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First record of the invasive worm *Branchiomma bairdi* (Annelida: Sabellidae) in the Balearic Sea (Western Mediterranean)

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The invasive sabellid Branchiomma bairdi *(McIntosh, 1885) was collected in the Estany des Peix lagoon (Formentera Island, Balearic Sea, Western Mediterranean). This species is native to Bermuda (Western Atlantic Ocean), being widely distributed through the Caribbean Sea. However, it has been described as invasive worldwide, being also present in the Indo-Pacific region, the Eastern Atlantic Ocean and the Mediterranean Sea. We here provide the first record of the species for the Balearic Sea, together with a comparison to other morphologically similar alien species,* Branchiomma boholense *(Grube, 1878), which is supposed to have also been introduced in the Mediterranean basin. We also include comprehensive taxonomic descriptions of both taxa based on the type material, a dichotomous key for the Mediterranean species of* Branchiomma *and hypothesize the most likely way of introduction of* B. bairdi *in the Balearic region.*

Keywords: alien species, biological invasions, polychaetes, fan worms, feather-duster worms, new records, taxonomy, dichotomous key

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INTRODUCTION

Biological invasions, produced by translocation of invasive species into non-native areas, are a major component of the current global change (MEA, 2005). According to Zenetos *et al.* (2010), a total of 328 alien species have been reported in the Western Mediterranean Sea, making it one of the most threatened areas of the world. Particularly, 11 species of macrophytes were introduced via ship transport in the Balearic Archipelago. Two of them show a remarkable invasive behaviour: *Caulerpa cylindracea* Sonder, 1845, *Lophocladia lallemandii* (Montagne) F. Schmitz, 1893 (Boudouresque & Verlaque, 2002; Ballesteros *et al.*, 2007), and also the toxic dinoflagellate *Alexandrium catenella* (Whedon & Kodoif) Balech, 1985 that was recorded near Majorca Island (Margalef & Estrada, 1987). Alien crustaceans reported from the Balearic Sea included *Hymenopenaeus debilis* Smith, 1882 and the widely distributed *Percnon gibbesi* (Milne Edwards, 1853), which was first recorded from the Balearic Archipelago (Cartes *et al.*, 2000; García & Reviriego, 2000). Other alien invertebrate species previously observed in the Balearic Sea are the ascidians *Cystodytes dellechiajei* (Della Valle, 1877) and *Microcosmus squamiger* Michaelsen, 1927, the gastropod *Sinum bifasciatum* (Récluz, 1851), the starfish *Protoreaster nodosus* (Linnaeus, 1758) with a likely accidental presence, and the invasive sea slug *Bursatella leachii* Blainville, 1817 (Gofas & Zenetos, 2003; Zenetos *et al.*, 2010; Otero *et al.*, 2013).

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Çinar (2013) listed 292 polychaete alien species in the world's oceans, almost 3.4% of the total number of species. Furthermore, 134 of the listed species (39.1%) were recorded from the Mediterranean Sea. Specifically, six polychaetes have been reported in the Balearic Sea as alien species: *Erinaceusyllis serratosetosa* (Hartmann-Schröder, 1982), *Hesionura serrata* (Hartmann-Schröder, 1960), *Mediomastus capensis* Day, 1961, *Neanthes agulhana* (Day, 1963), *Novafabricia infratorquata* (Fitzhugh, 1973) and *Syllis schulzi* (Hartmann-Schröder, 1960) (Desbruyères *et al.*, 1972; San Martín, 2003; Viéitez *et al.*, 2004; Cepeda & Lattig, 2016). According to Çinar (2013) and Zenetos *et al.* (2012), the Lessepsian migration across the Suez Canal is the main introduction route of polychaete alien species in the Mediterranean Basin.

The polychaetous family Sabellidae, commonly known as fan or feather-duster worms, is one of the most common groups of invasive polychaetes, constituting 7% of the total number of species (Çinar, 2013). Particularly, the genus *Branchiomma* Kölliker, 1858 possesses seven alien taxa (Keppel *et al.*, 2015), 22.4% of the total number of species of the genus. The invasive *Branchiomma bairdi* (McIntosh, 1885) was originally described from Bermuda (Western Atlantic Ocean), although it has spread across the Eastern Atlantic and the Indo-Pacific region. This species is considered as invasive due to its (1) huge ability of colonization and the high population density it reaches once established, (2) feeding mode, (3) anti-predation strategies and (4) hermaphrodite reproduction with short larval stage (Tovar-Hernández *et al.*, 2009*b*; Arias *et al.*, 2013). In the present paper, we provide the first record of *B. bairdi* in the Balearic Sea (Western Mediterranean Sea) and compare this taxon to a morphologically similar species, the Mediterranean alien species *Branchiomma boholense*, based on their type material.

MATERIALS AND METHODS

Sampling was performed in Estany des Peix (Formentera Island, Balearic Sea: 38.721556°N 1.415100°E) during October 2016. A single specimen of *B. bairdi* was found while snorkelling along the shoreline, living under a rock of the southernmost part of the lagoon. After its capture, it was fixed and preserved in absolute ethanol. The lagoon is shallow, with no more than 4 m depth, has a surface area of ~1 km², salinity is constant (39–40%), water temperature ranges between 11.5°C in early winter and 23°C in late summer and the bottom is composed of sand, silt and clay with a moderate to high organic content (2.72–13.5%) (Soler *et al.*, 1997; Carballo, 2000). The surrounding area where the specimen was found is dominated by the algae *Caulerpa prolifera* (Forsskål) J. V. Lamouroux, 1809 and the marine phanerogam *Cymodocea nodosa* (Ucria) Ascherson, 1870 (Dantart *et al.*, 1990).

