Fouling polychaete worms from the southern Gulf of California: Sabellidae and Serpulidae

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Fouling polychaete worms from the southern Gulf of California: Sabellidae and Serpulidae

Abstract Members of the tubicolous polychaete families, Sabellidae and Serpulidae, constitute two of the most important groups in the marine fouling biota. This paper describes three fouling sabellids and six serpulids from the southern Gulf of California and provides information about the reproductive biology of these species. The invasive species, *Branchiomma bairdi* and *Ficopomatus miamiensis*, are established in the southern Gulf of California as self-sustaining populations outside of their native range of the Caribbean Sea. Hull fouling is considered the most probable vector for the translocation of *B. bairdi* to the eastern Pacific, while the presence of *F. miamiensis* is most likely due to shrimp aquacultural activities. *Hydroides elegans* is probably an invasive species in the study area and is common as fouling on ships and piers in the Caribbean, Gulf of México, the Turkish Levantine coast, Hawaii and California. *Hydroides brachyacanthus* has been widely recorded in the Mexican Pacific. *Demonax pallidus* and *Megalomma coloratum* constitute new records for México. *Hydroides elegans*, *H. recurvispina* and *Vermiliopsis multiannulata* are new records for the Mazatlán port. *Hydroides cruciger*, *H. brachyacanthus*, *H. elegans*, *H. recurvispina* and *Megalomma coloratum* have separate sexes without sexual dimorphism. *Branchiomma bairdi* and *D. pallidus* are simultaneous hermaphrodites, although asexual reproduction via scissiparity is documented in *B. bairdi*. Sperm morphology (spherical nucleus, rounded or subtriangular cap-like acrosome and a long flagellum) suggests that the species recorded here are free-spawners with external fertilisation or ect-aquasperm type. This taxonomic effort is greatly enhanced by the integration of synonymies, characterisations and image collections with annotations archived in Morphbank.

Key words Sabellidae, Serpulidae, fouling, Gulf of California, alien species, reproduction

Introduction

Introductions of non-indigenous species, intentionally or accidentally resulting from anthropogenic activities, represent a great concern because of the negative ecological, economic and health hazard impacts associated with invasions of some of these species far from their native distribution area (El Haddad *et al.*, 2007).

The anthropogenic translocation of marine species between disjunctive biogeographical regions has three significant recognised vectors: the digging of canals, accidental transport on ships (as fouling or in ballast water) and introductions associated with aquaculture (e.g. Taylor *et al.*, 2001; Calado & Chapman, 2006). Out of these, the accidental transport of species due to hull fouling is recognised nowadays as an important, current and ongoing vector for species translocation (Gollasch, 2002). Thus, such invasive species are introduced species that are ecologically and/or economically harmful i.e. a pest (Williamson & Fitter, 1996; Boudouresque & Verlaque, 2002).

Fan worms and feather-duster worms, common names referring to their filter-feeding radiolar crowns, belong to the polychaete families Sabellidae Latreille, 1825, and Serpulidae Rafinesque, 1815, respectively, and are common and troublesome fouling organisms found on ship hulls. The two groups are easily distinguished in that serpulids always have a calcareous tube, whilst virtually all sabellids have a tube comprised of sediment and mucus (Kupriyanova & Rouse, 2008). The dispersal of several species, including *Hydroides elegans* (Haswell, 1883), *H. ezoensis* Okuda, 1934, *H. sanctaecrucis*

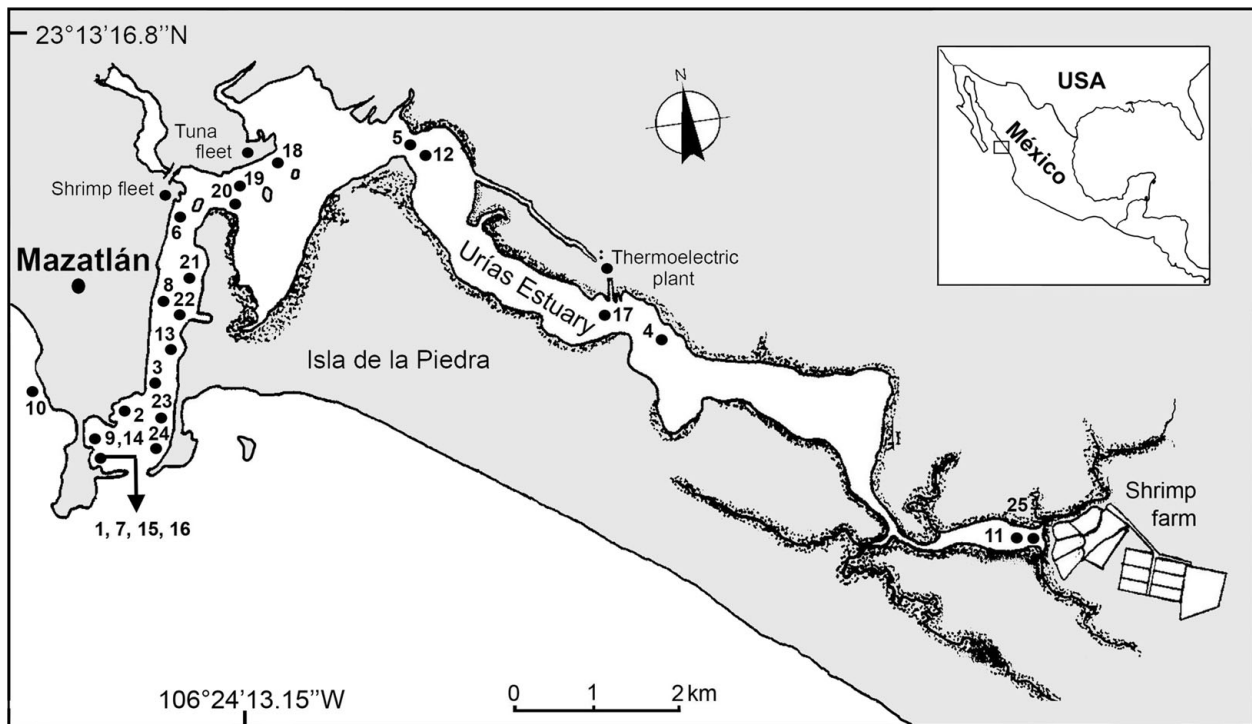*Corresponding author. Email: maria_ana_tovar@yahoo.com

Figure 1 Mazatlán port and Urías Estuary showing the sampling stations.

Krøyer in Mörch, 1863 and *Ficopomatus enigmaticus* (Fauvel, 1923), to subtropical and warm temperate harbours in different oceans and hemispheres has been well documented and attributed to shipping, particularly as hull fouling (Ben-Eliahu & ten Hove, 1992; Zibrowius, 1992; Çinar, 2006; Lewis *et al*., 2006).

Some sabellids have been translocated from their native distribution range in ballast water. For example, *Sabella spallanzanii* (Gmelin, 1791), which is a common species in the Mediterranean Sea, lives in shallow waters (< 30 m depth) in harbours, over dock pilings, rocks, sea grass mats, or sand. It is a large species with a high growth rate (10 cm/year) that has become established in Australian waters, where it competes for food with native oysters and clams (Giangrande & Petraroli, 1994; Giangrande *et al*., 2000).

Other Sabellidae species have been transported due to their close association with their aquaculture hosts. *Terebrasabella heterouncinata* Fitzhugh & Rouse, 1999, a parasite sabellid of an African abalone, was introduced to farms in California, where it has caused significant damage to native fauna and considerable economic losses (Culver *et al*., 1997). An introduction associated with shrimp aquaculture was also recorded for *Ficopomatus miamiensis* (Treadwell, 1934), a species from Florida, detected in shrimp farms and estuaries from the southeastern Gulf of California (Salgado-Barragán *et al*., 2004) but its effects in the colonised habitat are still unknown.

Although different international agencies are involved in the development of legislation concerning the introduction and control of non-indigenous species, México does not regulate ships' ballast water, or fouling biota of ships and boats, and has few regulations for aquaculture management,

live seafood, or the pet and bait trades (Okolodkov *et al*., 2007). The country has more than 11 000 km of coastal line with 47 ports in the Pacific Ocean and 43 in the Gulf of México and Caribbean. The Mazatlán port in the southeastern Gulf of California (Fig. 1) is one of the most important ports in the Mexican Pacific in terms of commercial traffic of agricultural, industrial, fishing, automobile, petroleum and derived products. It has a dense connection network throughout many ports in the world: Venezuela, Colombia, Ecuador, Brazil, Peru, Chile, Spain, Portugal, France, Italy, Greece, Cyprus, Malta, Lebanon, Libya, Syria, Saudi Arabia, United Arab Emirates, Romania, Bulgaria, Turkey, Egypt, Algeria, Morocco, Tunisia, South, Western and Eastern Africa (Secretaría de Comunicaciones y Transportes, 2006). The Mazatlán port also receives significant numbers of cruise ships and private sailing boats that connect it with the ports of the USA. These boats could transport on their hulls fouling biota from the coasts of California to the Gulf and vice versa.

