa (e.g., priapulids: Todaro and Shirley, 2003;  
29 gastrotrichs: Todaro et al., 2006; tardigrades: Villora-Moreno, 1996).  
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36 Order Kentrorhagata Sørensen, Dal Zotto, Rho, Herranz, Sánchez, Pardos and Yamasaki, 2015  
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39 Family Antygomonidae Adrianov and Malakhov, 1994  
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41 Genus *Antygomonas* Nebelsick, 1990  
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43 *Antygomonas caeciliae* Dal Zotto, 2015  
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45 Beside the original record (2008, see above), 12 specimens of this species have been found again at  
46 the Meloria Shoals (loc. 1), in 2009 in medium to coarse biogenic sediment, collected at 5-7 m water  
47 depth. Furthermore, some specimens resembling *A. caeciliae* have been collected from the nearby  
48 island of Pianosa (loc. 5), in medium to fine sand at 6-7 m.  
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54 *Antygomonas incommitata* Nebelsick, 1990  
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56 Specimens of this species have been found by us in the Ligurian, Tyrrhenian and Ionian Sea (loc. 1,  
57 5 and 13 respectively), in sediment types ranging from fine to coarse sand, collected at different  
58 water depths (2-7 m). *A. incommitata* has been found in sympatry with *A. caeciliae* at the Meloria  
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1 Shoals and at the near Pianosa Island. Considering the information from Nebelsick (1990) and  
2 Sørensen et al. (2009), the species appears to be widely distributed along the Italian coasts, and  
3 apparently not restricted to any specific type of sediment, as long as it is made of clean sand (i.e.,  
4 without mud).  
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9 Family Centroderidae Zelinka, 1896

10 Genus *Centroderes* Zelinka, 1907

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14 *Centroderes spinosus* (Reinhardt, 1881)

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16 We found this species at Chioggia (loc. 14), in sediment made of coarse silt, collected at 20-30  
17 meters depth, where it reached densities up to 2 ind./10 cm<sup>2</sup>. In Italy the species was previously  
18 reported for the Gulf of Trieste and, as *C. eisigii*, in the Gulf of Naples (Zelinka, 1928).  
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23 Genus *Condyloderes* Higgins, 1969

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27 *Condyloderes* sp. 1 (Figure 6)

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29 This is the first time that species of the genus *Condyloderes* Higgins, 1969 are reported from the  
30 Mediterranean Sea, and the third time from European waters (McIntyre, 1962; Sánchez et al., 2012).  
31 We found several specimens (densities ranging from 1 to 6 ind./10 cm<sup>2</sup>) of this taxon in Sicily  
32 (Lower Tyrrhenian sea, loc. 11 and 12) while engaged in studies monitoring the effects of some fish  
33 farms on meiofauna (see e.g., Dal Zotto et al., 2016). *Condyloderes* sp. 1 shows several  
34 morphological traits (e.g., number and position of cuspidate spines: paradorsal ones on segments 3  
35 and 7, subdorsal on segment 7, couples of lateroventral ones on segments 2, 8, and 9, and ventral  
36 cuspidate spines on segment 5), which clearly differentiate it from the other congeneric species.  
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46 *Condyloderes* sp. 2

47 We found a second apparently new species of *Condyloderes* at Leghorn (Ligurian Sea, loc. 3) and in  
48 sympatry with *Condyloderes* sp. 1 in Sicily (loc. 12). Specimens of this taxon resemble *C.*  
49 *multispinosus* (McIntyre, 1962) in the general morphology but seem to differ from it in some details  
50 (e.g., length of midterminal spine and lateral terminal spines, etc.). Additional specimens and further  
51 analyses will better clarify the taxonomic status of these kinorhynchs. In contrast with the relative  
52 high abundance showed by *Condyloderes* sp. 1 in the Gulf of Castellammare, *Condyloderes* sp. 2  
53 was quite rare, both in this area (only two specimens found) as well as at Leghorn (four specimens).  
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1 The wider distribution range of this taxon registered during our studies indicated that distribution  
2 sometimes is decupled from abundance.  
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5 Family Semnoderidae Remane, 1929

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7 Genus *Semnoderes* Zelinka, 1907  
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10 *Semnoderes armiger* Zelinka, 1928

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12 This is the only species reported for the family. *S. armiger* has been found from Leghorn,  
13 Castellammare, Trappeto, and Chioggia (loc. 3, 11, 12, 14), where it has reached densities of 1-8  
14 ind./10 cm<sup>2</sup>. Originally reported by Zelinka (1928) from the Gulf of Trieste (Upper Adriatic Sea)  
15 our findings in locations 3, 11 and 12, greatly widens the Italian distribution to include now also the  
16 Ligurian Sea and the Tyrrhenian Sea. Outside Italy the species has been reported from the  
17 Mediterranean Spain, the Black Sea, and several localities in the North-eastern Atlantic Ocean,  
18 making it one of the most widely distributed kinorhynch species in Europe (Băcescu, 1968;  
19 Neuhaus, 2013; Sánchez et al., 2012). As far as the microhabitat concerns, *S. armiger* inhabits  
20 several kinds of sediments, from coarse sand to mud, and it has been collected at depths ranging  
21 from 15 to more than 300 m (Sánchez et al., 2012).  
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### 32 3.4. Remarks on the new data

#### 33 3.4.1. Fauna

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35 The analyses of samples from 16 new or newly investigated locations yielded 6 families, 9  
36 genera, and 29 species, of which only 14 were previously recorded from peninsular waters (Figure 7,  
37 Table 2). Overall, we registered one new genus (*Condyloderes*) and two new species records for  
38 Italy, together with 13 additional species that appear new to science. Particularly interesting is the  
39 finding of two new species of the rare genus *Condyloderes*, as it represents the first records of this  
40 taxon in the Mediterranean Sea.  
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47 Most of the species found in this study belong to the genera *Echinoderes* and *Pycnophyes*;  
48 this datum is not surprising since these taxa are the most species-rich in the phylum. The most  
49 common species is the allomaloragidan *Pycnophyes communis* reported from seven localities out of  
50 16: almost half of the surveyed locations. The most common cyclorhagidan was *Echinoderes*  
51 *capitatus* (four localities), which is also the species reaching the highest abundances (184 ind./10  
52 cm<sup>2</sup> at Castellammare, location 11). Details on abundance of the latter species in the Sicilian  
53 locations are reported in a dedicated paper (Dal Zotto et al., this volume).  
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Considering the relatively low number of surveyed localities and the low species richness reported (ca. 3.6 species/site), it is noticeable that almost half of the recorded species appear to be new to science. The only previous extensive studies carried out in the Italian waters focused on the Gulfs of Trieste and Naples (Zelinka, 1928). A survey of the Gulf of Naples was recently repeated, even though only partial results have been published so far (Sánchez, 2015). Two of our sampling locations in the Gulf of Castellammare (Sicily, loc. 11 and 12) show characteristics (sediment type and water depth) similar to the Tyrrhenian sites visited by Zelinka; so it is not surprising that here we found eight species out of 11 (12 if data by Sánchez, 2015 are considered) previously reported from Naples.

By contrast, in the Upper Adriatic Sea, we found many additional species (6) not reported by Zelinka (1928). Likely this is related to the habitats we have sampled, that appear quite different from those investigated by Zelinka. In fact, our three collecting locations are situated relatively south compared to Zelinka's sites; yet, they are most likely affected by the largest Italian waterways, the Po River, and one is positioned inside a lagoon. By contrast, the locations sampled by Zelinka are restricted in the uppermost portion of the northern Adriatic Sea, in a more confined area.

Additional new species and/or species new to the Italian waters were from areas (Ligurian Sea) or habitat not investigated before e.g.: deep sediment of the Ligurian Sea, the medium-coarse sand from Sardinia and Capraia islands or the sandy sediment from the submarine Nereo Cave.

Besides the putative new taxa, it is worth noting that 14 out the 20 previously known species have been found also during our investigations, even though some of the recorded specimens show details not reported from the original material e.g., *Pycnophyes flaveolatus* and *P. rugosus* (see above). Ongoing and future taxonomic analyses including specimens from other areas and the type localities will clear out the uncertainties.

Combining our new data with the accepted species (i.e. *nomina dubia* excluded) by Zelinka (1928) the number of know species from the Italian waters amount to 37 (see Table 5), of which 22 are formally described (Figures 8,9), and 15 will be described at the end of the ongoing taxonomic survey.

### 3.4.2. Ecological remarks

With regards to the bathymetry, most of the samples analyzed during our research were from relatively shallow coastal waters, less than 50 m deep; however the numerous samples (> 100 cores) from Leghorn (loc. 3) are much deeper (90-130 m) providing an ample bathymetric range.

Considering the scanty information about the basic ecology of the Kinorhyncha, our information

1 may turn out to be insightful with regard to a possible depth preference of the species found.