Material was studied using a Leica MZ16A stereomicroscope and photographed with a Leica DFC500 camera attached to the above mentioned optic. Illustrations were edited using Adobe© Photoshop CS6 and Illustrator CS6. Material was deposited in the Invertebrate Collection of the National Museum of Natural Sciences of Madrid (MNCN-CSIC).

SYSTEMATICS

Genus *Branchiomma* Kölliker, 1858

Branchiomma bairdi (McIntosh, 1885)

(Figures 1A–D & 2)

Dasychone bairdi McIntosh, 1885, pp. 495–497, Pl. 30A, figures 13–15 and Pl. 39A, figures 2 & 9.

Branchiomma cf. *bairdi* – Capa & López, 2004, p. 370, figure 5A–I.

Branchiomma bairdi – Tovar-Hernández & Knight-Jones, 2006, pp. 13–17, figures 3A–D, H–K, 9C–D, 10C & 11B; Tovar-Hernández *et al.*, 2009*b*, pp. 3–8, figures 2–4; Çinar, 2009, p. 2320, figure 13A–C; Giangrande *et al.*, 2012, pp. 285–286, figures 3–5; Arias *et al.*, 2013, pp. 162–171, figures 2–4; Ramalhosa *et al.*, 2014, pp. 235–239, figure 2; Corsini-Foka *et al.*, 2015, p. 357, figure 3C.

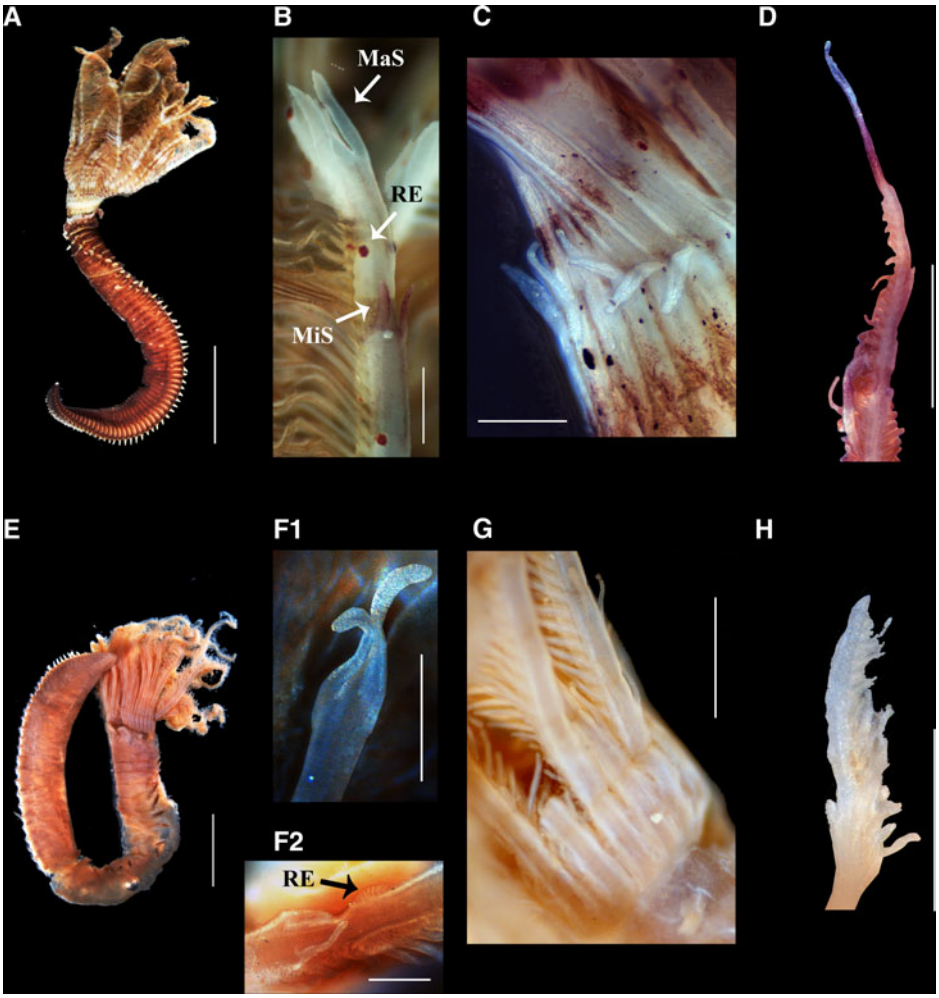

Fig. 1. Morphological comparison of the invasive species *Branchiomma bairdi*, based on Balearic specimen MNCN 16.01/17776 (A–D), and *B. boholense*, based on syntype MPW 365 (E–H). (A) Complete specimen in lateral view; (B) Distal part of radiole showing stylodes; (C) Basal part of crown; (D) Radiolar tip; (E) Complete specimen in latero-ventral view; (F_1) Distal part of radiole showing macrostylodes; (F_2) Basal part of radiole showing microstylodes; (G) Basal part of crown; (H) Radiolar tip. MaS, macrostylode; MiS, microstylode; RE, radiolar eye. Scale bars: A, 4 mm; B and F_1, 250 μm; C, 200 μm; D and G–H, 500 μm; E, 2 mm; F_2, 125 μm.