In order to improve the management and the regulations on the introduced fauna in the region, it is necessary to understand regional biodiversity and consider the impacts produced by marine non-indigenous species. The first initiatives to detect non-native fauna in the harbour and in the inner waters of the Urías Estuary are recent; as a result at least five non-native invertebrate species have been found: the copepod *Enhydrosoma lacunae* Jakubisiak, 1933 (Gómez, 2003); the ascidian *Styela canopus* Savigny, 1816; the serpulid *Ficopomatus miamiensis* (Treadwell, 1934) (Salgado-Barragán *et al*., 2004); the false mussel *Mytiliopsis adamsi* Morrison, 1946 (Salgado-Barragán & Toledano-Granados, 2006) and recently, the sabellid *Branchiomma bairdi* (McIntosh, 1885) (Tovar-Hernández *et al*., 2009). This study deals with the identification of fouling

sabellid and serpulid polychaetes in the southeastern Gulf of California, and provides information about the reproductive biology of these species.

Materials and methods

Sampling was carried out on hard anthropogenic substrata (dock pilings, buoys and hull of vessels) from 23 stations located in the Mazatlán port and two on mangrove roots from the adjacent lagoon, Urías Estuary (Fig. 1). Locality names, coordinates, dates, substrates, salinity and temperature of the water and collector(s) are presented in the Appendix, which is available as "Supplementary data" available on Cambridge Journals Online: http://www.journals.cup.org/abstract_S1477200009990041. At each station the fouling organisms were collected manually or by scraping from hard surfaces and were placed in a seawater-filled container for transportation to the laboratory. After the initial sorting to the higher groups (Algae, Mollusca, Pycnogonida, Crustacea, Sipuncula, Equinodermata, Tunicata, Cnidaria and Polychaeta), sabellid and serpulid worms were maintained in an aquarium for 2 days to document their live colouration and reproductive mode. Worms were anaesthetised with 7.5% magnesium chloride or menthol crystals, and fixed in 10% formalin-seawater. Specimens were washed in the lab with tap water for 24 h, and transferred to 70% ethanol for long-term preservation.

A Leica MZ75 stereomicroscope and Olympus CH30 optical microscope were used for identification and digital photographs were taken with an attached Canon S5 digital camera. Longitudinal sections from two specimens of *B. bairdi* were made to record spermatozoa morphology by means of SEM. Opercula, thoracic and abdominal parapodia, and tori were dissected. All samples were processed after final dehydration in two changes of 100% ethanol at the Laboratorio de Microscopía Electrónica de Barrido (Facultad de Ciencias, Universidad Nacional Autónoma de México). Samples were critical point dried, mounted on stubs with platinum tape, and coated with gold (200 Å thickness) for observation with a Cambridge 250 scanning electron microscope.

For each species, complete specimens were measured to record the width of the posterior thorax, the body length (from peristomium to pygidium), the branchial crown length, the number of radiolar pairs and the number of thoracic and abdominal segments. In the description section, these measurements are expressed as mean values ± standard deviation, while the number of individuals analysed (n) and the range of such values are given between parentheses: e.g. length 6.93 ± 1.10 mm ($n = 100$; 2–13 mm). Number of radiolar pairs, thoracic and abdominal segments and their respective standard deviations were rounded to the nearest integer.

One hundred complete specimens of *B. bairdi* and 50 of *F. miamiensis* were selected to assess sexual maturation using longitudinal sections throughout the entire body length. Thoracic and abdominal regions were stained with methyl green to facilitate the search of gametes and to record their distribution in these body regions. When gametes were detected, a sample of gamete tissue was taken and placed in ethanol-glycerol on a slide and examined by compound microscopy. The diameter of oocytes was measured using a stage micrometer.

We used some tools available in Morphbank (http://morphbank.net/), mainly due to the ability to create image collections and the capability to make annotations to the images. Specimens collected were deposited at the Colección de Referencia de Invertebrados del Laboratorio de Invertebrados Bentónicos, Universidad Nacional Autónoma de México, Instituto de Ciencias del Mar y Limnología, Unidad Académica Mazatlán (UNAM-ICML).

Results

Characterisations of species studied, including information about their reproductive biology, their distribution and remarks, are presented here.

<div align="center">

Order SABELLIDA Latreille, 1825

Family SABELLIDAE Latreille, 1825

Genus *Branchiomma* Kölliker, 1858

Branchiomma bairdi (McIntosh, 1885)
Figs 2a, d–e, h, 3a–b, 4a–b, 5a–b

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Dasychone bairdi McIntosh, 1885: 495–497, pl. 30A, figs 13–15; pl. 39A, figs 2, 9.– Monro, 1933: 267.– Rioja, 1951: 513–516: pl. 1, figs 1–7.– Rioja, 1958: 286–287.

Branchiomma bairdi. – Tovar-Hernández & Knight-Jones, 2006: 13–17, figs 3A–D, H–K, 9C–D, 10C, 11B.– Tovar-Hernández *et al.*, 2009: 2–5, figs 2–4.

MATERIAL EXAMINED: UNAM–ICML Cat. EMU–8514B, Sta. 14 (274 specs); EMU–8514C, Sta. 15 (2998 specs); EMU–8502G, Sta. 17 (9 specs); EMU–8510, Sta. 18 (1572 specs); EMU–8511, Sta. 19 (5185 specs); EMU–8512, Sta. 20 (6086 specs); EMU–8513, Sta. 21 (1104 specs); EMU–8502H, Sta. 22 (19 specs); EMU–85021, Sta. 23 (23 specs).

CHARACTERISATION: Leathery tubes covered with bryozoans, green algae or associated with compound ascidians (*Polyclinum* sp.) and sponges (*Halichondria* sp.). Individuals isolated or forming small aggregations of 4–12 individuals. Branchial crown length 6.93 ± 1.10 mm ($n = 100$; 2–13 mm); radiolar pairs 16 ± 3 ($n = 100$; 10–24 pairs); crown base bearing longitudinal bands of diffuse brown spots in each radiole axis; radioles with olive-green bands alternating with white bands, each colour band extending for three pinnules, colour extending onto pinnules and stylodes; rachis with orange rhomboidal spots; macrostylodes strap-like, up to four times as long as neighbouring pairs (Fig. 3b), mainly in distal half of radiole, with remaining stylodes digitiform; all stylodes about one third the width of rachis (http://www.morphbank.net/Show/?pop=Yes&id=463996); compound eyes, red to orange, small (with sub-conical lenses), absent between the last pair of stylodes and radiolar tip
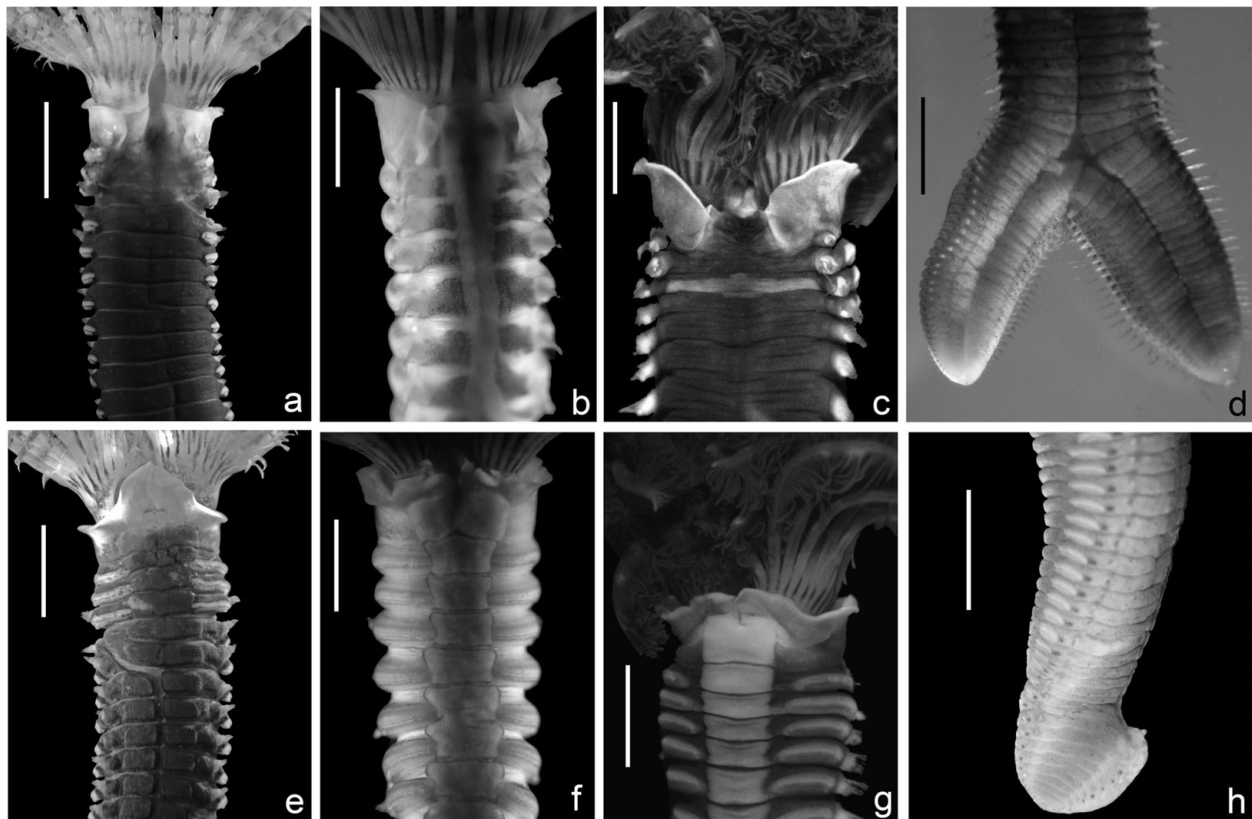
Figure 2 Thoracic region in sabellids and posterior abdominal scissiparity. (a–c) Dorsal views, (d–g) ventral views, (h) lateral view. (a, d, e, h) *Branchiomma bairdi*, (b, f) *Demonax pallidus*, (c, g) *Megalomma coloratum*. Scale bars: 2 mm.