2 Consequently, based on the depth at which the samples were taken, we subjectively subdivided the  
3 recorded fauna into four water depth intervals: 1-9, 10-29, 30-50, 90-130 m. The distribution of  
4 species by depth interval is shown in Table 3.  
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7 Ten species in six genera (*Condyloderes*, *Semnoderes*, *Echinoderes*, *Paracentrophyes*,  
8 *Kinorhynchus*, and *Pycnophyes*) appeared in samples from deeper waters (>90 m), though only four  
9 of them were exclusively found in this habitat, namely: *Echinoderes* sp. 2, *Echinoderes* sp. 3,  
10 *Pycnophyes* cf. *rugosus*, and *Pycnophyes* sp. 3. Three out of four species seem new to science; this  
11 feature stresses the potentially high kinorhynch diversity in deep waters and at the same time the  
12 scarce knowledge about this fauna in the Italian waters. Of the remaining six species found at 90-  
13 130 m depth, five (*Condyloderes* sp. 2, *Echinoderes capitatus*, *Paracentrophyes quadridentatus*,  
14 *Kinorhynchus giganteus*, and *Pycnophyes communis*) have a depth range that includes also  
15 shallower waters (see Neuhaus, 2013 and Table 3) while one, *Semnoderes armiger*, has been  
16 reported mostly from shallow waters (Sánchez et al., 2012; Sørensen et al., 2009) and rarely from  
17 water depths below 100 m (see Sánchez et al., 2012). Six species found during our surveys occurred  
18 only at 30-50 m depth, namely *Condyloderes* sp. 1, *Echinoderes ferrugineus*, *E. gerardi*,  
19 *Echinoderes* sp. 4, *Pycnophyes carinatus*, and *P. robustus*. However, previous records indicate that  
20 these taxa are not restricted to this bathymetric range. For example, *E. gerardi* was known for  
21 shallow waters sponges (Higgins, 1978), and was recently reported from intertidal algal washing  
22 (Sönmez et al., 2016), whilst *E. ferrugineus* was previously reported from 1 to 35 m (Zelinka,  
23 1928); *P. carinatus* and *P. robustus* were found at 12-35 m and 17-35 m. respectively (Sánchez et  
24 al., 2012; Zelinka, 1928).  
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28 Other five species were found only at 10-29 m depth: *Centroderes spinosus*, *Echinoderes*  
29 *agigens*, *Echinoderes* sp. 1, *Kinorhynchus* sp. 1, *Pycnophyes* sp. 1, with *C. spinosus* previously  
30 found in several locations at similar depths (e.g., Gulf of Naples, 35 m; Zelinka, 1928), while *E.*  
31 *agigens* was known previously for depths down to 60 m, in the Black Sea type locality (Bâcescu,  
32 1968).  
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36 Six species occurred only in our shallower samples (<10 m): *Antygomonas caeciliae*, *A.*  
37 *incomitata*, *Echinoderes* sp. 5, *Kinorhynchus* sp. 2, *P. cf. flaveolatus*, *Pycnophyes* sp. 2. For some  
38 of them, our records confirm previous findings and could indicate a potential preference for this  
39 depth. Nonetheless, *P. flaveolatus* was reported at greater depths (17-35 m; Zelinka, 1928),  
40 similarly to *A. incomitata* which has been recorded from 2-25 m deep sediments (Nebelsick, 1990;  
41 Sánchez et al., 2012; Sørensen et al., 2009).  
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1 *Meristoderes macracanthus* was reported from both shallower samples and greater depth  
2 ones (10-29 m). The latter samples were collected in a submarine cave (Nereo Cave, loc. 9),  
3 characterized by relatively coarse sediment (medium-fine sand, see below), not very different in  
4 terms of granulometry from the shallower site's one (Budelli Island, loc. 8). Previously, Herranz et  
5 al. (2012) reported this species from 11-37 m deep sandy sediments. It is likely that the sediment  
6 type influences the presence of this taxon more than depth.  
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10 To summarize, the depth range showing the highest species richness was 90-130 m (5.0  
11 species/site), followed by the depth intervals 30-50 m (3.2 species/site), 10-29 m (3.0 species/site),  
12 and finally 1-9 m (1.3 species/site). These results underline a scarce diversity of kinorhynchs in  
13 shallow waters, and, by contrast, a high richness in deeper habitats.  
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18 The distribution of species in function of the sediment type is summarized in Table 4. Most  
19 species (23 out of 29 spp.) were found in very fine sand/coarse silt; it should be emphasized that  
20 associated to our finer sediments there was always a fraction of clay, hence confirming literature  
21 data describing the Kinorhyncha (mud dragons) as being mostly mud dwelling animals (see  
22 Neuhaus, 2013). Six species occurred only in coarser sediment (fine to coarse sand), namely:  
23 *Antygomonas caeciliae*, *A. incomitata*, *Echinoderes* sp. 4, *Echinoderes* sp. 5, *Echinoderes* sp. 6, and  
24 *Meristoderes macracanthus*. Considering the relatively high number of locations characterized by  
25 this sediment type (7 out of 16) the associated species richness is very low (ca. 0.9 species/site). By  
26 contrast, the locations showing very fine sand/coarse silt generally yielded a much higher species  
27 richness (ca. 2.6 species/site). Again, the datum confirms results from previous studies accounting  
28 for a higher species richness associated with muddy sediments compared to the clean, sandy  
29 bottoms (Neuhaus, 2013).  
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40 At a genus level our study confirms that *Antygomonas* tends to be restricted to clean sandy  
41 sediments, while *Echinoderes* appears to be polytopic; however the finding of three putative new  
42 species, belonging to this genus, associated with clean sand (Table 1) calls for additional surveys in  
43 localities characterized by this kind of substratum.  
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47 It must be noted for the context that the present knowledge on kinorhynch ecology doesn't  
48 allow to discriminate clearly between depth and sediment type. As these two features are generally  
49 correlated, it could be possible to observe an apparent species-depth correlation, whilst actually it  
50 would be a species-sediment type one.  
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### 56 3.4 Geographic distribution of the Italian Kinorhyncha 57 58 59 60 61 62 63 64 65

1 Notwithstanding the addition of new 16 locations, the number of Italian localities  
2 investigated for the kinorhynch fauna remains limited. Furthermore, a large portion of the  
3 peninsular coastline appears virtually unexplored, notably: the Mid Tyrrhenian, Ionian, Mid and  
4 Southern Adriatic. Consequently, any discussion about geographic distribution if based on the 9  
5 marine biogeographic zones recognized by the Italian checklist of marine species (see Relini and La  
6 Posta, 2005) would be particularly confounding. At this early stage, a discussion about the  
7 biogeographic distribution based on the sea basins appears more appropriate. Hence, of the 36  
8 species known for the Italian waters some appear to be: i) restricted to a single basin: eight  
9 exclusively of the Adriatic Sea: *Echinoderes agigens*, *E. setiger*, *E. subfuscus*, *Echinoderes* sp. 1,  
10 *Kinorhynchus* sp. 1, *Kinorhynchus* sp. 2, *Pycnophyes* sp. 1, and *Pycnophyes* sp. 2. Three found only  
11 in the Ligurian Sea: *Echinoderes* sp. 2, *Echinoderes* sp. 3, *Pycnophyes* sp. 3. Ten peculiar of the  
12 Tyrrhenian Sea: *Condyloderes* sp. 1, *Echinoderes citrinus*, *E. ferrugineus*, *E. gerardi*, *Echinoderes*  
13 sp. 4, *Echinoderes* sp. 5, *Meristoderes macracanthus*, *Pycnophyes echinoderoides*, *P. ponticus*, *P.*  
14 *zelinkaiei*; ii) present in two basins (ten): *Centroderes spinosus*, *Echinoderes dujardinii*, *Pycnophyes*  
15 *carinatus*, *P. flaveolatus*, and *P. robustus* are present in the Adriatic and Tyrrhenian Seas;  
16 *Antygomonas caeciliae*, *Condyloderes* sp. 2, *Echinoderes* sp. 6, *Paracentrophyes quadridentatus*,  
17 and *Pycnophyes rugosus* are present in the Tyrrhenian and Ligurian Seas, and iii) virtually  
18 ubiquitous (five): *Antygomonas incomitata*, *Semnoderes armiger*, *Echinoderes capitatus*,  
19 *Kinorhynchus giganteus*, and *Pycnophyes communis*.

20 More than half of the Italian species (21 out of 36) appears to be restricted to a single Italian  
21 sea basin, moreover, 11 of these taxa appear new to science. Consequently, one could think that the  
22 greatest part of the Italian kinorhynch diversity is due to species with a restricted geographic range.  
23 However, as 8 of the known species recorded for a single Italian basin have been found also outside  
24 Italy, it is likely that the range of the putative new species will be widened in the future.

25 One out of 36 species known for the country has been reported from all the four Italian  
26 basins: *A. incomitata*, found by us in the Ligurian, Tyrrhenian, and Ionian Sea and by Nebelsick  
27 (1990) in the Adriatic Sea. Additional four species may also be considered ubiquitous, *Semnoderes*  
28 *armiger*, *Echinoderes capitatus*, *Kinorhynchus giganteus*, and *Pycnophyes communis*, as the  
29 apparent absence of these species from the Ionian Sea is likely due to the fact that only a single  
30 location (two, if the study by Sørensen et al., 2009 is included) has been surveyed in this sea and  
31 moreover the investigated sediment was made up of sand, and not of the finer type inhabited by  
32 these species.