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EXAMINED MATERIAL

Estany des Peix, Formentera Island (Western Mediterranean Sea). MNCN 16.01/17776 (1 specimen).

COMPARATIVE EXAMINED MATERIAL

Branchiomma bairdi. Lectotype 1885.12.1.391 of the Natural History Museum (NHM) of London, Bermuda shore. Four specimens from Mazarrón Port (Murcia, Western Mediterranean) from the personal collection of Dr Andrés Arias (University of Oviedo).

DIAGNOSIS (BASED ON TYPE AND EXAMINED MATERIAL)

Body light brownish, with dark brownish and whitish spots (Figure 1A). Two pairs of whitish, strap-like macrostylodes per radiole, 2–3 times longer than microstylodes (Figures 1B & 2C, E), alternating randomly and mostly in distal half of crown. First pair of microstylodes unpaired, whitish (Figure 1C). Radiolar tips medium to long, filiform, progressively tapering, distally pointed, approximately occupying the space of 10–25 pinnules (Figures 1D & 2C). Abdominal neuropodia composed of C-shaped compact tufts of spine-like chaetae surrounding a central bundle of modified elongate narrowly hooded chaetae (Figure 2L).

DESCRIPTION (BASED ON TYPE MATERIAL)

Body small, thin-walled, uniformly pale-creamed with darker spots, about 15 mm long and 2 mm wide throughout most of trunk, composed of 9 thoracic and approximately 70 abdominal chaetigers. Trunk slightly flattened dorso-ventrally, progressively tapering towards posterior end (Figure 2A, B).

Crown about 9–10 mm long, with semicircular branchial lobes, each one bearing 20 radioles. Palmate membrane poorly developed, low, reaching 1/15 length of the radioles. Radiolar and basal flanges absent. Radiolar tips medium to long, occupying the space of 10–15 pairs of pinnules, filiform, distally pointed (Figure 2C). Radiolar skeleton axis composed of four longitudinal rows of vacuolated, quadrangular to subquadrangular cells (Figure 2D). Radioles bearing several pairs of compound, radiolar eyes and two types of stylodes: (1) macrostylodes and (2) microstylodes (Figure 2C, E), from palmate membrane almost to radiolar tips. Two pairs of macrostylodes per radiole, two to three times longer than microstylodes, strap-like, completely covering the radiolar