(Fig. 3a); mid-rib of dorsal lips olive-green, ventrum unpigmented. Body olive-green with small brown and white spots over entire surface; interramal dark spots large on first thoracic segments, becoming progressively smaller towards the posterior. Thin worm when alive, plump after relaxation-fixation (http://www.morphbank.net/Show/?pop=Yes&id=463994). Body length 16.98 ± 4.53 mm ($n = 100$; 6–25 mm), thorax width 2.35 ± 0.66 mm ($n = 100$; 1–4 mm) with 8 ± 1 segments ($n = 100$; 4–8 segments). Collar well separated dorsally (Fig. 2a); ventral lappets sub-triangular with rounded apices (Fig. 2e) (http://www.morphbank.net/Show/?pop=Yes&id=463998). Thoracic uncini avicular with main fang surmounted by 2–3 rows of teeth, occupying about one third to half of main fang length (Fig. 4b). Abdominal segments 53 ± 11 ($n = 100$; 20–72 segments).

GROWTH: The relationship between body length (y) and the total number of segments (x) is described by the power function $y = 0.8381x^{0.758}$ ($r = 0.517$, $P < 0.001$, $n = 100$) indicating continuous growth in *B. bairdi* (Fig. 5a). Body length (x) was significantly correlated with the branchial crown length (y), described by the power function $y = 0.72831x^{0.7898}$ ($r = 0.715$, $P < 0.001$, $n = 100$) (Fig. 5b).

REPRODUCTION: *Branchiomma bairdi* is a simultaneous hermaphrodite, with male and female gametes occurring in the same segments (Fig. 4a). Based on the sperm morphology (spherical nucleus, rounded cap-like acrosome and a long flagellum), Tovar-Hernández *et al.* (2009) suggested that this species is free-spawning with external fertilisation, an *ect-aquasperm* type. In 100 randomly selected specimens, 84% were sexually mature simultaneous hermaphrodites with the sex of the remaining 16% undefined (no gametes were identified). Oocytes were 237.1 ± 14.8 μm ($n = 953$; 75–1100 μm) in diameter. Some individuals had developing scissiparous offspring on posterior segments (Figs 2d, h). This regeneration is usually imperfect with some individuals having fewer (four) thoracic segments than the usual eight. This asexual mode is a reproductive mechanism common for colonial individuals and its occurrence in *B. bairdi* was not surprising because individuals from Mazatlán port were found isolated or in small aggregations (from 8 to 14 individuals).

REMARKS: The most distinctive character separating *B. bairdi* from other species from tropical America (*B. coheni* Tovar-Hernández & Knight-Jones, 2006, *B. conspersum* (Ehlers, 1887), *B. curtum* (Ehlers, 1901), *B. iliffei* Tovar-Hernández & Knight-Jones, 2006, *B. nigromaculatum* (Baird, 1865)) is the presence of slender springy radioles bearing long, strap-like macrostylodes on the distal half of the radiole. These are up to four (or more) times the length of the smallest stylode. They may vary in size amongst themselves, but they are always much longer than other stylodes on the radiole, including their immediate neighbours.

Branchiomma bairdi and *B. boholense* (Grube, 1878), an alien species fairly common in the Indo-West Pacific and Mediterranean Sea, have macrostylodes. In both species, the
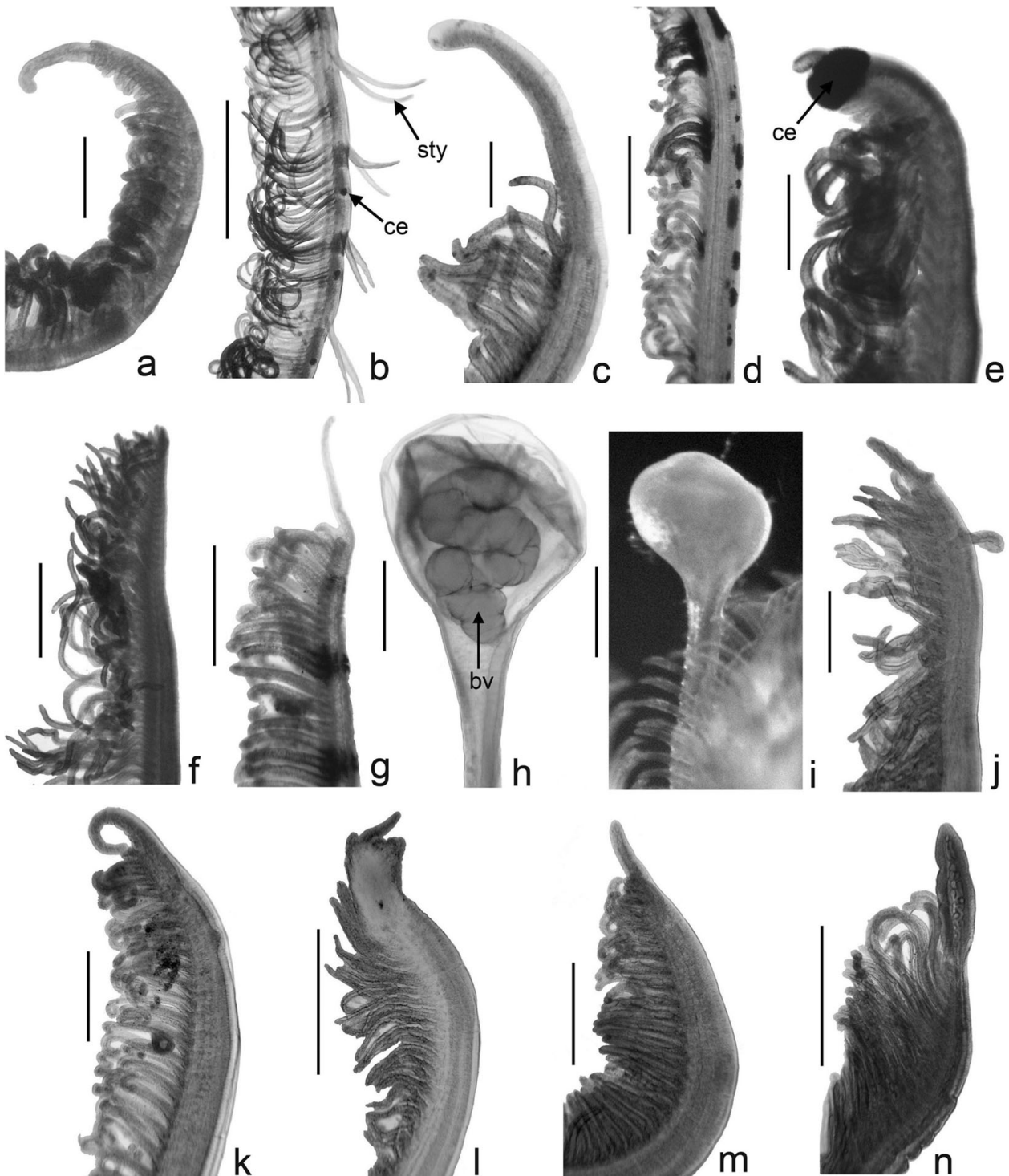
Figure 3 Radiolar tips, opercula and radiolar structures. (a, b) *Branchiomma bairdi*, (c, d) *Demonax pallidus*, (e, f) *Megalomma coloratum*, (g–i) *Ficopomatus miamiensis*, (j) *Hydroides brachyacanthus*, (k) *H. cruciger*, (l) *H. elegans*, (m) *H. recurvispina*, (n) *Vermiliopsis multiannulata*. Abbreviations: bv = blood vessel, ce = compound eye, sty = stylodes. Scale bars: a, b, d–g, j–n = 0.5 mm; c, h–i = 0.25 mm.

macrostylodes vary in size amongst themselves, somewhat irregularly, but in *B. boholense* they differ sharply from all the other stylodes, being tongue-like (flattened), while in *B. bairdi* the macrostylodes are strap-like, including the immediate neighbours.