33 In absolute values the richest basin in terms of number of species appears to be the  
34 Tyrrhenian, followed by the Adriatic, the Ligurian, and finally by the Ionian Sea, with 25, 19, 13

1 and 1 species, respectively. However, if the effort of sampling (i.e., number of investigated  
2 locations by us, Sánchez, 2015, and Zelinka, 1928) is taken into account, the Ligurian basin stands  
3 out as the richest (4 locations; 3.2 species/site), followed by the Ionian Sea (1 location; 1.0  
4 species/site), the Tyrrhenian Sea (27 locations; 0.9 species/site), and finally the Adriatic Sea (23  
5 locations, 0.8 species/site). The richness of Ligurian Sea in terms of kinorhynch fauna is highlighted  
6 by this datum, which encourages further analyses within this basin. It must be noted for the context  
7 that 4 out of 8 locations surveyed by us in the Tyrrhenian basin yielded single species, which is  
8 likely to be related to the sediment type at these sites and also to the fact that samples often were not  
9 specifically collected for the study of the Kinorhyncha. The Ionian Sea seems to be characterized by  
10 a low kinorhynch diversity, however, it is anticipated that future investigation of deeper and finer  
11 sediments most likely will reveal a much richer fauna.  
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#### 22 **4. Conclusion**

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25 Prior to this study, the number of the Italian Kinorhyncha summed to 48 (Sandulli and de Zio  
26 Grimaldi, 2008); however, a careful taxonomic revision of the taxa reported in the previous checklist  
27 revealed that 31 of them were in fact to be considered *nomina dubia* and hence of doubtful  
28 utility/application. These names were eliminated from the update checklist, and the remaining 17  
29 taxa were accompanied with 19 further species reported in published papers but mainly found during  
30 our studies. All together the new checklist of Italian kinorhynchs includes 36 species in 9 genera and  
31 6 families, more or less equally subdivided between the newly recognized Classes Allomalorhagida  
32 and Cyclorhagida.  
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40 Thirteen out of the 36 species appear new to science and will be described in forthcoming  
41 papers. Several interesting taxa were found in areas not previously investigated, and often  
42 characterized by peculiar habitats, such as submarine caves, lagoons, and coarse sediments. This  
43 study confirms the existence of a relatively high kinorhynch diversity along the Italian coasts, and  
44 encourage further surveys in the peninsular waters, with a particular focus on neglected habitats,  
45 often representing biodiversity hotspots. Along with qualitative sampling, quantitative surveys are  
46 particularly encouraged in order to obtain those basic ecological information. This is crucial to  
47 improve our understanding of the fascinating mud dragons – something that this study has provided  
48 only to a limited extend.  
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**Fig. 1.** Map of Italy and surrounding seas, with indication of the nine marine biogeographic zones proposed by Relini and La Posta (2005) for the checklist of the Italian marine biota. Numbers in the circles identify the 16 locations investigated during the present study. See text for further details.

**Fig. 2.** *Paracentrophyes quadridentatus*, adult females from the Gulf of Casellammare (Sicily). SEM photomicrographs. **A**, habitus with the introvert retracted, ventrolateral view; **B**, different specimen, close up of the introvert. oos, outer oral styles; ps, primary spinoscalids.

**Fig. 3.** *Pycnophyes robustus*, adult male from the Gulf of Castellammare (Sicily). SEM photomicrographs. **A**, habitus with the introvert retracted, ventrolateral view; **B**, close up of the anterior segments; **C**, close up of posterior region showing a spermatophore. spp, spermatophore; vt, ventral tubes.

**Fig. 4.** *Echinoderes* sp. 5, adult female from Le Formiche di Grosseto (Tuscany, Tyrrhenian Sea). DIC photomicrographs. **A**, dorsal view; **B**, close up of segments 2-5 in ventral view; **C**, close up of segments 1-2 in dorsal view. mds, middorsal spine.

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**Fig. 5.** *Meristoderes macracanthus*, adult female from the submarine Nereo Cave (Sardinia). SEM photomicrographs. **A**, habitus, ventro-lateral view; **B**, close up of the introvert. ios, inner oral styles; oos, outer oral styles; ps, primary spinoscalids.

**Fig. 6.** *Condyloderes* sp. 1, adult female from the Gulf of Castellammare (Sicily). DIC photomicrographs. **A**, ventral view; **B**, close up of the trunk showing an oocyte; **C**, close up of segments 9-11. go, gonopores; ltas, lateral terminal accessory spine; mts, midterminal spine; oo, oocyte.

**Fig. 7.** Number of species and genera found in the 16 locations investigated during the present study.

**Fig. 8.** Italian Kinorhyncha; drawings of the described Allomalorhagida. **Neocentrophyidae: 1**, *Paracentrophyes quadridentatus*; **Pycnophyidae: 2**, *Kinorhynchus giganteus*; **3**, *Pycnophyes carinatus*; **4**, *Pycnophyes communis*; **5**, *Pycnophyes echinoderoides*; **6**, *Pycnophyes flaveolatus*; **7**, *Pycnophyes ponticus*; **8**, *Pycnophyes robustus*; **9**, *Pycnophyes rugosus*; **10**, *Pycnophyes zelinkaei*. (**1-4,6-10** modified from Adrianov and Malakhov, 1999; **5** modified from Zelinka, 1928).

**Fig. 9.** Italian Kinorhyncha; drawings of the described Cyclorhagida. **Antygomonidae: 1**, *Antygomonas caeciliae*; **2**, *Antygomonas incomitata*; **Centroderidae: 3**, *Centroderes spinosus*; **Echinoderidae: 4**, *Echinoderes agigens*; **5**, *Echinoderes capitatus*; **6**, *Echinoderes citrinus*; **7**, *Echinoderes dujardinii*; **8**, *Echinoderes ferrugineus*; **9**, *Echinoderes gerardi*; **10**, *Echinoderes setiger*; **11**, *Echinoderes subfuscus*; **12**, *Meristoderes macracanthus*; **Semnoderidae: 13**, *Semnoderes armiger*. (**1** modified from Dal Zotto, 2015; **2** modified from Sørensen et al., 2010b, 2008; **3** modified from Sørensen and Pardos, 2008; **4,6,8,10** modified from Adrianov and Malakhov, 1999; **5** modified from Nebelsick, 1992; **7** modified from Higgins, 1985; **9** modified from Higgins, 1978; **11** modified from Zelinka, 1928; **12** modified from Herranz et al., 2012; **13** modified from Sørensen et al., 2009).

**Table 1** – Sixteen new or newly sampled Italian locations. The geographic coordinates, water depth, sediment type and date of sampling are reported. Numbers in brackets indicate the biogeographic zone in which the Italian seas are partitioned (Figure 1), according to the checklist of Italian marine species (Relini and La Posta, 2005).

LOCATION (BIOGEOGRAPHIC ZONE)	COORDINATES	DEPTH (m)	SEDIMENT TYPE	DATE
<b>Ligurian Sea</b>				
1. Meloria Shoals (1)	43°32'50.06'' N, 10°12'58.80'' E	2-7	Coarse sand	10/2008
2. Leghorn 1 (1)	43°37'49.31'' N, 10°08'24.18'' E	105-110	Fine sand-coarse silt	07/1996
3. Leghorn 2 (1)	43° 37' 58,50'' N, 9° 59' 31,6'' E	97-130	Fine sand-coarse silt	08/2012 – 09/2015
4. Lo Scollione, Capraia (1)	43°02'01.46'' N, 09°43'52.64'' E	30	Medium sand	05/2007
<b>Tyrrhenian Sea</b>				
5. P.ta del Marchese, Pianosa (2)	42°36'00.34'' N, 10°05'46.76'' E	6-7	Medium-fine sand	06/2004
6. Formiche di Grosseto (2)	42°34'43.12'' N, 10°52'56.77'' E	37	Medium sand	06/2009
7. Gulf of Follonica (2)	42°53'41.50'' N, 10°46'51.20'' E	3-8	Fine sand-coarse silt	06/2010
8. Budelli Island, Sardinia (2)	41°16'45.62'' N, 09°21'21.74'' E	7	Medium-fine sand	09/2009
9. Nereo Cave, Sardinia (2)	40°34'10.50'' N, 08°10'02.90'' E	20	Medium sand	07/2005
10. Le Bombarde, Sardinia(2)	40°35'02.00'' N, 08°15'37.90'' E	1,5-3	Medium sand	07/2005
11. Castellammare, Sicily (3)	38°02'58.00'' N, 12°52'97.00'' E	35-50	Fine sand-coarse silt	06/2006 – 12/2007
12. Trappeto, Sicily (3)	38°04'51.79'' N, 13°01'19.45'' E	30-40	Fine sand-coarse silt	06/2006 – 01/2008
<b>Ionian Sea</b>				
13. Porto Cesareo (6)	40°13'09.10'' N, 17°55'35.50'' E	2	Medium-fine sand	06/2005
<b>Adriatic Sea</b>				
14. Chioggia (9)	45°05'74.01'' N, 12°35'82.59'' E	20-29	Coarse silt	06/2011 – 07/2015
15. Vallona Lagoon (9)	45°02'05.32'' N, 12°23'25,72'' E	1-3	Coarse silt	06/2011 – 07/2015
16. Cesenatico (9)	44°13'14.00'' N, 12°28'61.00'' E	11-12	Coarse silt	10/2008