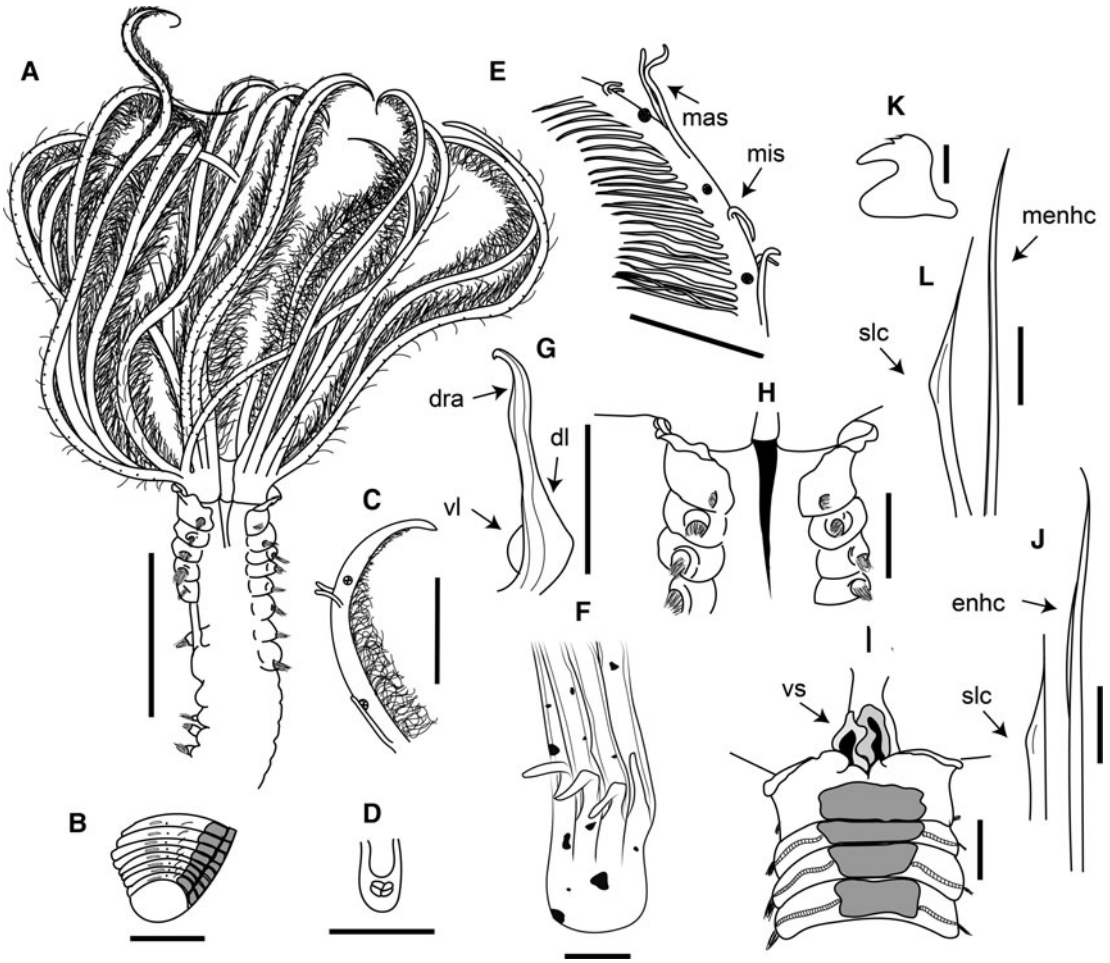

Fig. 2. Drawing of *Branchiomma bairdi*, based on the lectotype NHM 1885.12.1.391 (A–E and G–L) and the Balearic specimen MNCN 16.01/17776 (F). (A) Anterior body, dorsal view; (B) Posterior body, ventro-lateral view; (C) Radiolar tip; (D) Radiolar skeleton axis; (E) Stylodes; (F) First unpaired stylodes; (G) Crown appendages; (H) Detail of the anterior body, dorsal view; (I) Detail of the anterior body, ventral view; (J) Thoracic notochaetae; (K) Thoracic uncinus; (L) Anterior abdominal neurochaetae. dl, dorsal lip; dra, dorsal radiolar appendage; enhc, elongate narrowly hooded chaeta; mas, macrostylodes; menhc, modified elongate narrowly hooded chaeta; mis, microstylodes; slc, spine-like chaeta; vl, ventral lip; vs, ventral sacs. Scale bars: A 3 mm; B, H, I 1 mm; C, E 250 μm; F 200 μm; D, G 500 μm, J–L 30 μm.

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eyes, alternating randomly and mostly in distal half of crown (Figure 2E). Microstylodes digitiform, not covering the radiolar eyes (Figure 2E). First microstylodes unpaired (Figure 2F). Dorsal lips fused to dorsal-most pair of radioles, erect, broader at base, much longer than broad, triangular-shaped, reaching 1/3 length of radioles, with dorsal radiolar appendages, lacking dorsal pinnular appendages (Figure 2G). Ventral lips broad, low, rounded, reaching 1/5 length of dorsal lips (Figure 2G). Parallel lamellae and ventral sacs present, protruding outside crown (Figure 2I).

Anterior peristomial ring and branchial base dorsally visible, lateral and ventrally covered by collar of posterior peristomial ring (Figure 2H, I). Ventral margins of the collar slightly higher than dorsal ones, the collar being oblique in lateral view. Collar margins smooth, with a pair of small ventral incisions (Figure 2I). Mid-dorsal collar margins not fused to faecal groove, forming a wide mid-dorsal gap (Figure 2H). Dorsal pockets absent. Mid-ventral collar margins slightly elevated, forming a pair of small ventral lappets, which are widely separated, broad, abruptly tapered, distally rounded and pentagonal-shaped, not overlapping medially (Figure 2I). First chaetiger about three times longer than following ones (Figure 2H, I). Collar chaetae with an inferior, transversal row of spine-like chaetae and a superior, transversal row of elongate narrowly hooded chaetae.

Thoracic chaetigers rectangular, 7–8 times wider than long, not biannulated (Figure 2A, H, I). Abdominal chaetigers also rectangular, shorter than thoracic ones (Figure 2B). Ventral shields conspicuous, rectangular, the first ones wider than following ones, which are constant in width (Figure 2I). Gap between thoracic tori and ventral shields absent (Figure 2I). Interramal eyespots present. Thoracic notopodia prominent, conical. Thoracic notochaetae with a superior group of elongate narrowly hooded chaetae and an inferior group of spine-like chaetae (Figure 2J). Thoracic spine-like chaetae slightly wider than shaft at knee region (Figure 2J). Thoracic, neuropodial uncini avicular, with short and curved neck, well-developed breast (main fang not extending beyond breast in lateral view) and short handle (Figure 2K). Main fang of thoracic neuropodial uncini followed by two or three rows of secondary, equally sized teeth (Figure 2K). Abdominal neurochaetae with a single row of spine-like chaetae arranged in an arc pattern, surrounding a central bundle of modified elongate narrowly hooded chaetae (Figure 2L). Anterior abdominal spine-like chaetae similar to thoracic ones. Posterior abdominal spine-like chaetae narrower at knee's region but longer after knee than thoracic and anterior abdominal ones. Abdominal, notopodial uncini avicular, similar to thoracic ones. Pygidium broad, distally rounded, without pygidial eyespots (Figure 2B).

VARIATIONS

Branchiomma bairdi shows morphological variation in some of the characters, including body length and width, crown length and number of radioles, number of chaetigers, body pigmentation, length of radiolar tips and visibility of ventral shields.

The holotype measures 15 mm long and 2 mm wide, with a crown of 9–10 mm length bearing 20 pairs of radioles, and a body composed of 9 thoracic and ~70 abdominal chaetigers. However, the Mediterranean specimens from the Italian Faro coastal lake (Giangrande *et al.*, 2012), Tunisia (Khedhri *et al.*, 2016), Greece (Corsini-Foka *et al.*, 2015), Malta and the Spanish coast of Murcia (Arias *et al.*, 2013) are notably bigger, except in the crown length which is similar to holotype's, measuring 22–44 mm long and 2.00–4.65 mm wide, with a crown bearing 20–25 pairs of radioles and a body composed of 4–8 thoracic and 30–75 abdominal chaetigers. Although the body size is higher in the Mediterranean specimens, the number of thoracic and abdominal chaetigers is usually lower. Moreover, the specimen herein studied from Formentera Island is 13 mm long and 2 mm wide, with a crown of 9.5 mm length bearing 20 pairs of radioles, and a body composed of 8 thoracic and 59 abdominal chaetigers, being more similar to the holotype in these characters than the remaining Mediterranean specimens.