Branchiomma bairdi was originally described from off the shores of Bermuda. Rioja (1951, 1958) recorded it as a frequent and abundant species along the entire Gulf of México littoral. Capa and López (2004) recorded *Branchiomma* cf. *bairdi* for the Pacific coast of Panama. They found some differences between the Pacific specimens and those described from the Atlantic Ocean related to the length of the branchial crown and dorsal lips, number of radioles and shape of breast on the thoracic uncini. After that, the authors were
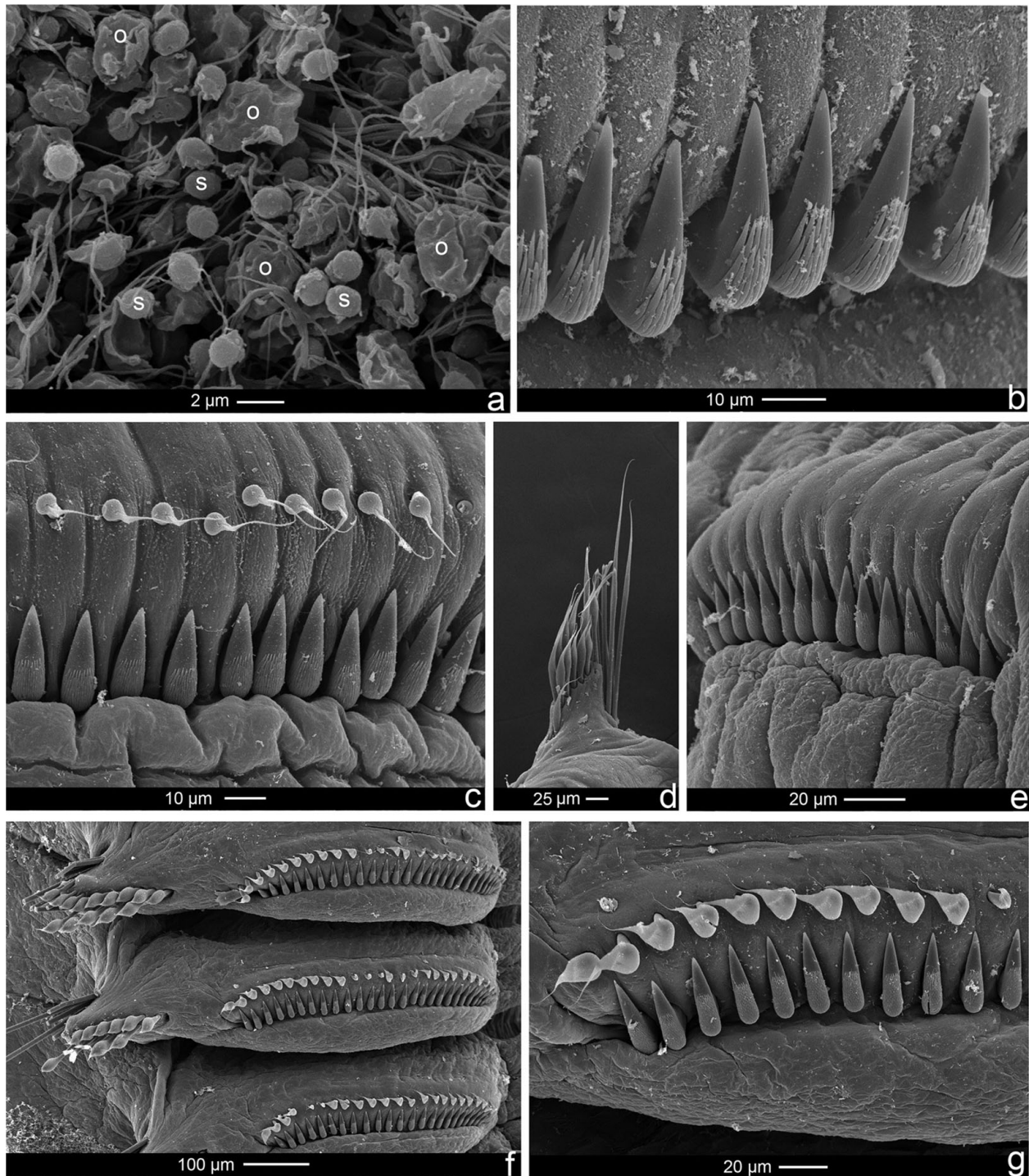
Figure 4 Spermatozoa, uncini and chaetae. (a) Spermatozoa and collapsed ovules from anterior abdomen, (b) thoracic uncini, (c, g) thoracic uncini and companion chaetae, (d) thoracic parapodium, (e) abdominal uncini, (f) thoracic noto- and neurochaeta. (a, b) *Branchiomma bairdi*, (c–e) *Demonax pallidus*, (f, g) *Megalomma coloratum*. Abbreviations: o = oocytes, s = spermatozoids.

cautious to assign this species as *B. bairdi*. However, based on the re-description of *B. bairdi* by Tovar-Hernández and Knight-Jones (2006) and taking into account the illustrations provided by Capa and López (2004) it could in fact, belong to *B. bairdi*, although re-examination of their specimens is needed to corroborate this hypothesis. In the Mexican Caribbean, *B. bairdi* is common in sheltered places, on dock pilings and on sea-grass beds to 1 m depth; it also has been reported from dock pilings on the Atlantic coasts of Panama, and on mangrove roots to 1 m depth in Aruba, Curaçao, Jamaica and Saint-Thomas (Tovar-Hernández & Knight-Jones, 2006). The highest abundances of *B. bairdi* in the Mazatlán port were found on metal buoys and hulls of vessels, occurring with seaweeds, sponges, ascidians and crustaceans. In contrast, few worms were found in metal pilings connected directly to the bottom and occurring with vermetids, on floating
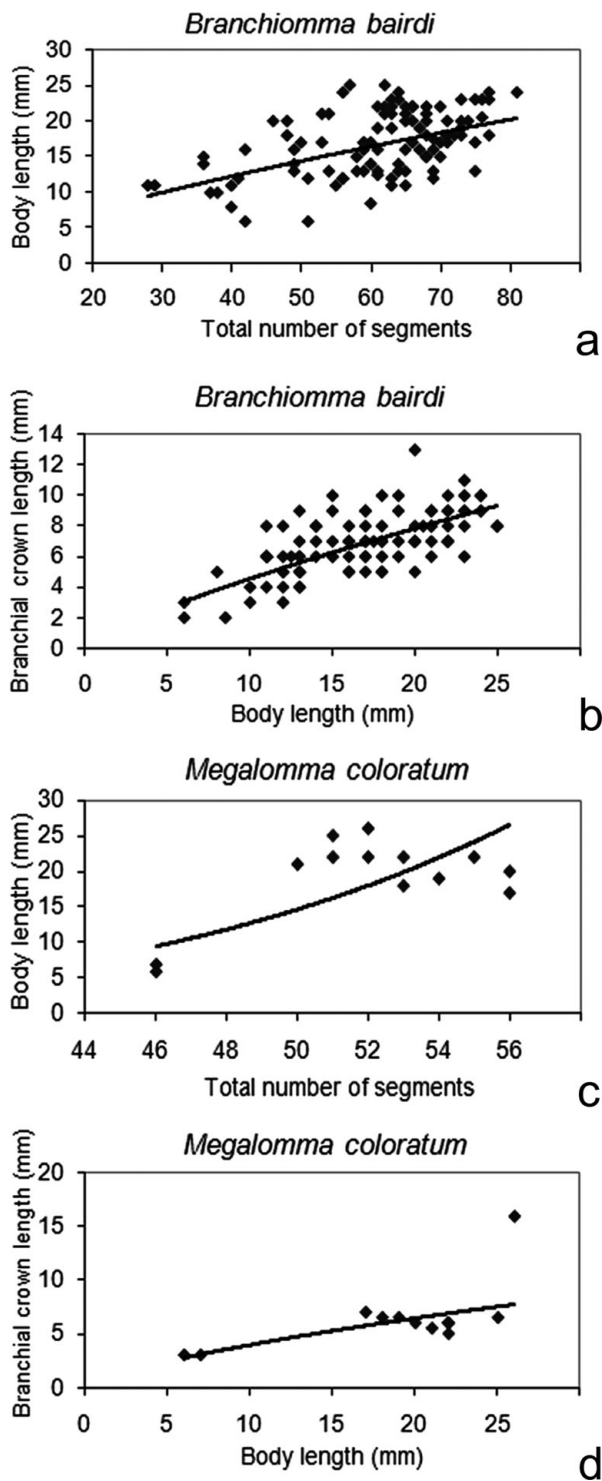
Figure 5 Relationships between biometrical features in some sabellids. (a, b) *Branchiomma bairdi*, (c, d) *Megalomma coloratum*.

docks occurring with barnacles and on a wood dock occurring with seaweeds. One of the sampled vessels is used for tourism purposes (game fish and tours around the Mazatlán Bay), while the second one is used for shrimp fishery, reaching Guatemala during the fishery season. Sabellid worms, being sessile marine invertebrates, are good model organisms for investigations of how predator deterrence (chemical, structural) and

avoidance (behavioural escape, refuge use) strategies may be integrated to persist in predator-rich environments. Kicklighter and Hay (2007) conducted a study using two ecologically relevant fishes and a crab. For comparison, *B. bairdi* relied less on behavioural escapes during sampling and when they were placed into the aquaria. Worms retracted their crowns partially and slowly until nearly being touched (50% of their radiole length was exposed). The worms and their tubes were very easily collected by plucking the intact worm and tube from the substrates to which they were attached. Thus, they would have been easier to detach and eat by consumers than other species. However, it seems that *B. bairdi* has chemical defences that prevent them from being a desirable choice for consumers (like the other two congeneric species) and can co-habit with other chemically defended species such as seaweeds, sponges and ascidians. However, to test this hypothesis, further research is certainly needed.