**Table 2** – Kinorhynch species list and distribution in the 16 investigated locations and four sea basins.

Taxon	Location	Ligurian Sea				Tyrrhenian Sea								Ionian Sea		Adriatic Sea	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<b>ALLOMALORHAGIDA</b>																	
<b>NEOCENTROPHYIDAE</b>																	
<i>Paracentrophyes quadridentatus</i>		-	-	+	-	-	-	-	-	-	-	+	+	-	-	-	-
<b>PYCNOPHYIDAE</b>																	
<i>Kinorhynchus giganteus</i>		-	-	+	-	-	-	-	-	-	-	+	+	-	+	-	-
<i>Kinorhynchus</i> sp. 1		-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
<i>Kinorhynchus</i> sp. 2		-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
<i>Pycnophyes carinatus</i>		-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-
<i>Pycnophyes communis</i>		-	-	+	-	-	-	+	-	-	-	+	+	-	+	+	+
<i>Pycnophyes robustus</i>		-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-
<i>Pycnophyes</i> cf. <i>flaveolatus</i>		-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
<i>Pycnophyes</i> cf. <i>rugosus</i>		-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Pycnophyes</i> sp. 1		-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
<i>Pycnophyes</i> sp. 2		-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
<i>Pycnophyes</i> sp. 3		-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>CYCLORHAGIDA</b>																	
<b>ANTYGOMONIDAE</b>																	
<i>Antygomonas caeciliae</i>		+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Antygomonas inomitata</i>		+	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-
<b>CENTRODERIDAE</b>																	
<i>Centroderes spinosus</i>		-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
<i>Condyloderes</i> sp. 1		-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-
<i>Condyloderes</i> sp. 2		-	-	+	-	-	-	-	-	-	-	-	+	-	-	-	-
<b>ECHINODERIDAE</b>																	
<i>Echinoderes agigens</i>		-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+
<i>Echinoderes capitatus</i>		-	-	+	-	-	-	-	-	-	-	+	+	-	+	-	-
<i>Echinoderes ferrugineus</i>		-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-
<i>Echinoderes gerardi</i>		-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-
<i>Echinoderes</i> sp. 1		-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
<i>Echinoderes</i> sp. 2		-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Echinoderes</i> sp. 3		-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Echinoderes</i> sp. 4		-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>Echinoderes</i> sp. 5		-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
<i>Echinoderes</i> sp. 6		-	-	-	+	-	-	-	-	+	-	-	-	-	-	-	-
<i>Meristoderes macracanthus</i>		-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-
<b>SEMNERIDAE</b>																	
<i>Semneres armiger</i>		-	-	+	-	-	-	-	-	-	-	+	+	-	-	-	-
<b>Total number of species</b>		<b>2</b>	<b>1</b>	<b>10</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>10</b>	<b>11</b>	<b>1</b>	<b>8</b>	<b>4</b>	<b>2</b>

+, species present; - species absent

**Table 3** – Species found during our research listed according to depth ranges.

DEPTH (m)	LOCATION	SPECIES
1-9	1, 5, 7, 8, 10, 13, 15	<i>Antygomonas caeciliae</i> ; <i>Antygomonas inomitata</i> ; <i>Echinoderes</i> sp. 5; <i>Echinoderes</i> sp. 6; <i>Meristoderes macracanthus</i> ; <i>Kinorhynchus</i> sp. 2; <i>Pycnophyes communis</i> ; <i>Pycnophyes</i> cf. <i>flaveolatus</i> ; <i>Pycnophyes</i> sp. 2
10-29	9, 14, 16	<i>Centroderes spinosus</i> ; <i>Echinoderes agigens</i> ; <i>Echinoderes capitatus</i> ; <i>Echinoderes</i> sp. 1; <i>Meristoderes macracanthus</i> ; <i>Kinorhynchus giganteus</i> ; <i>Kinorhynchus</i> sp. 1; <i>Pycnophyes communis</i> ; <i>Pycnophyes</i> sp. 1
30-50	4, 6, 11, 12	<i>Condyloderes</i> sp. 1; <i>Condyloderes</i> sp. 2; <i>Semnoderes armiger</i> ; <i>Echinoderes capitatus</i> ; <i>Echinoderes ferrugineus</i> ; <i>Echinoderes gerardi</i> ; <i>Echinoderes</i> sp. 4; <i>Echinoderes</i> sp. 6; <i>Paracentrophyes quadridentatus</i> ; <i>Kinorhynchus giganteus</i> ; <i>Pycnophyes carinatus</i> ; <i>Pycnophyes communis</i> ; <i>Pycnophyes robustus</i>
90-130	2, 3	<i>Condyloderes</i> sp. 2; <i>Semnoderes armiger</i> ; <i>Echinoderes capitatus</i> ; <i>Echinoderes</i> sp. 2; <i>Echinoderes</i> sp. 3; <i>Paracentrophyes quadridentatus</i> ; <i>Kinorhynchus giganteus</i> ; <i>Pycnophyes communis</i> ; <i>Pycnophyes</i> cf. <i>rugosus</i> ; <i>Pycnophyes</i> sp. 3

**Table 4** – Species found during our research grouped according to the sediment type.

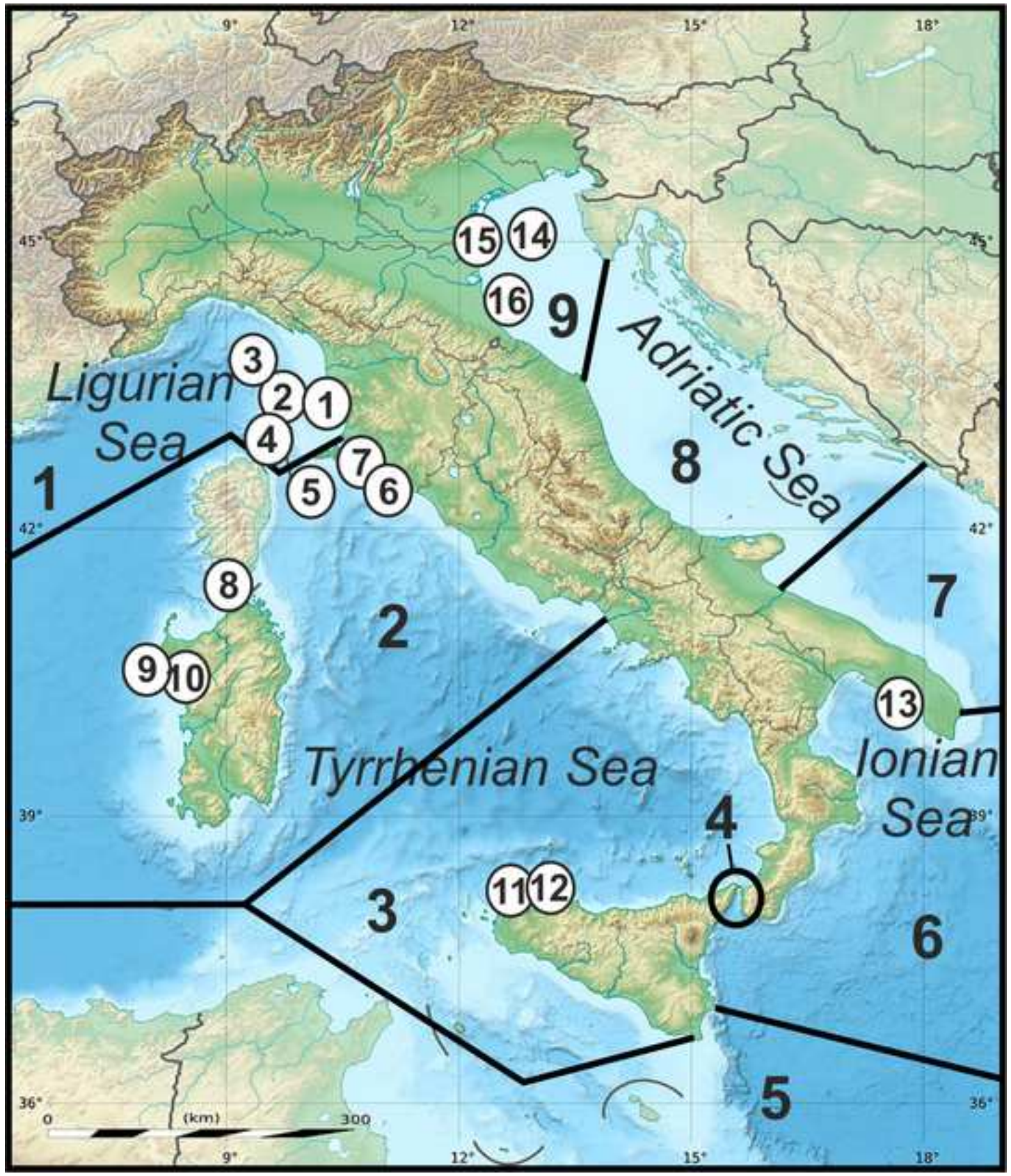
SEDIMENT TYPE	LOCATION	SPECIES
<b>Coarse sand</b>	1	<i>Antygomonas caeciliae</i> ; <i>Antygomonas incommitata</i>
<b>Medium/fine sand</b>	4, 5, 6, 8, 9, 10, 13	<i>Antygomonas caeciliae</i> ; <i>Antygomonas incommitata</i> ; <i>Echinoderes</i> sp. 4; <i>Echinoderes</i> sp. 5; <i>Echinoderes</i> sp. 6; <i>Meristoderes macracanthus</i>
<b>Very fine sand/ coarse silt</b>	2, 3, 7, 11, 12, 14, 15, 16	<i>Centroderes spinosus</i> ; <i>Condyloderes</i> sp. 1; <i>Condyloderes</i> sp. 2; <i>Semno deres armiger</i> ; <i>Echinoderes agigens</i> ; <i>Echinoderes capitatus</i> ; <i>Echinoderes ferrugineus</i> ; <i>Echinoderes gerardi</i> ; <i>Echinoderes</i> sp. 1; <i>Echinoderes</i> sp. 2; <i>Echinoderes</i> sp. 3; <i>Paracentrophyes quadridentatus</i> ; <i>Kinorhynchus giganteus</i> ; <i>Kinorhynchus</i> sp. 1; <i>Kinorhynchus</i> sp. 2; <i>Pycnophyes carinatus</i> ; <i>Pycnophyes communis</i> ; <i>Pycnophyes robustus</i> <i>Pycnophyes</i> cf. <i>flaveolatus</i> ; <i>Pycnophyes</i> cf. <i>rugosus</i> ; <i>Pycnophyes</i> sp. 1; <i>Pycnophyes</i> sp. 2; <i>Pycnophyes</i> sp. 3