The body pigmentation was described as creamed-pale with darker spots based on the holotype. The Italian specimens from Faro coastal lake were described as yellow-green with small brownish and whitish spots (Giangrande *et al.*, 2012), while the Tunisian ones are pale brownish with small dark brownish spots (Khedhri *et al.*, 2016) and the Maltese and Spanish specimens pale-creamed or brownish with sparse black spots (Arias *et al.*, 2013). The Balearic specimen possesses a dark brownish body with darker and whitish spots randomly placed. However, these differences in the body pigmentation may be a result of the specimens' preservation.

The radiolar tips of the holotype are medium to long, occupying the space of ~10–15 pairs of pinnules, filiform, distally pointed. This character, which is usually used to distinguish between species in some Sabellidae genera, has not been described in the Mediterranean populations. The Balearic specimen is characterized by having longer radiolar tips, occupying the space of 20–25 pairs of pinnules, and are also filiform and distally pointed. The specimens from the Spanish coast of Murcia, that were also examined, have radiolar tips very similar to the Balearic one.

Finally, the ventral shields of *B. bairdi* are quite conspicuous on the holotype, the Tunisian and Balearic specimens. However, they were described as poorly conspicuous for specimens from the Italian Faro coastal lake (Giangrande *et al.*, 2012).

REMARKS

Branchiomma bairdi is characterized by having two pairs of strap-like, whitish macrostylodes per radiole completely covering the radiolar eyes, alternating randomly and mostly in distal half of crown, up to 2–3 times longer than microstylodes, which are digitiform and purplish, never covering the radiolar eyes. This main diagnostic character allows differentiating *B. bairdi* from the remaining congeners. Despite this, the species has been frequently misidentified as *B. boholense* (Figure 1E), another invasive species that also appears to be present in the Mediterranean Sea (Knight-Jones *et al.*, 1991) (see its description below).

Macrostylodes of *B. bardi* are defined as strap-like, having progressively tapering distal halves and narrow, distally pointed tips (Figure 1B). However, macrostylodes of *B. boholense* are tongue-like, with expanded, flattened distal halves and wide, distally rounded tips (Figure 1F$_1$). Furthermore, the former possesses 2 pairs of macrostylodes per radiole, whereas the latter has 1–4 pairs of macrostylodes on each radiole. Microstylodes in both species are characterized by being digitiform and never cover the radiolar eyes (Figure 1B, F$_2$).

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We first report more morphological differences between both species that can be useful to avoid misidentifications. The unpaired microstylodes after the palmate membrane of *Branchiomma bairdi* (Figure 1C) are absent in *B. boholense* (Figure 1G). Additionally, *B. bairdi* possesses long, filiform radiolar tips, occupying the space of ~10–25 pinnules (Figure 1D), whereas *B. boholense* has short, abruptly tapering radiolar tips, occupying the space of ~3–5 pinnules (Figure 1H).

DISTRIBUTION

Branchiomma bairdi is indigenous to Bermuda (W Atlantic Ocean), being also present in the Caribbean region (McIntosh, 1885; Monro, 1933; Rioja, 1951, 1958; Tovar-Hernández & Knight-Jones, 2006; Tovar-Hernández *et al.*, 2009*a*). It has been reported as invasive in the Eastern Pacific coast of Panama, Mexico and California (Capa & López, 2004; Tovar-Hernández *et al.*, 2009*a*, *b*, 2011; Bastida-Zavala *et al.*, 2016), the western Pacific coast of Lizard Island in Australia (Capa & Murray, 2015), the Eastern Atlantic coast of the Canary Islands and Madeira (Arias *et al.*, 2013; Ramalhosa *et al.*, 2014) and the Mediterranean Sea (Çinar, 2005, 2009; Giangrande *et al.*, 2012; Arias *et al.*, 2013; Corsini-Foka *et al.*, 2015; Khedhri *et al.*, 2016). This is the first record of the species in the Balearic Sea.

ECOLOGY

Shallow waters (up to 6 m depth), in rocks, muddy bottoms, photophilic algae, marine phanerogams, mangrove roots and artificial substrates such as harbours, docks, boats hulls, buoys, ropes and aquaculture farms (Tovar-Hernández & Yáñez-Rivera, 2012; Bastida-Zavala *et al.*, 2016). *Branchiomma bairdi* is a common component of boat fouling (Çinar, 2009; Tovar-Hernández *et al.*, 2009*b*; Giangrande *et al.*, 2012) and has also been reported as an epibiont of molluscs (Tovar-Hernández & Yáñez-Rivera, 2012). The species is able to tolerate broad environmental conditions, including high variations in temperature, salinity and dissolved oxygen concentrations, desiccation periods and pollution (Keppel *et al.*, 2015; Khedhri *et al.*, 2016).

Branchiomma boholense (Grube, 1878) (Figures 1E–H & 3)

Sabella (*Dasychone*) *boholensis* Grube, 1878, pp. 261–262.

Branchiomma boholense – Knight-Jones *et al.*, 1991, pp. 852–854, figure 6P.

EXAMINED MATERIAL

Syntype MPW 365 (3 specimens) from the Museum of Natural History (Wroclaw University), off Philippines.