Branchiomma bairdi can be considered as a primary coloniser due to its hermaphrodite condition and because it has a short pelagic phase that may produce high population densities starting from only few individuals. Thus, due to the high densities of *B. bairdi* on the hull of ships and buoys on the Mazatlán port, its anti-predation strategies, and feeding mode, it could be considered that this invasive species ecologically impairs the environment.

Genus *Demonax* Kinberg, 1867

Demonax pallidus (Moore, 1923)
Figs 2b, f, 3c–d, 4c–e

Parasabella pallida Moore, 1923: 241, 242.– Loi, 1980: 144.
Sabella media. – Hartman, 1944: 285 [in part, not pl. 23, fig. 42] *fide* Perkins, 1984.
Demonax medius. – Hartman, 1969: 675, 676 [in part, not figs 1–5] *fide* Perkins, 1984.
Demonax pallidus .– Perkins, 1984: 313–315, figs 15–16.

MATERIAL EXAMINED: UNAM–ICML Cat. EMU–8514A, Sta. 12 (16 specs); EMU–8514B, Sta. 14 (3 specs); EMU–8514C, Sta. 15 (73 specs); EMU–8514D, Sta. 18 (15 specs); EMU–8514E, Sta. 19 (4 specs); EMU–8514F, Sta. 20 (12 specs); EMU–8514G, Sta. 21 (3 specs); EMU–8514H, Sta. 24 (1 spec.).

CHARACTERISATION: Leathery tubes, covered with fine sediment. Crown with brown bands, each band extending over three pinnules, colour extending onto pinnules; radiolar rachis with numerous brown-coloured spots (ocelli), unequal in size, distributed irregularly along radiolar length (Fig. 3d) (http://www.morphbank.net/Show/?pop=Yes&id=463984); branchial crown length 5.45 ± 1.34 mm ($n = 10$; 3–7.5 mm); radiolar pairs 14 ± 2 ($n = 10$; 11–17 pairs); radiolar tips (Fig. 3c) with broad flanges (http://www.morphbank.net/Show/?pop=Yes&id=463999), some as tongue-like tips; dorsal lips with pinnular and radiolar appendages. Body plump, cream-coloured (http://www.morphbank.net/Show/?pop=Yes

&id=463983). Body length 15.15 ± 4.98 mm (*n* = 10; 8–22 mm), thorax width 1.93 ± 0.34 mm (*n* = 10; 1.2–2.2 mm) with 8 ± 0 segments (*n* = 10; 8–8 segments). Collar well separated dorsally (Fig. 2b); ventral lappets sub-triangular with rounded apices, separated (Fig. 2f); ventral shield of collar rectangular, three times wider than long, incised anterior-medially (Fig. 2f). Thoracic tori contacting ventral shields (Fig. 2f); thoracic ventral shields trapezoidal with broader anterior margins; shields gradually wider posteriorly; inferior thoracic chaetae broadly hooded with long mucronate tips (Fig. 4d) about half the total length of remaining hooded region, arranged in two transverse rows, blades broader and shorter in anterior of bundles (Fig. 4d); thoracic uncini avicular with equal-size teeth above main fang and covering half of the main fang length (Fig. 4c), breast well developed, manubrium of moderate length; companion chaetae with very long, tapered mucros (Fig. 4c). Abdominal segments 50 ± 10 (*n* = 10; 27–64 segments); abdominal uncini with equal-size teeth above main fang (Fig. 4e), similar to those in thorax but shorter. Pygidium rounded with irregularly arranged eyespots.

GROWTH: Body length was not significantly correlated with total number of segments or branchial crown length; although the sample size was low (*n* = 10).

REPRODUCTION: Simultaneous hermaphrodites with male and female gametes developed in the same segments, from the 8th thoracic chaetiger to the entire abdomen. Gametes fill the ventral side of mesenteries in anterior abdomen, but the germinal products fill the entire coelom cavity in the posterior abdomen. Fully developed oocytes were found in dense packages with sperm tissue in the coelom. Oocytes diameter 103.3 ± 12.9 μm (*n* = 67; 91.3–132.8 μm). The mature spermatozoa have a diameter of 2 μm with a spherical nucleus, subtriangular cap-like acrosome, four mitochondria and a long flagellum of about 20 μm. This sperm morphology suggests that the species is a free-spawner with external fertilisation or an *ectaquasperm* type.

REMARKS: *Demonax pallidus*, described from Santa Cruz, California, by Moore (1923) and *D. medius* (Bush, 1905), a species described from Kodiak, Alaska, differ in the number of radiolar skeletal cells in cross section (10 or fewer in *D. pallidus*, 20–60 in *D. medius*) and the shape of inferior thoracic, broadly hooded, chaeta (a very short hooded region and long mucronate tip about half total length of remainder hooded region in *D. pallidus* and moderate short with hooded part including tip about twice broader than shaft and 5–7 times longer than broad in *D. medius*). Rioja (1962) reported one specimen from Islas de Cedros, at the Mexican Pacific as *D. medius*. However, the characters described and illustrated for this nominal taxon by Rioja are consistent with those mentioned above, thus, his specimen could in fact, belong to *D. pallidus*. Unfortunately, this cannot be corroborated because his collection has been lost. In this study, *D. pallidus* constitutes the first record for México, being common as hull fouling. The species is native in the Californian Province, distributed from Mazatlán to southern California (USA).

Genus *Megalomma* Johansson, 1925

Megalomma coloratum (Chamberlin, 1919)
Figs 2c, g, 3e–f, 4f–g, 5c–d

Potamilla colorata Chamberlin, 1919: 21.
Megalomma coloratum.– Knight-Jones, 1997: 318, figs 2M–T.

MATERIAL EXAMINED: UNAM–ICML Cat. EMU–8522A, Sta. 1 (1 spec.); EMU–8522B, Sta. 4 (1 spec.); EMU–8522C, Sta. 7 (5 specs); EMU–8522D, Sta. 8 (3 specs); EMU–8522, Sta. 9 (1 spec.); EMU–8522F, Sta. 12 (1 spec.); EMU–8522G, Sta. 13 (1 spec.); EMU–8522H, Sta. 14 (2 specs); EMU–8522I, Sta. 21 (6 specs).

CHARACTERISATION: Tubes covered with fine sand grains. Branchial crown length 6.38 ± 3.15 mm (*n* = 13; 3–16 mm); radiolar pairs 18 ± 3 (*n* = 13; 9–22 pairs); radioles with several narrow red bands distributed over outer and lateral radiole margins and adjacent pinnules, each colour band extending for 4–6 pinnules; radiolar basis olive-green; sub-distal compound eyes present in dorsal-most pair of radioles, distinctly larger and spherical (Fig. 3e) (http://www.morphbank.net/Show/?pop=Yes& id=464009); fifth dorsal most radiolar pair with spherical eyes distinctly smaller than dorsal most ones and medium-sized filiform radiolar tips (http://www.morphbank.net/Show/?pop=Yes&id=464011); other radioles with very short, digitiform tips (Fig. 3f). Body olive-green with ventral shields cream coloured; thorax with white spots dorsally, mainly surrounding the lateral margins of faecal groove, also dispersed in thoracic dorsal epithelium; a dorsal, broad whitish glandular ring on segment 3 (Fig. 2c) (http://www. morphbank.net/Show/?pop=Yes&id=464010). Specimens medium-sized and plump (http://www.morphbank. net/Show/?pop=Yes&id=464005). Body length 19 ± 6 mm (*n* = 13; 6–26 mm), thorax width 3 ± 1 mm (*n* = 13; 1.5–3.5 mm) with 8 ± 0 segments (*n* = 13; 8–8 segments). Mid-dorsal collar margins fused to faecal groove, forming a broad gap (Fig. 2c); ventral lappets rounded, not overlapping (Fig. 2g) (http://www.morphbank.net/Show/?pop=Yes&id= 464013); dorsal pockets well developed, 'U-shaped' (Fig. 2c) (http://www.morphbank.net/Show/?pop=Yes&id=464007). Notopodial fascicles with a superior group of elongate, narrowly hooded chaetae, a median group of short, narrowly hooded chaetae, and two inferior rows of thoracic broadly hooded chaetae (Fig. 4f); thoracic uncini with main fang surmounted by 8–10 rows of numerous minute teeth, occupying one half of the main fang length (Fig. 4g), breast well developed, manubrium long; companion chaetae with membranous, tear-drop shaped distal end, perpendicular to slender shaft (Fig. 4g). Abdominal segments 44 ± 3 (*n* = 13; 38–48 segments); abdominal neuropodia with two transverse rows of elongate, narrowly hooded chaetae; chaetae in posterior row longer than those in anterior row; abdominal notopodia with avicular uncini, main fang surmounted by 8–10 rows of numerous minute teeth; breast well developed; manubrium reduced. Three groups of 4–5 red pygidial eyespots, unequal in size.