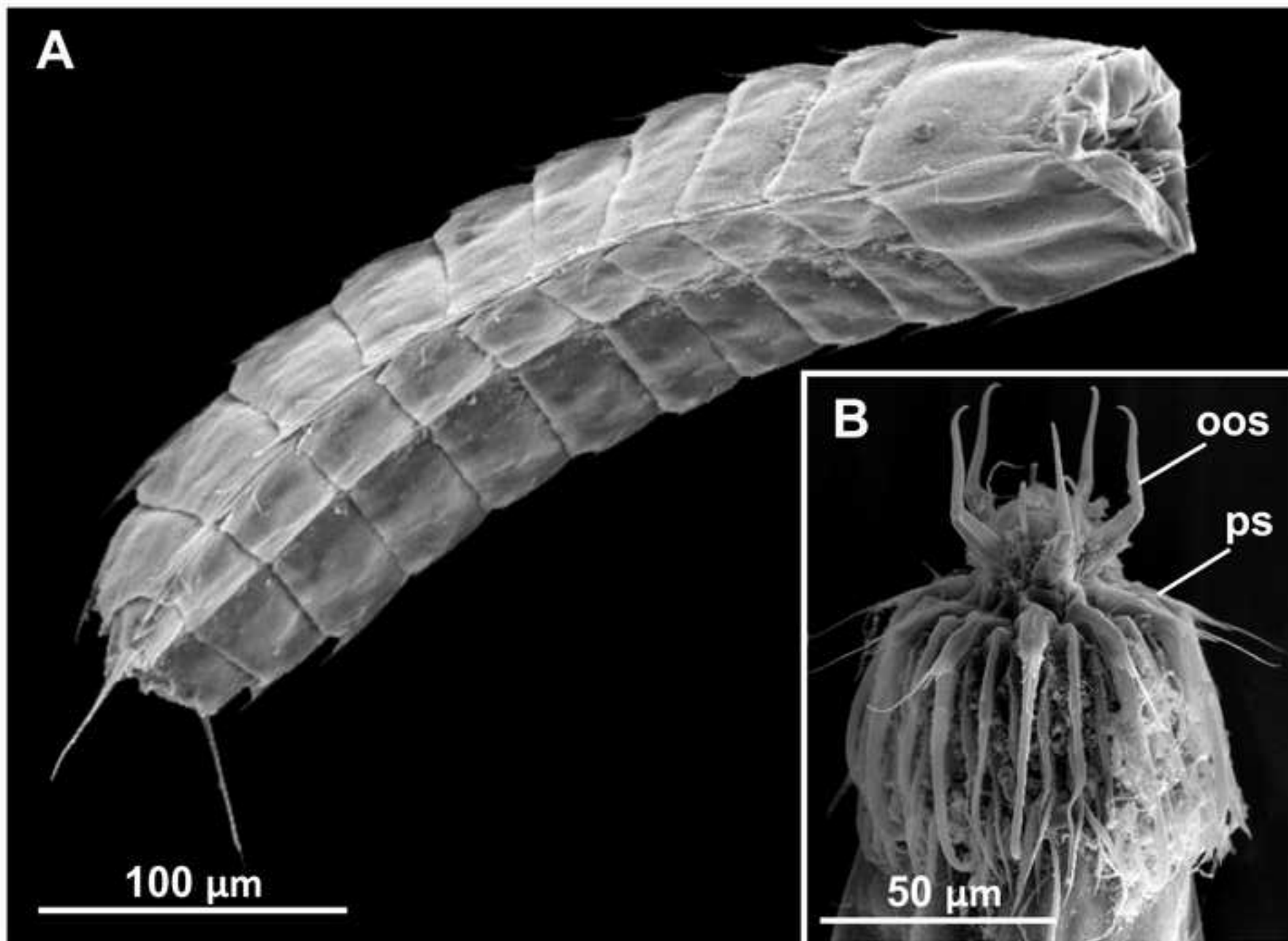
**Table 5** – An updated checklist of the Italian kinorhynch species. Distribution is according to the 9 marine biogeographic zones recognized by 2008 National checklist of marine species (see Relini and La Posta, 2005). References point to the author(s) credited for the record(s).

Taxon	Biogeographic zone									References
	1	2	3	4	5	6	7	8	9	
<b>CLASS ALLOMALORHAGIDA</b>										
<b>FAMILY NEOCENTROPHYIDAE</b>										
<i>Paracentrophyes quadridentatus</i> (Zelinka, 1928)	X		X							Zelinka, 1928; Sánchez, 2015; present study
<b>FAMILY PYCNOPHYIDAE</b>										
<i>Kinorhynchus giganteus</i> (Zelinka, 1928)	X		X						X	Zelinka, 1928; present study
<i>Kinorhynchus</i> sp. 1									X	Present study
<i>Kinorhynchus</i> sp. 2									X	Present study
<i>Pycnophyes carinatus</i> Zelinka, 1928			X						X	Zelinka, 1928; present study
<i>Pycnophyes communis</i> Zelinka, 1928	X	X	X						X	Zelinka, 1928; F. Semprucci and M.V. Sørensen, pers. comm.; present study
<i>Pycnophyes echinoderoides</i> Zelinka, 1928			X							Zelinka, 1928
<i>Pycnophyes flaveolatus</i> Zelinka, 1928			X						X	Zelinka, 1928; Sánchez, 2015; present study
<i>Pycnophyes ponticus</i> (Reinhardt, 1881)			X							Zelinka, 1928; Sánchez, 2015
<i>Pycnophyes robustus</i> Zelinka, 1928			X						X	Zelinka, 1928; Sánchez, 2015; present study
<i>Pycnophyes rugosus</i> Zelinka, 1928	X		X							Zelinka, 1928; Sánchez, 2015; present study
<i>Pycnophyes zelinkaei</i>			X							Sánchez, 2015
<i>Pycnophyes</i> sp. 1									X	Present study
<i>Pycnophyes</i> sp. 2									X	Present study
<i>Pycnophyes</i> sp. 3	X									Present study
<b>CLASS CYCLORHAGIDA</b>										
<b>FAMILY ANTYGOMONIDAE</b>										
<i>Antygomonas caeciliae</i> Dal Zotto, 2015	X	X								Dal Zotto and Todaro, 2009; Dal Zotto, 2015
<i>Antygomonas inomitata</i> Nebelsick, 1990	X	X				X			X	Nebelsick, 1990; Sørensen et al., 2009; Dal Zotto, 2015; present study
<b>FAMILY CENTRODERIDAE</b>										
<i>Centroderes spinosus</i> (Reinhardt, 1881)			X						X	Zelinka, 1928 (as <i>C. eisigii</i> ); present study
<i>Condyloderes</i> sp. 1			X							Present study
<i>Condyloderes</i> sp. 2	X		X							Present study
<b>FAMILY ECHINODERIDAE</b>										
<i>Echinoderes agigens</i> Băcescu, 1968									X	Present study
<i>Echinoderes capitatus</i> (Zelinka, 1928)	X		X						X	Zelinka, 1928; present study
<i>Echinoderes citrinus</i> Zelinka, 1928			X							Zelinka, 1928
<i>Echinoderes dujardinii</i> Claparède, 1863			X				X		X	Metschnikoff, 1865; Panceri, 1878; Schepotieff, 1907; Zelinka, 1928; Mari and Morselli, 1987
<i>Echinoderes ferrugineus</i> Zelinka, 1928			X						X	Zelinka, 1928; present study
<i>Echinoderes gerardi</i> Higgins, 1978			X							Higgins, 1978; present study
<i>Echinoderes setiger</i> Greeff, 1869									X	Zelinka, 1928; present study
<i>Echinoderes subfuscus</i> Zelinka, 1928									X	Zelinka, 1928
<i>Echinoderes</i> sp. 1									X	Present study
<i>Echinoderes</i> sp. 2	X									Present study
<i>Echinoderes</i> sp. 3	X									Present study
<i>Echinoderes</i> sp. 4		X								Present study
<i>Echinoderes</i> sp. 5		X								Present study
<i>Echinoderes</i> sp. 6	X	X								Present study

<i>Meristoderes macracanthus</i> Herranz et al., 2012		X								Herranz et al., 2012; present study
<b>FAMILY SEMNODERIDAE</b>										
<i>Semnoderes armiger</i> Zelinka, 1928	X		X						X	Zelinka, 1928; Mari and Morselli, 1987; present study