DIAGNOSIS (BASED ON TYPE MATERIAL)

Body uniformly brownish after preservation in ethanol (Figure 1E), with darker spots randomly placed through the trunk in live specimens (Grube, 1878). One to four pairs of whitish, tongue-like macrostylodes per radiole, 2–3 times longer than microstylodes (Figures 1F$_1$, F$_2$ & 3C, E), alternating randomly and mostly in distal half of crown. First microstylodes paired, whitish (Figure 1G). Radiolar tips short, abruptly tapering, occupying the space of ~3–5 pinnules (Figures 1H & 3C). Abdominal neuropodia composed of C-shaped compact tufts of spine-like chaetae surrounding a central bundle of modified elongate narrowly hooded chaetae (Figure 3L).

DESCRIPTION (BASED ON TYPE MATERIAL)

Body small, thin-walled, uniformly brownish after preservation in ethanol, about 16.5 mm long and 1.5 mm wide throughout most of trunk, composed of 9 thoracic and ~52 abdominal chaetigers. Trunk slightly flattened dorso-ventrally, progressively tapering towards posterior end (Figure 3A, B).

Crown about 4 mm long, with semicircular branchial lobes, each one bearing 15 radioles. Palmate membrane poorly developed, low, reaching 1/13 length of the radioles. Radiolar and basal flanges absent. Radiolar tips short, occupying the space of 3–5 pairs of pinnules, blunt, abruptly tapering, distally rounded (Figure 3C). Radiolar skeleton axis flattened, compressed, being difficult to determine the number of cells rows (Figure 3D). Radioles bearing several pairs of compound, radiolar eyes and two types of stylodes: (1) macrostylodes and (2) microstylodes, from palmate membrane almost to radiolar tips. One to four pairs of macrostylodes per radiole, two to four times longer than microstylodes, tongue-like, with expanded, flattened distal halves and wide, distally rounded tips, completely covering the radiolar eyes (Figure 3E), alternating randomly and mostly in distal half of crown. Microstylodes digitiform, not covering the radiolar eyes (Figure 3E). First microstylodes paired (Figure 3F). Dorsal lips fused to dorsal-most pair of radioles, erect, broader at base, much longer than broad, triangular-shaped, reaching 1/3 length of radioles, with dorsal radiolar appendages, lacking dorsal pinnular appendages (Figure 3G). Ventral lips broad, low, slightly convoluted, distally rounded, reaching 1/5 length of dorsal lips (Figure 3G). Parallel lamellae and ventral sacs small and poorly developed, slightly protruding outside the crown (Figure 3I).

Anterior peristomial ring and branchial base dorsally visible, lateral and ventrally concealed by collar of posterior peristomial ring (Figure 3A, H, I). Ventral margins of the collar slightly higher than dorsal ones, the collar being oblique in lateral view (Figure 3A). Collar margins smooth, with a pair of shallow ventral incisions (Figure 3A, I). Mid-dorsal collar margins not fused to faecal groove, forming a wide mid-dorsal gap (Figure 3H). Dorsal pockets absent. Mid-ventral collar margins slightly elevated, forming a pair of small ventral lappets, which are widely separated, broad, abruptly tapered, distally rounded, laterally expanded and rectangular-shaped, slightly overlapping medially (Figure 3I). Collar chaetae with an inferior, transversal row of spine-like chaetae and a superior, transversal row of elongate narrowly hooded chaetae.

Thoracic chaetigers rectangular, much wider than long, 6–8 times wider than long, not biannulated (Figure 3A, H, I). Abdominal chaetigers also rectangular, shorter than thoracic ones (Figure 3B). Ventral shields conspicuous, rectangular, the first ones wider than the following ones, the remaining ones constant in width (Figure 3A, I). Gap between thoracic tori and ventral shields absent (Figure 3A, I). Interramal eyespots present, very small and difficult to distinguish after preservation in ethanol. Thoracic notopodia prominent,