GROWTH: The relationship between the body length (y) and the total number of segments (x) is described by the power function $y = 2E\text{-}08x^{5.2359}$ ($r = 0.724$, $P < 0.01$, $n = 13$) indicating a continuous growth in *M. coloratum* (Fig. 5c). Body length (x) was significantly correlated with the branchial crown length (y) and is described by the power function $y = 0.8195x^{0.6866}$ ($r = 0.773$, $P < 0.01$, $n = 13$) (Fig. 5d).

REPRODUCTION: Several mature females with oocytes visible through the abdominal epithelium between chaetiger and torus. Early and fully developed oocytes were found free-floating in the coelom along the entire abdomen, apparently having undergone vitellogenesis in the coelom (extraovarian oogenesis) as indicated by change in shape (rounded to polygonal) and the appearance of the cytoplasm. Oocyte diameter 109.7 ± 92.5 μm ($n = 66$; 41.5–166 μm). Spermatozoa with a spherical nucleus, subtriangular cap-like acrosome, four mitochondria and long flagellum.

REMARKS: *Megalomma coloratum* was described originally for Laguna Beach, California by Chamberlin (1919). The most distinctive character separating *M. coloratum* from other species from the tropical Eastern Pacific (*M. carunculata* Tovar-Hernández & Salazar-Vallejo, 2008, *M. circumspectum* (Moore, 1923), *M. gesae* Knight-Jones, 1997, *M. pacifici* Grube, 1859 and *M. pigmentum* Reish, 1963) is the presence of a dorsal, broad whitish glandular ring on segment 3. This constitutes the first record for México, as a very common hull fouling. The species is native in the Californian Province, known from Mazatlán and southern California (USA).

Family SERPULIDAE Rafinesque, 1815

Genus *Ficopomatus* Southern, 1921

Ficopomatus miamiensis (Treadwell, 1934)
Figs 3g–i, 6a, 7a–c

Sphaeropomatus miamiensis Treadwell, 1934: 339–341, figs 1–5, 9.
Ficopomatus miamiensis.– ten Hove & Weerdenburg, 1978: 106–109, figs 1f–i, 3c, 4h–i, q, v–w, ee–ii, xx, 5a–b.– Bastida-Zavala, 2008: 19, 21, figs 5B–D.

MATERIAL EXAMINED: UNAM–ICML Cat. EMU–8515, Sta. 11 (+300 specs); EMU–8516, Sta. 25 (+500 specs).

CHARACTERISATION: Tubes gregarious (http://www.morphbank.net/Show/?pop=Yes&id=462764), white, 3–5 peristomes, < 1 mm diameter, < 25 mm length, lacks longitudinal ridges or alveoli (http://www.morphbank.net/Show/?pop=Yes&id=462762). Branchial crown length 1.94 ± 0.33 mm ($n = 50$; 1.4–3.1 mm); radiolar pairs 8 ± 1 ($n = 50$; 7–9 pairs); radiolar tips filiform, long (Fig. 3g); radioles olive-green with 4–5 purple bands distributed over outer and lateral radiole margins and adjacent pinnules, each band extending over 2–3 pairs of pinnules (Fig. 3g). Peduncle and operculum yellow to olive green (http://www.morphbank.net/Show/?pop=Yes&id=462763); operculum spherical, smooth, without spines (Figs 3h–i); opercular blood vessel always visible in fresh material (http://www.morphbank.net/Show/?pop=Yes&id=463973), often in preserved material (Fig. 3h) (http://www.morphbank.net/Show/?pop=Yes&id=462765); no opercular duplicity observed ($n = 50$). Body length 11.11 ± 2.21 mm ($n = 50$; 7.5–19 mm), thorax width – excluding thoracic membrane – 0.95 ± 0.14 mm ($n = 50$; 0.6–1.2 mm) with 7 ± 0 segments ($n = 50$; 7–7 segments); thorax brown to olive-green, thoracic membranes translucent, united ventrally on the anterior abdominal segments. Collar entire ventrally (Fig. 7a); chaetae with coarse curve teeth alongside the distal part of chaetae. Long thoracic chaetae narrowly limbate (Fig. 7b); thoracic uncini saw-shaped with 6–8 curved teeth (Fig. 7c), the most anterior one is gouged and apparently bifurcated. Abdominal segments 57 ± 4 ($n = 50$; 48–64 segments); abdomen cream-coloured; anterior two or three segments apparently lack chaetae or uncini, subsequent segments have very few uncini (5–10); anterior abdominal uncini partly rasp-shaped and partly saw-shaped; eight or nine teeth visible in profile, including anterior gouged tooth; posterior abdominal uncini smaller, rasp-shaped, with 3–4 rows of small curved teeth, with about 12 teeth visible in profile, including anterior gouged tooth; abdominal chaetae truly trumpet-shaped.

GROWTH: Body length (y) was significantly correlated with the total number of segments (x) through the power function $y = 0.0333x^{1.3904}$ ($r = 0.544$; $P < 0.001$; $n = 50$) (Fig. 6a); its correlation with the branchial crown length was non-significant.

REPRODUCTION: Three worms with tubes were placed in a Petri dish to document live colouration. Three minutes later, two ripe females emitted numerous small ova, diameter 43 ± 13 μm ($n = 119$; 12–68 μm). About one minute later the neighbouring third individual began to emit a thin greyish cloud similar to smoke rings from the centre of its radioles. These spermatozoa had a spherical nucleus, a rounded, cap-like acrosome, four mitochondria and a very long flagellum (up to eight times the nucleus diameter). Based on body colour, *Ficopomatus miamiensis* does not show sexual dimorphism. From the 50 specimens selected from station 11, 96% were sexually mature (72% females, 24% males), while the sex of the other 4% was undefined (no gametes were identified). Gametes in mature specimens are distributed mostly from the median abdomen to the posterior abdomen, although in a few specimens, gametes extended into the anterior abdomen. According to Lacalli (1977), *F. miamiensis* is a free-spawning species with planktotrophic larval development. Hermaphroditism has not been recorded in this species, but hermaphroditism appears to be significantly under-reported in serpulids because studies of fouling serpulins often reveal sequential (protandric) hermaphroditism with a very short intermediate stage (Kupriyanova *et al.*, 2001). Therefore, hermaphroditism in *F. miamiensis* cannot be discounted.
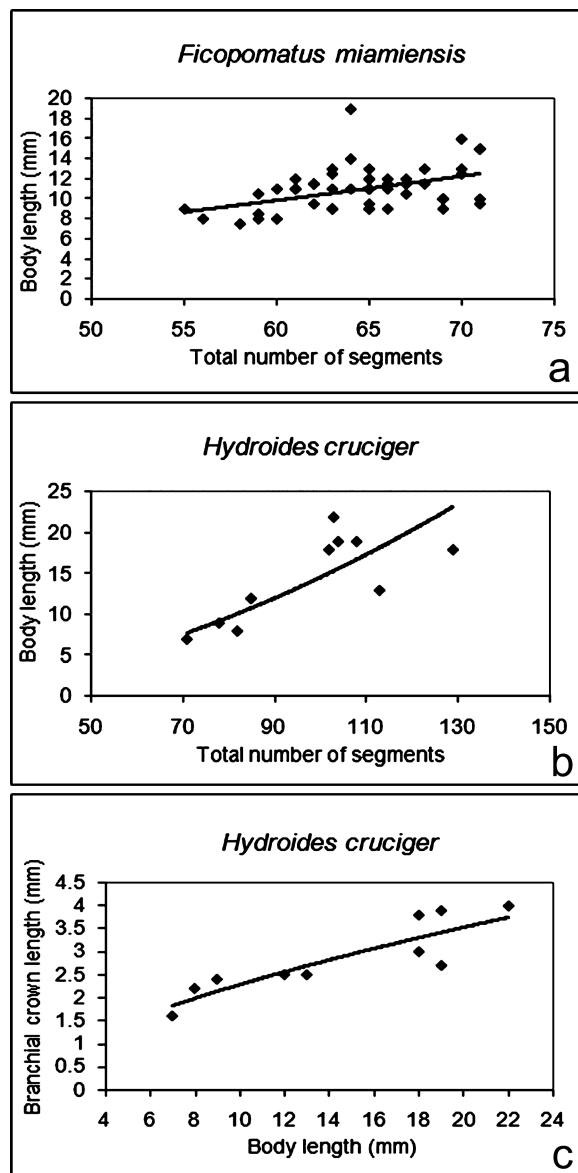
Figure 6 Relationships between biometrical features in some serpulids. (a) *Ficopomatus miamiensis*, (b, c) *Hydroides cruciger*.