Figure 1-revised  
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**A**

100  $\mu\text{m}$

**B**

oos

ps

50  $\mu\text{m}$

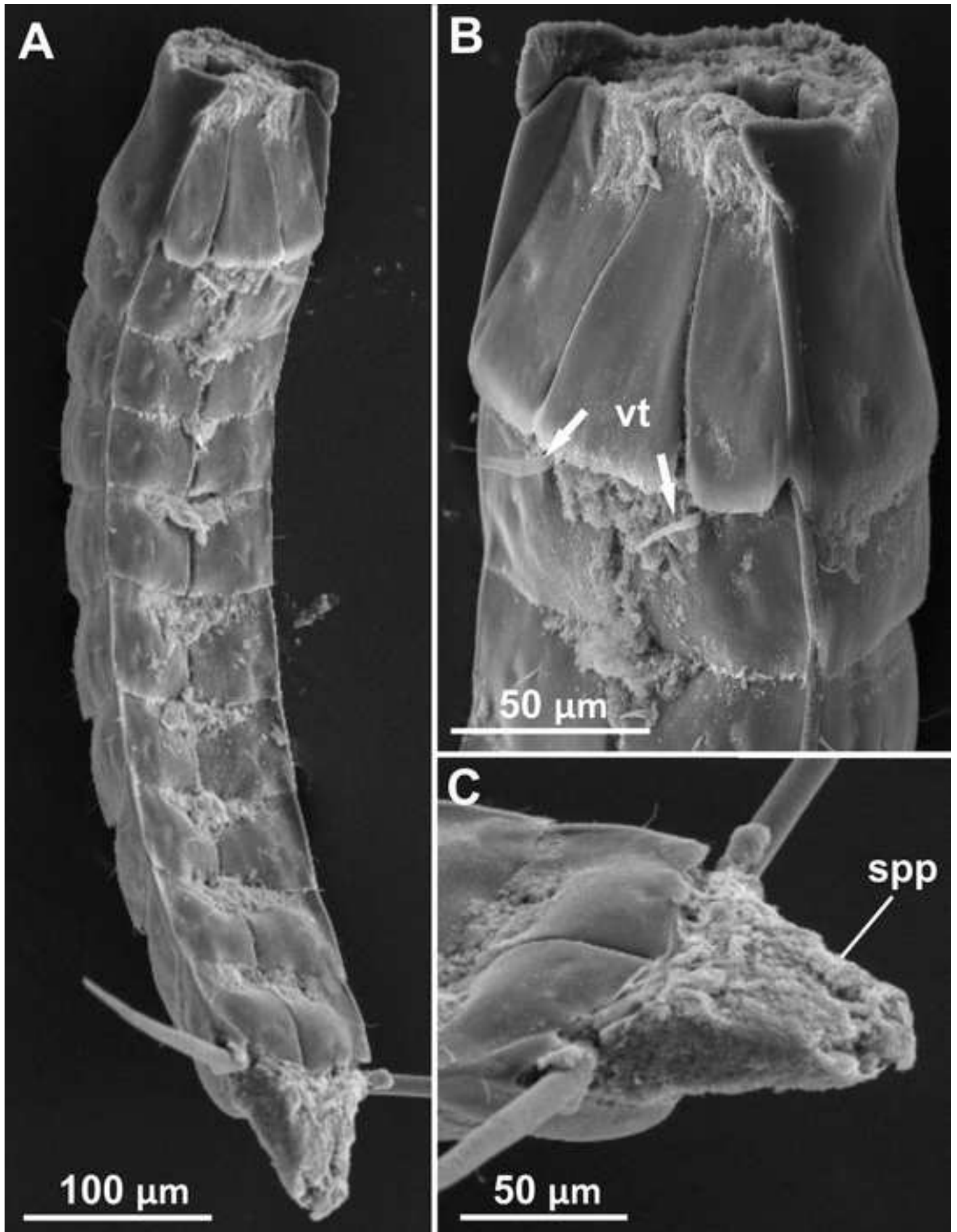


Figure 4-revised

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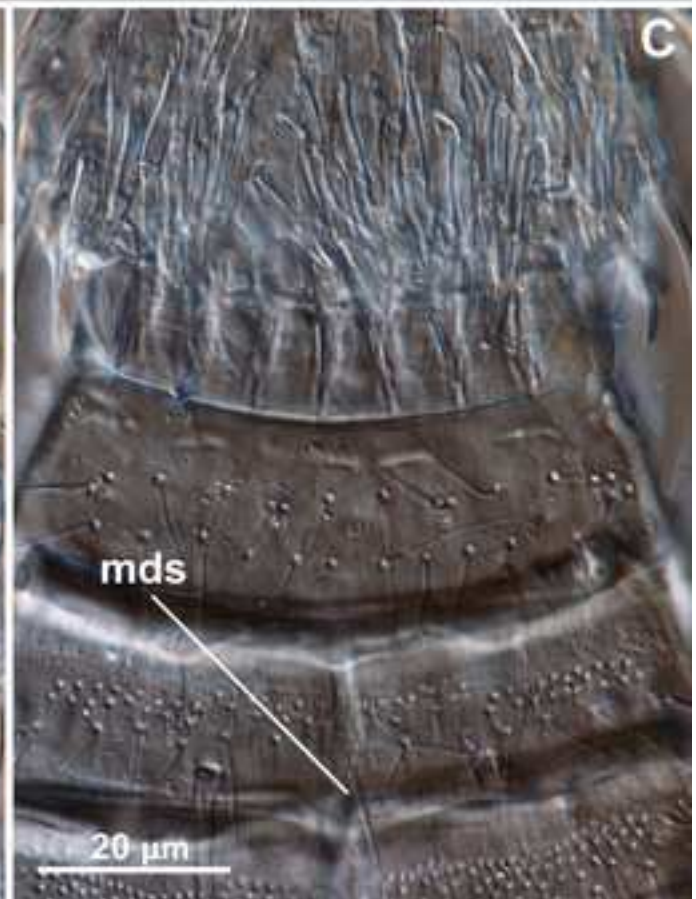
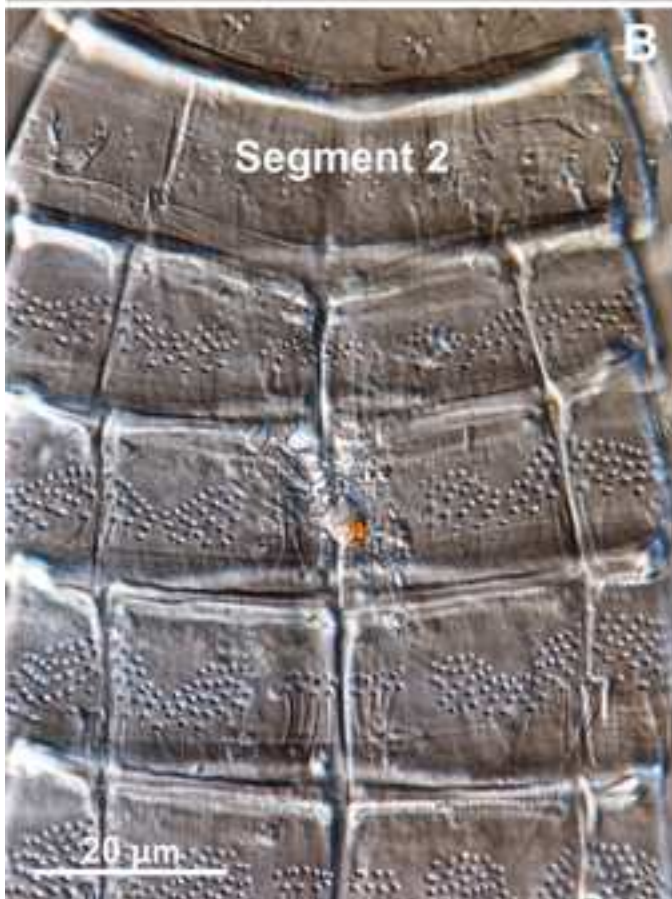
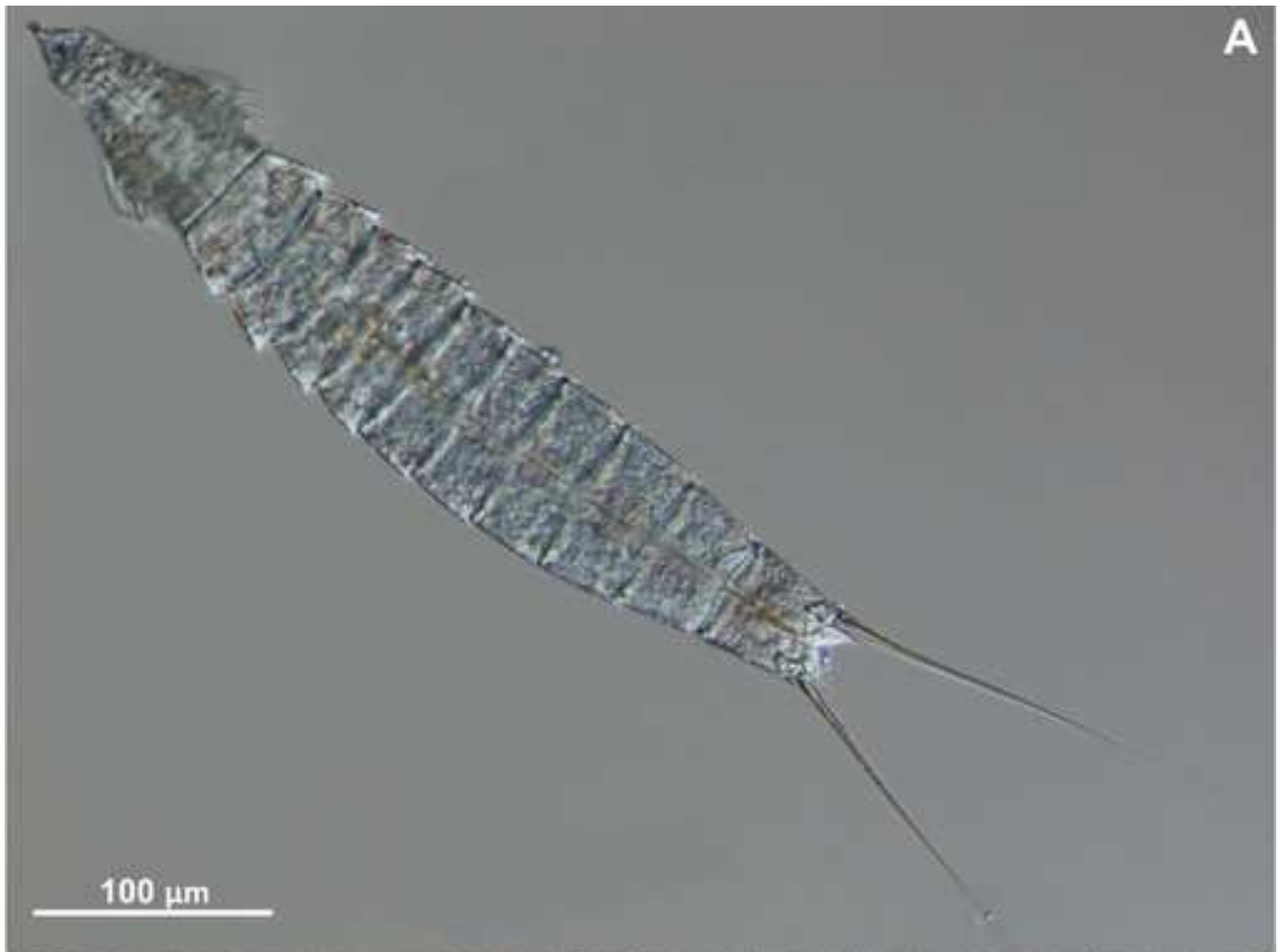