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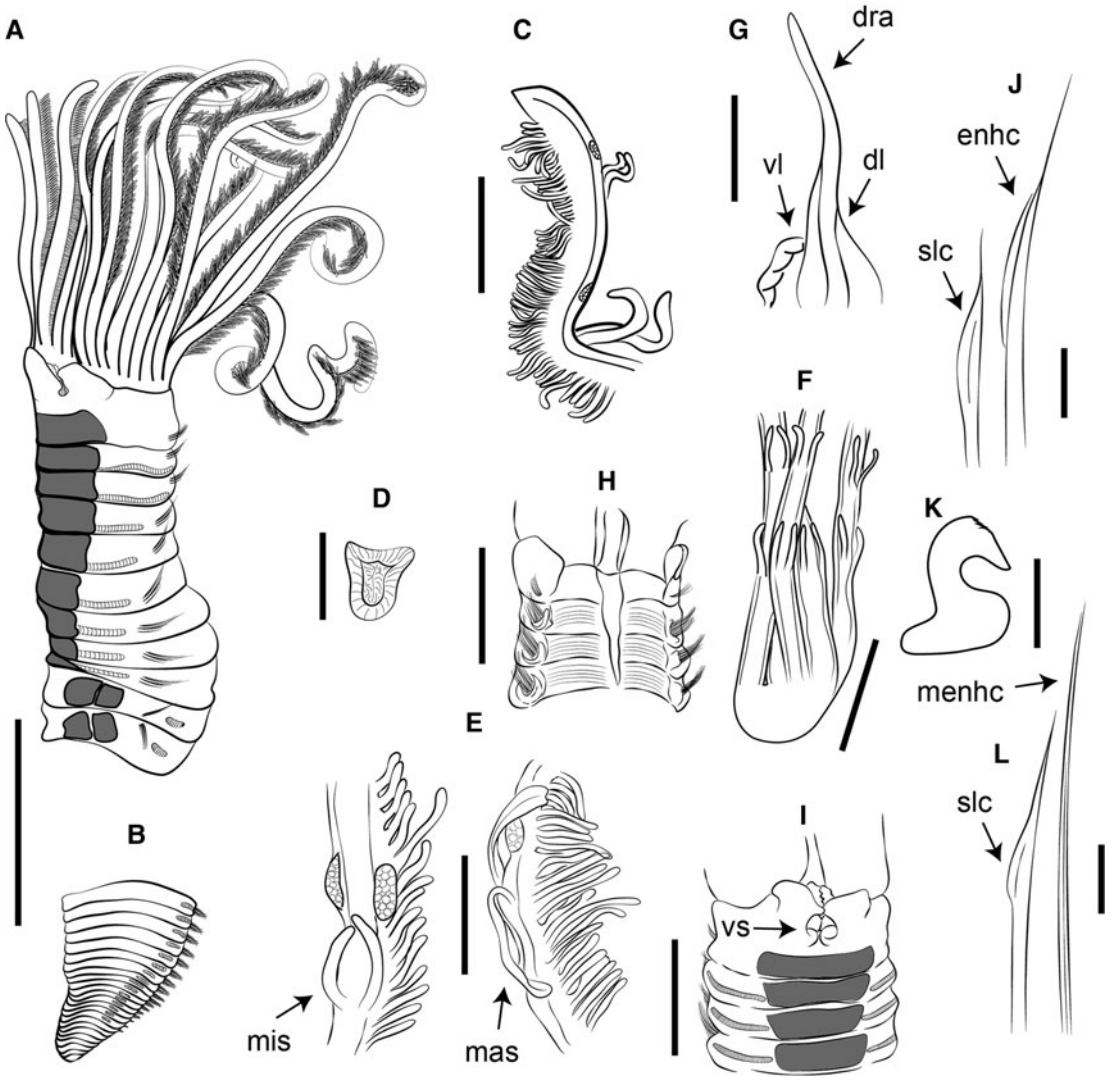

Fig. 3. Drawing of *Branchiomma boholense*, based on the syntype MPW 365. (A) Anterior body, ventro-lateral view; (B) Posterior body, dorso-lateral view; (C) Radiolar tip; (D) Radiolar skeleton axis; (E) Stylodes; (F) First paired stylodes; (G) Crown appendages; (H) Detail of the anterior body, dorsal view; (I) Detail of anterior body, ventral view; (J) Thoracic notochaetae; (K) Thoracic uncinus; (L) Anterior abdominal neurochaetae. dl, dorsal lip; dra, dorsal radiolar appendage; enhc, elongate narrowly hooded chaeta; mas, macrostylodes; menhc, modified elongate narrowly hooded chaeta; mis, microstylodes; slc, spine-like chaeta; vl, ventral lip; vs, ventral sacs. Scale bars: A, B 2 mm; F 500 μm; C–E, G 250 μm; H, I 1 mm; J–L 30 μm.

conical. Thoracic notochaetae with a superior group of elongate narrowly hooded chaetae and an inferior group of spine-like chaetae (Figure 3J). Thoracic spine-like chaetae slightly wider than shaft at knee region (Figure 3J). Thoracic, neuropodial uncini avicular, with short and curved neck, well-developed breast (main fang not extending beyond breast in lateral view) and short handle (Figure 3K). Main fang of thoracic neuropodial uncini followed by 2–3 rows of secondary, equally sized teeth (Figure 3K). Abdominal neurochaetae with a single row of spine-like chaetae arranged in an arc pattern, surrounding a central bundle of modified elongate narrowly hooded chaetae (Figure 3L). Anterior abdominal spine-like chaetae similar to thoracic ones (Figure 3L). Posterior abdominal spine-like chaetae narrower at knee's region but longer after knee than thoracic and anterior abdominal ones. Abdominal, notopodial uncini avicular, similar to thoracic ones. Pygidium broad, distally rounded, without pygidial eyespots (Figure 3B).

VARIATIONS

Branchiomma boholense shows morphological variations in some of the characters, including body length and width, crown length and number of radioles and the degree of overlap of the ventral collar lappets. Thus, the specimens reported by Knight-Jones *et al.* (1991) for the Eastern Mediterranean have bodies 15–25 mm long and 2–4 mm wide, and crowns 5–11 mm long with 21–24 pairs of radioles. However, the holotype is 16.5 mm long and 1.5 mm wide and has a crown 4 mm long with 15 pairs of radioles. Furthermore, the ventral collar lappets of the material from the Eastern Mediterranean are quite variable: they remarkably overlap in the midline in most of the specimens, but slightly overlap or not at all in some of them. In the holotype, the ventral collar lappets slightly overlap in the midline.

DISTRIBUTION

The taxon is indigenous to the Indo-Pacific area, being present in the Philippines, Hong Kong and Sri Lanka. It has also been

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reported as an alien species in Malta, Israel and Egypt (Eastern Mediterranean Sea) by Knight-Jones *et al.* (1991). However, this species has been traditionally misidentified as *B. bairdi*, so the material reported by Knight-Jones *et al.* (1991) for the Eastern Mediterranean should be revised in order to confirm its presence in this area.