REMARKS: *Ficopomatus miamiensis* differs from the invasive reef-forming *F. enigmaticus* by having an operculum spherical, smooth, without spines (fig-like with horny distal plate and some rows of black spines, curving inwards and sometimes with internal spinules in *F. enigmaticus*).

Ficopomatus miamiensis was originally described from the Miami River, Florida by Treadwell (1934). Its distribution was restricted to the Atlantic tropical and subtropical areas in North and Central America, and a more or less isolated locality at the Pacific end of the Panama Channel (ten Hove & Weerdenburg, 1978). *Ficopomatus miamiensis* was recorded for the Mexican Pacific in the shrimp farm 'Don Jorge' and adjacent arms of the Urías Estuary in 2004 (Salgado-Barragán *et al.*, 2004). However, the first visual records of the tubeworm in the shrimp containers date back to 30 years ago, when shrimp larvae of *Litopenaeus vannamei* (Boone) from the farms in

Panama and El Salvador were often transported towards the Gulf of California (veteran workers, pers. comm.). Presently, *F. miamiensis* forms true reef colonies in shrimp culture containers and small aggregates on the mangrove roots in the adjacent arms to the farm drain channel, where it lives with the mussel *Mytella strigata* (Hanley, 1843). The associated polychaete families living among the pseudocolony branches include Dorvilleidae, Eunicidae, Nereididae, Phyllodocidae, Spionidae and Syllidae.

Presently, the 'Don Jorge' shrimp farm has two culture cycles per year. To prepare the ponds for each culture cycle, they are emptied, dried and sediments are removed. Once clean, the ponds are filled with water from the adjacent estuary and afterwards the shrimp post larvae are sown. The culture season lasts five months, during which numerous massive colonies of *F. miamiensis* form complete mats in the culture containers (http://www.morphbank.net/Show/?pop= Yes&id=463963) and on wood pilings (http://www.morphbank.net/Show/?pop=Yes&id=463969). This suggests that *F. miamiensis* larvae from the adjacent estuary are transported to the ponds during filling and water exchange over the whole culture cycle.

On the other hand, shrimp production has not shown a negative effect due to the size and high number of *F. miamiensis* colonies established in the ponds. The lack of chaetae or worm fragments in the stomach content of 10 shrimps analysed suggested that these crustaceans do not feed on *F. miamiensis*. At the same time, this filter-feeder serpulid can probably partly feed on non-consumed shrimp food and faeces. This fact and the lack of natural predators or space competitors enhance its opportunistic character with high growth rates during the shrimp culture cycle. Despite the high abundance and distribution of *F. miamiensis* observed inside the ponds, its presence is periodic and does not produce any harm to the cultured shrimps. Nevertheless, in the mangrove roots from the adjacent estuary, small patches of *F. miamiensis* are present mostly in the entire year but its effects in the colonised habitat are still unknown.

Sinaloa state has the highest shrimp aquaculture development in the country, with 488 farms recorded in 2006 (Comisión Nacional de Acuacultura y Pesca, 2006). Likewise Sinaloa has a large number of coastal ecosystems such as bays, estuaries and lagoons, 20 of them are directly associated with shrimp aquaculture activities (Ruíz & Berlanga, 2001). Unfortunately, no efforts have been undertaken to determine whether this species has established in other shrimp farms and/or coastal systems in the Gulf of California.

Genus *Hydroides* Gunnerus, 1768

Hydroides brachyacanthus Rioja, 1941
Figs 3j, 7d–f

Hydroides brachyacantha Rioja, 1941a: 169–172, pl. 3, fig. 2, pl. 4, figs 1–9.

Hydroides brachyacanthus.– Bastida-Zavala & ten Hove, 2003: 73–76, figs 3A–M, 7A–F.– Çinar, 2006: 225–226, fig. 2.– Bastida-Zavala, 2008: 22–23, fig. 6C.
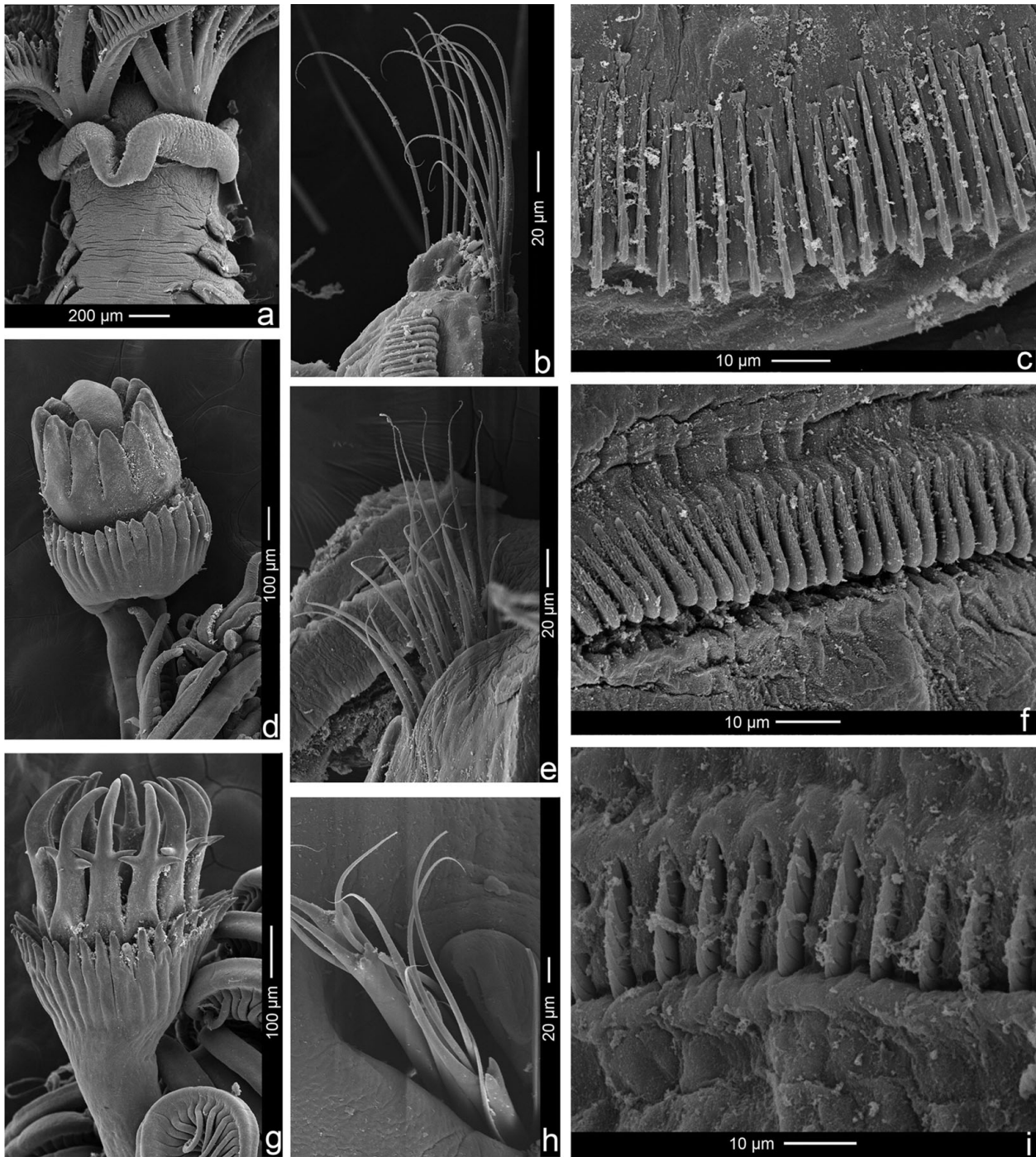
Figure 7 Collar, opercula, chaetae and uncini. (a) Collar in ventral view, (b, e) thoracic chaetigers, (c) thoracic uncini, (d, g) opercula, (f, i) abdominal uncini, (h) bayonet chaetae. (a–c) *Ficopomatus miamiensis*, (d–f) *Hydroides brachyacanthus*, (g–i) *Hydroides cruciger*.

MATERIAL EXAMINED: UNAM–ICML Cat. EMU–8517A, Sta. 2 (1 spec.); EMU–8517B, Sta. 3 (3 specs); EMU–8517C, Sta. 7 (3 specs); EMU–8517D, Sta. 8 (2 specs); EMU–8517E, Sta. 12 (1 spec.); EMU–8517F, Sta. 14 (12 specs); EMU–8517G, Sta. 15 (5 specs); EMU–8517H, Sta. 16 (6 specs).