Figure 5-revised

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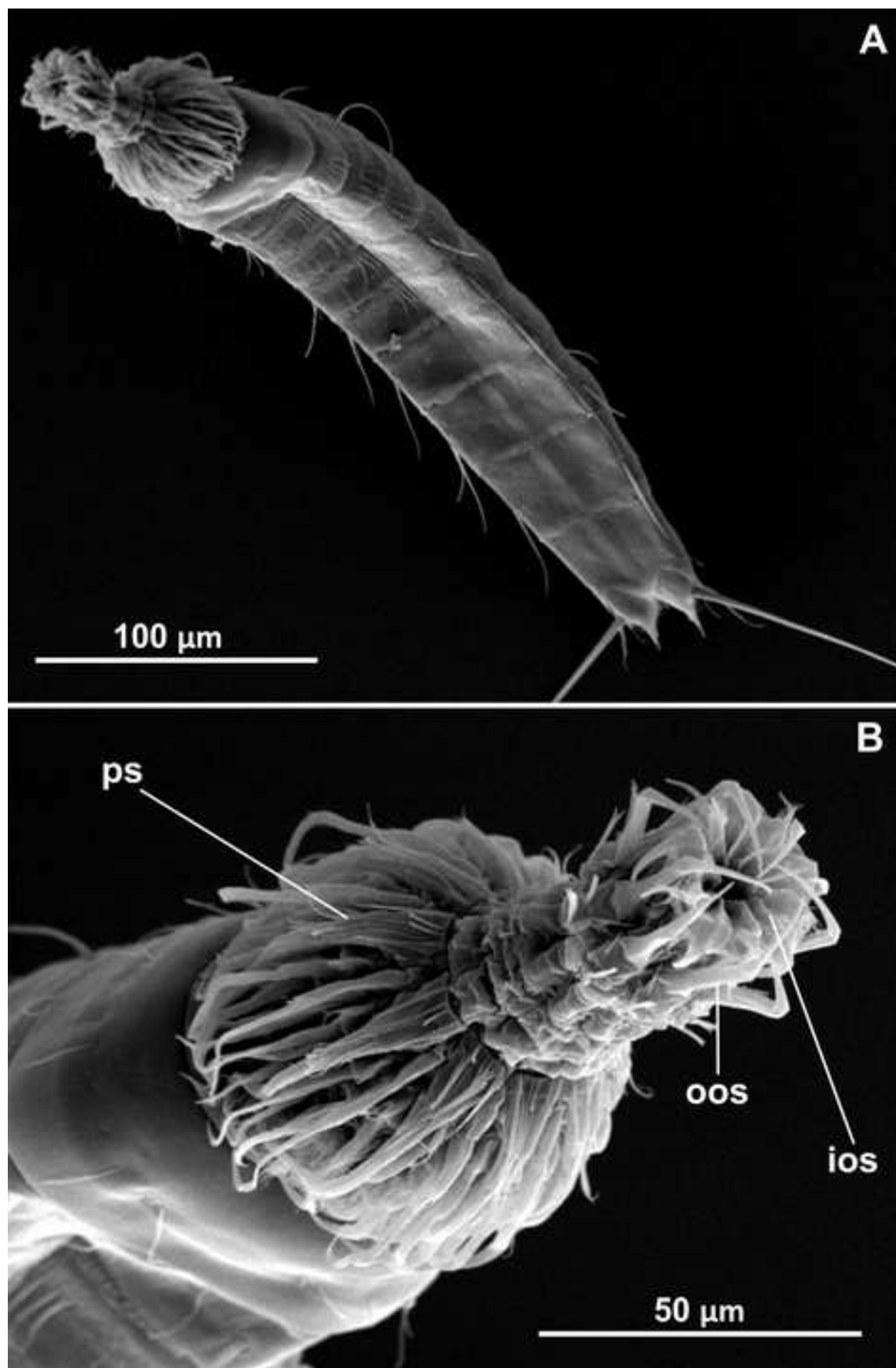


Figure 6-revised  
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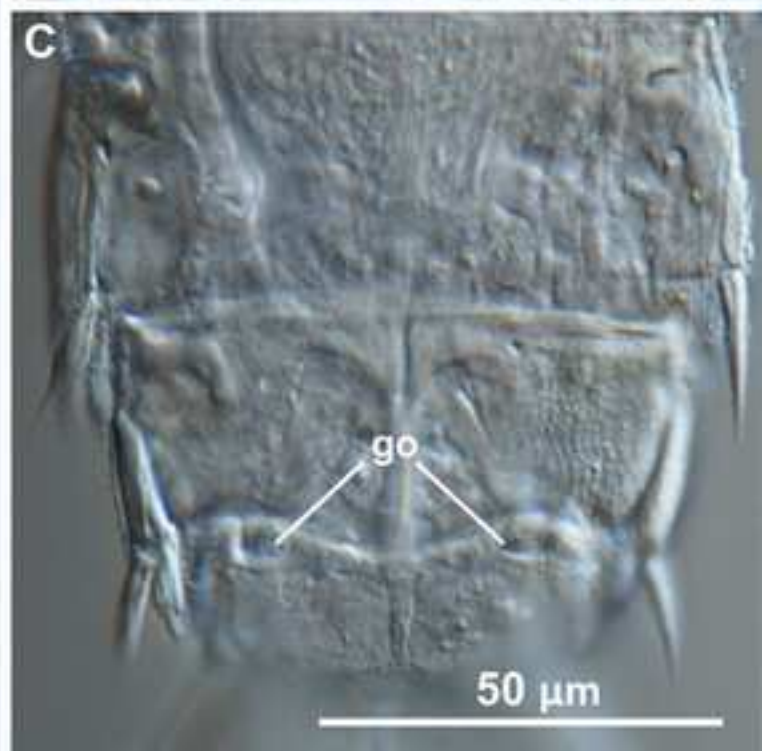
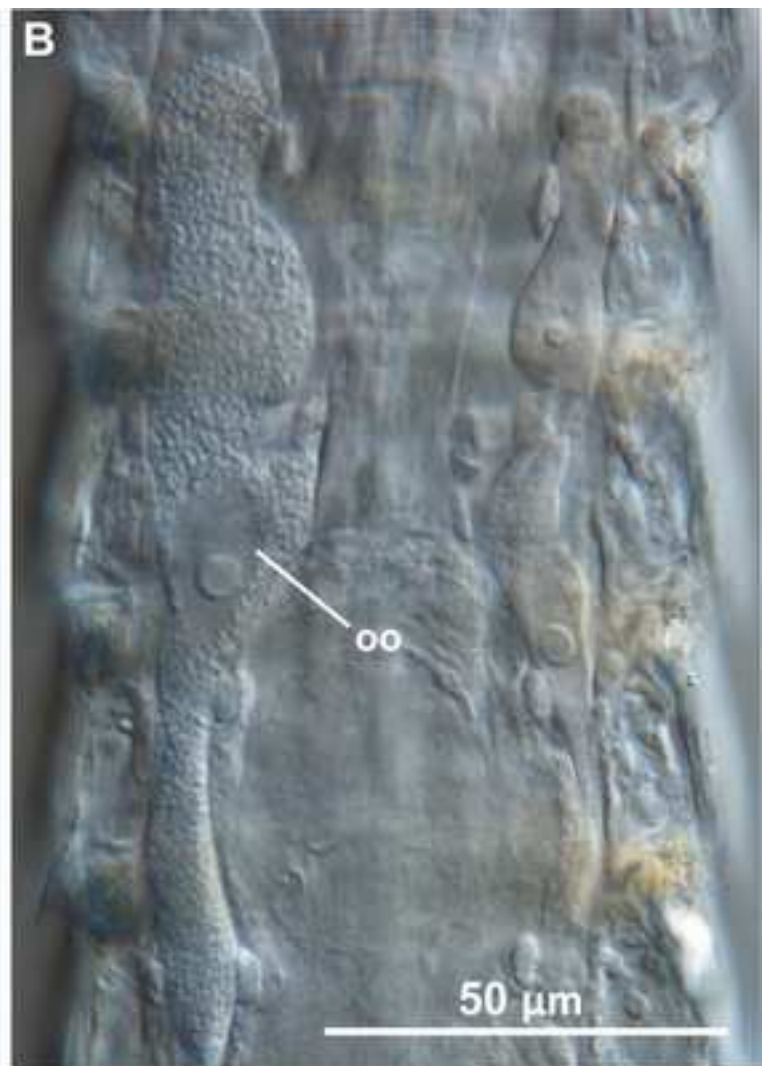