ECOLOGY

Data about the habitat of *B. boholense* has not been previously included in the available references of the species.

KEY FOR THE MEDITERRANEAN BRANCHIOMMA, INCLUDING ALIEN SPECIES (*)

1. Macrostylodes present 2
   – Macrostylodes absent 3
2. Strap-like macrostylodes. First microstylodes unpaired, immediately after palmate membrane. Radiolar tips long, filiform, progressively tapering, distally pointed, occupying the space of 15–25 pinnules..... *Branchiomma bairdi* *
   – Tongue-like macrostylodes. First microstylodes paired, beyond palmate membrane. Radiolar tips short, broad, abruptly tapering, distally blunt, occupying the space of 3–5 pinnules ..... *Branchiomma boholense* *
3. Dorsal lips short and blunt, about 1/6–1/10 length of radioles ..... *Branchiomma lucullanum* (Delle Chiaje, 1828)
   – Dorsal lips long and filiform, about 1/2–1/4 length of radioles..... 4
4. Dorsal collar margins fused to faecal groove 5
   – Dorsal collar margins not fused to faecal groove 6
5. Digitiform stylodes, only covering the radiolar eyes in the middle part of the radioles. Large, irregular spots of blackish pigment in the crown and along the body..... *Branchiomma maerli* Licciano & Giangrande, 2008
   – Palmate to foliaceous stylodes (in adults) completely covering the radiolar eyes. Spots of pigment as above absent ..... *Branchiomma bombyx* (Dalyell, 1853)
6. Stylodes constant in length and shape along the radioles. Palmate membrane with digitiform processes between radioles. Irregular spots of brownish pigment randomly present all along the body..... *Branchiomma luctuosum* (Grube, 1870) *
   – Stylodes varying in length and shape (from tongue-shape to digitiform) along the radioles. Palmate membrane without digitiform processes. D-shaped, transversal triangular and large quadrangular patches of brownish pigment regularly present along the body *Branchiomma moebii* Knight-Jones, 1994

DISCUSSION

Since its first report in Girne Harbour (Cyprus, Eastern Mediterranean) in 1998, the invasive *B. bairdi* was misidentified as *B. boholense* (Çinar, 2005). It was hypothesized to have encroached the Mediterranean Sea on ship hulls through the Suez Canal (Çinar, 2009). However, due to its high population density levels on the Western Mediterranean Basin (Giangrande *et al.*, 2012; Arias *et al.*, 2013; Lezzi *et al.*, 2016) and its presence in the central-eastern Atlantic Ocean (Arias *et al.*, 2013; Ramalhosa *et al.*, 2014) it is more likely that the introduction was across the Strait of Gibraltar, as also hypothesized by Arias *et al.* (2013), Ramalhosa *et al.* (2014) and Khedhri *et al.* (2016). This first report in the Balearic Sea reinforces this hypothesis, though only one specimen was collected.

In addition, the morphologically similar species *B. boholense* has also been reported as an alien species in the Eastern basin of the Mediterranean Sea (Knight-Jones *et al.*, 1991). Although there were other records of this taxon throughout the Mediterranean region, most of them were misidentifications and unequivocally corresponded to *B. bairdi* (e.g. Román *et al.*, 2009). In the absence of a revision of the specimens reported by Knight-Jones *et al.* (1991), only *B. bairdi* should be considered as invasive taxa, whereas *B. boholense* may be considered as an alien species in the Eastern Mediterranean Basin. The species *B. boholense* is barely able to colonize new areas and there are no new records of this species since it was first detected in the Mediterranean Sea. In contrast, *B. bairdi* has been detected in many Mediterranean localities. Its reproductive strategy probably allows it to encroach new areas. *Branchiomma bairdi* is a simultaneous hermaphrodite, developing male and female gametes in the same body segments, which are released into the tube where fertilization takes place, and later embryos and larvae are retained and brooded inside the tube or the crown of the parent (Tovar-Hernández *et al.*, 2009*a*, *b*, 2011). Moreover, *B. bairdi* shows a huge plasticity on the trade-off between egg size and egg number per brood, depending on the environment and being able to adapt to different conditions (Arias *et al.*, 2013). Also, *B. bairdi* is characterized by having asexual reproduction via scissiparity of the posterior end, which may occurs simultaneously with the sexual reproduction (Tovar-Hernández *et al.*, 2011). Nevertheless, the reproductive strategy of *B. boholense* has not been determined yet, and further studies are needed in order to compare both taxa and better assess its potential invasive capability.

The presence of several leisure harbours and maritime stations near the Estany des Peix lagoon may explain the invasion of Formentera Island from the Mediterranean coast of the Iberian Peninsula, where *Branchiomma bairdi* has also been reported (Román *et al.*, 2009 as *B. boholense*; Arias *et al.*, 2013). As previously known, *B. bairdi* is a common fouling species (Çinar, 2009; Tovar-Hernández *et al.*, 2009*b*; Giangrande *et al.*, 2012), with ballast water or the ship hulls being the most likely way of specimens translocation. However, studies of its genetic diversity and phylogeographic structure are needed in order to confirm and better understand the Mediterranean invasion of this alien species (Arias *et al.*, 2013; Khedhri *et al.*, 2016). Furthermore, it would be necessary to eventually resample the location and see the evolution of the species in the area to confirm its high reproductive potential and dispersal capability.

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