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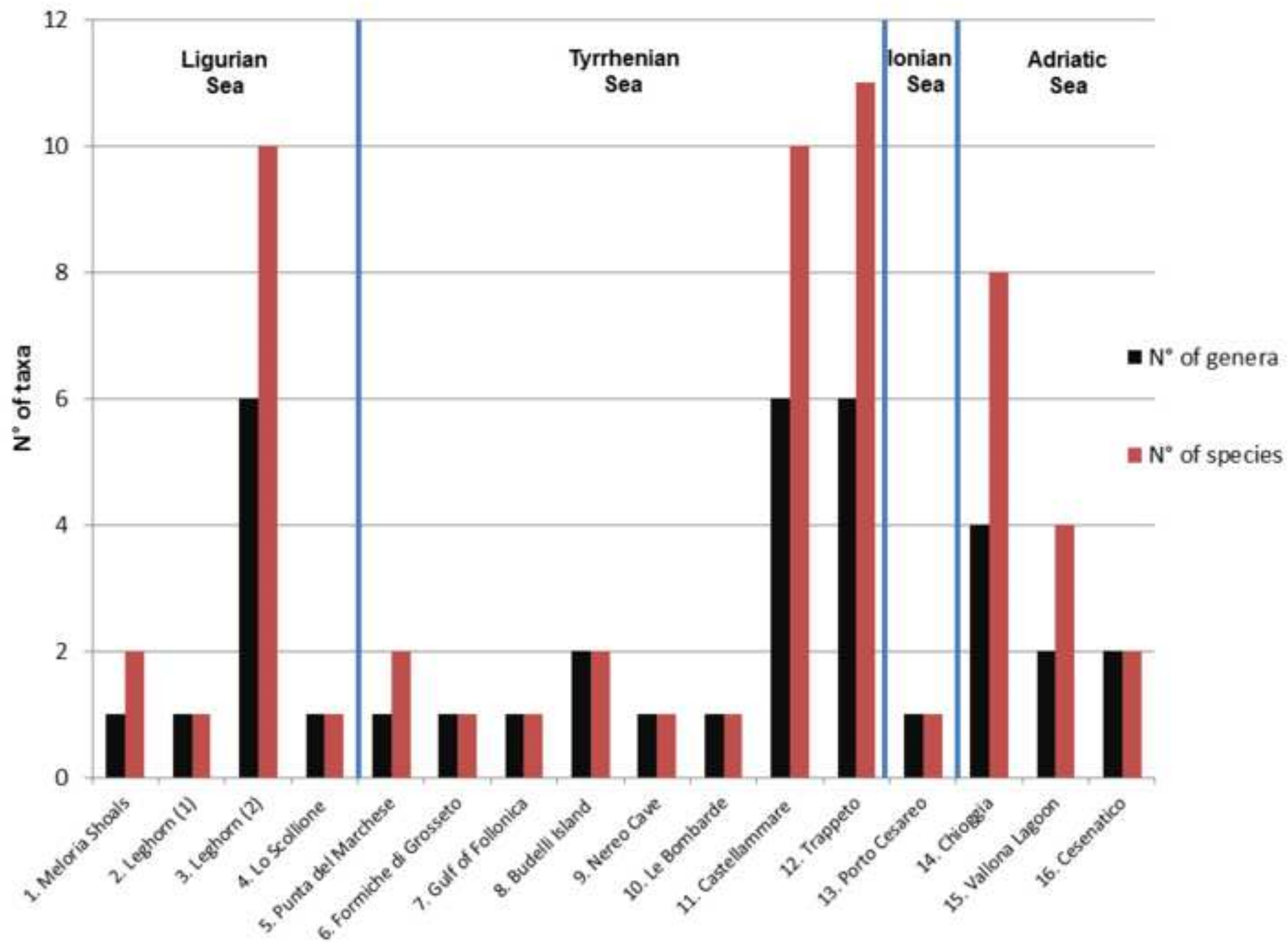


Figure 8-revised  
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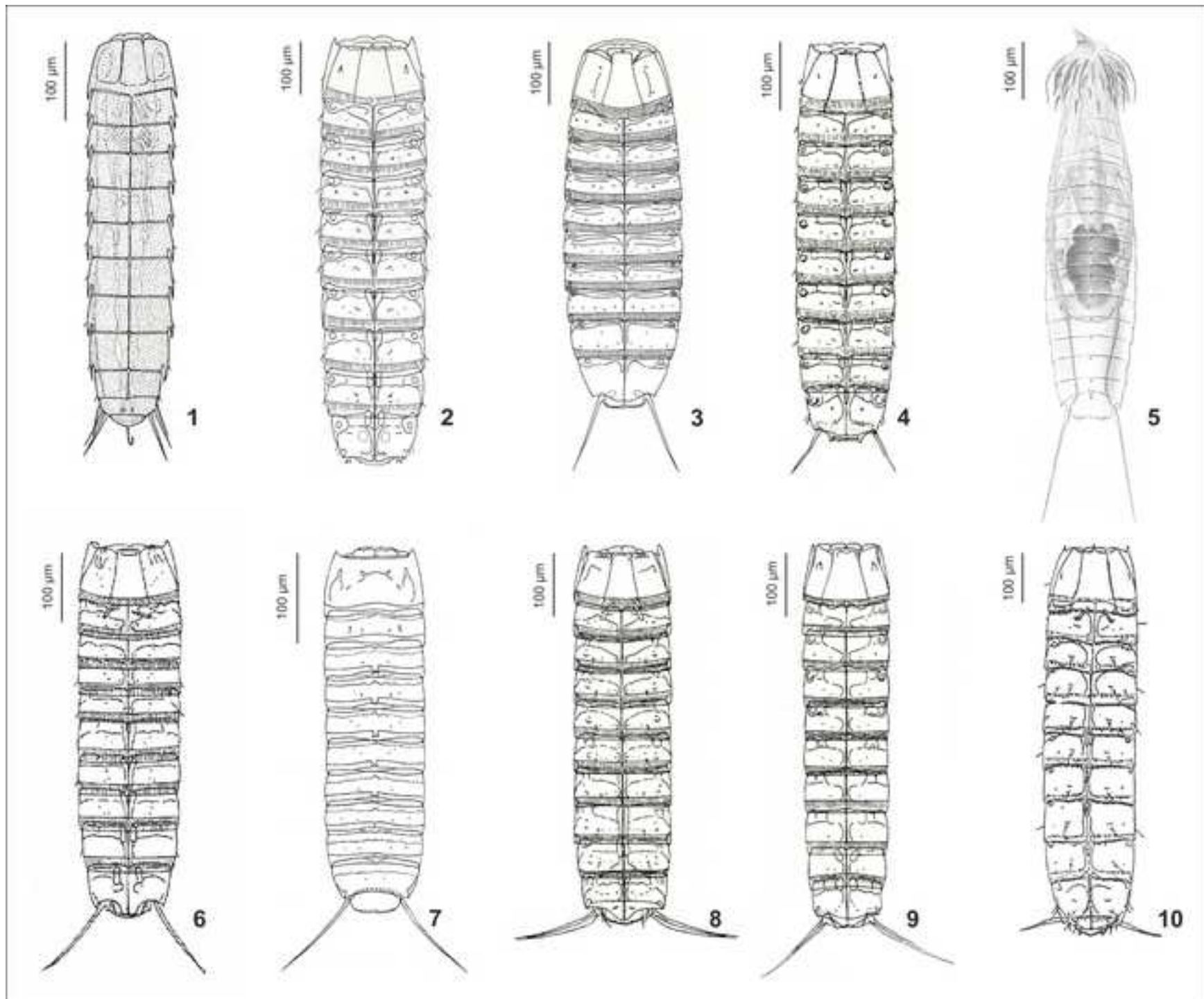


Figure 9-revised

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