CHARACTERISATION: Tubes white, with transversal ridges, without peristomes, frequently covered with epibionts. Branchial crown length 1.6 ± 0.39 mm ($n = 10$;

1.1–2.2 mm); radiolar pairs 10 ± 2 ($n = 10$; 8–13 pairs); radiolar tips digitiform, short (Fig. 3j); branchial crown alternating white and brown coloured bands distributed over outer and lateral radiole margins and adjacent pinnules, each band extending over 3–4 pairs of pinnules (http://www.morphbank.net/Show/?pop=Yes&id=464016). Peduncle with a shallow to well-defined constriction; funnel reddish to purple with 28–34 radii and pointed tips; verticil without central tooth (Fig. 7d) and with 9–10 amber to yellow spines strongly curving inwards; dorsal spine notably bigger

than the others, covering the central disc (Fig. 7d), other spines similar in shape and size, with pointed tip and a knob (http://www.morphbank.net/Show/?pop=Yes&id=467689); spines with one short basal internal spinule, sometimes long or lacking; without external and lateral spinules and or wings; pseudoperculum in five specimens (50%, $n = 10$) (http://www.morphbank.net/Show/?pop=Yes&id=467688). Thoracic membrane translucent, with a short apron across the first abdominal segment; thorax and abdomen cream-coloured. Body length 8.35 ± 2.39 mm ($n = 10$; 3.5–11 mm); thorax width excluding thoracic membrane 0.72 ± 0.20 mm ($n = 10$; 0.5–1.2 mm) with 7 ± 0 segments ($n = 50$; 7–7 segments). Collar chaetae bayonet with two pointed-elongate teeth at the base of the smooth distal limbate zone and very narrowly limbate chaetae (capillary). Thorax with narrowly limbate chaetae (Fig. 7e) and saw-shaped uncini. Abdominal segments 80 ± 11 ($n = 10$; 65–95 segments); anterior and mid-abdomen with flat-trumpet chaetae; posterior abdominal segments with very narrowly limbate chaetae; uncini from anterior abdomen saw-shaped, posterior abdomen with uncini rasp-shaped (Fig. 7f).

GROWTH: The correlations between body length, total number of segments and branchial crown length were not significant; although the sample size was low ($n = 10$).

REPRODUCTION: Gonochoric, broadcast spawning species lacking sexual dimorphism. Spermatozoa with spherical nucleus, rounded acrosome and long flagellum. Fully developed oocyte diameter 44.0 ± 4.1 µm ($n = 70$; 41.5–58.1 µm).

REMARKS: Mazatlán, Sinaloa, México, is the type locality for *Hydroides brachyacanthus*, where it is a native and very common fouling species. *Hydroides brachyacanthus* has an operculum with dorsal spine notably bigger than other spines, covering the central disc. This character clearly separates *H. brachyacanthus* from the otherwise similar species *H. similis* (Treadwell, 1929), described from Baja California, showing 2–4 hooks. Moreover, *H. brachyacanthus* has 9–10 verticil spines against 11–16 in *H. similis*. The operculum of *H. brachyacanthus* is also similar to that of *H. deleoni* Bastida-Zavala & ten Hove, 2003 (described from Baja California Sur); however, *H. brachyacanthus* has a knob in the spines, which lacks in *H. deleoni*.

The nominal species *H. brachyacanthus* and a number of closely resembling taxa have been reported from tropical and subtropical localities all around the world, as discussed by Imajima and ten Hove (1984). Bastida-Zavala and ten Hove (2002) recognised that *H. brachyacanthus* is either a taxon with a long record of being ship-transported, or it belongs to a complex of species, where only a revision of all material will permit clarification of its taxonomic status. The specimens reviewed in this study fall within both the original description provided by Rioja (1941a) and the variability given in Bastida-Zavala & ten Hove (2003) for specimens reported from the region comprising the Western coast of Baja California Sur, Gulf of California to Ecuador.

Hydroides cruciger Mörch, 1863
Figs 3k, 6b–c, 7g–i

Hydroides (*Eucarphus*) *crucigera* Mörch, 1863: 378, pl. 11, fig. 8.
Hydroides cruciger.– Bastida-Zavala & ten Hove, 2003: 78–80, figs 5A–Q.– Bastida-Zavala, 2008: 23, fig. 6E.
Hydroides crucigera.– Álvarez-León, 2007: 35.

MATERIAL EXAMINED: UNAM–ICML Cat. EMU–8518A, Sta. 1 (3 specs); EMU–8518B, Sta. 2 (1 spec.); EMU–8518C, Sta. 3 (6 specs); EMU–8518D, Sta. 4 (3 specs); EMU–8518E, Sta. 6 (7 specs); EMU–8518F, Sta. 7 (7 specs); EMU–8518G, Sta. 8 (3 specs); EMU–8518H, Sta. 9 (2 specs); EMU–8518I, Sta. 14 (24 specs); EMU–8519, Sta. 15 (55 specs); EMU–8518J, Sta. 16 (2 specs); EMU–8518K, Sta. 20 (3 specs); EMU–8518L, Sta. 24 (2 specs).

CHARACTERISATION: Tubes white covered with epibionts, lacking peristomes (http://www.morphbank.net/Show/?pop=Yes&id=464023). Branchial crown length 2.86 ± 0.80 mm ($n = 10$; 1.6–4 mm); radiolar pairs 20 ± 4.1 ($n = 10$; 11–26 pairs); radiolar tips filiform, short (Fig. 3k); radioles with 3–4 brown to purple bands distributed over outer and lateral radiole margins and adjacent pinnules, each band extending over 2–3 pairs of pinnules. Peduncle with a shallow constriction and three narrow black bands along entire length (http://www.morphbank.net/Show/?pop=Yes&id=464019); funnel reddish (http://www.morphbank.net/Show/?pop=Yes&id=464018) with 26 radii with pointed tips (Fig. 7g); verticil with 11–13 amber-yellow spines, curving inwards; all spines similar in shape and size with pointed tips; spines with one short to long basal internal spinule, without external spinules; with one pair or well-developed lateral spinules in the middle section of the spines (http://www.morphbank.net/Show/?pop=Yes&id=464022), without wings (Fig. 7g); verticil without central tooth; opercular duplicity (100%, $n = 10$) (http://www.morphbank.net/Show/?pop=Yes&id=464021). Thoracic membrane well developed and translucid, with a short apron across the first two abdominal segments; thorax and abdomen cream-coloured. Body length 14.5 ± 5.36 mm ($n = 10$; 7–22 mm), thorax width 1.98 ± 0.35 mm ($n = 10$; 1.4–2.5 mm) with 7 ± 0 segments ($n = 10$; 7–7 segments). Collar chaetae bayonet with two blunt-short teeth, distal blade smooth (Fig. 7h) and narrowly limbate chaetae. Thorax with narrowly limbate chaetae of two sizes; thoracic uncini saw-shaped with 6–7 teeth. Abdominal segments 91 ± 18 ($n = 10$; 64–122 segments); anterior and middle abdominal chaetigers with flat-trumpet chaetae; posterior abdominal chaetigers with narrowly limbate chaetae; anterior abdominal uncini saw-shaped (Fig. 7i); posterior abdominal uncini rasp-shaped.

GROWTH: The relationship between body length (y) and the total number of segments (x) is described by the power function $y = 0.0033x^{1.824}$ ($r = 0.832$; $P < 0.01$; $n = 10$) suggesting continuous growth (Fig. 6b). Body length (x) is significantly correlated with the branchial crown length (y), through the

power function $y = 0.537x^{0.6284}$ (r = 0.892; $P < 0.001$; $n = 10$) (Fig. 6c).

REPRODUCTION: Gonochoric, broadcast spawning species, without sexual dimorphism. Spermatozoa length 2.49 μm (excluding flagellum), with spherical nucleus, rounded acrosome and a long flagellum. Fully developed oocytes, diameter: 48.8 ± 7.4 μm ($n = 65$; 33.2–58.1 μm).

REMARKS: *Hydroides cruciger* was described from Punta Arenas, Costa Rica, by Mörch (1863). *Hydroides cruciger*, *H. chilensis* Hartmann-Schröder, 1962, and *H. panamensis* Bastida-Zavala & ten Hove, 2008, have incurving verticil spines with one pair of lateral spinules. In *H. cruciger* and *H. chilensis* those spinules are always in lateral position, while they shift to a more external position in the ventral spines of *H. panamensis*. *Hydroides cruciger* differs from *H. chilensis* by the presence of a radial symmetric arrangement of the verticil spines, as opposed to the asymmetric arrangement in *H. chilensis* (larger dorsally). *Hydroides cruciger* is distributed from Baja California to the Colombian Pacific, and recently it was reported in Hawaii (Bastida-Zavala, 2008).

Hydroides elegans (Haswell, 1883)
Figs 3l, 8a–c

Eupomatus elegans Haswell, 1883: 633, pl. 12, fig. 1.
Hydroides elegans.– Bastida-Zavala & ten Hove, 2003: 86–87, figs 11A–S.– Çinar, 2006: 226–227, figs 3D, E.– Bastida-Zavala, 2008: 25–26, fig. 6H.

MATERIAL EXAMINED: UNAM–ICML Cat. EMU–8520A, Sta. 14 (3 specs); EMU–8520B, Sta. 15 (2 specs).

CHARACTERISATION: Tube white with transversal ridges, with or without peristomes and longitudinal ridges. Branchial crown length: 2.1–2.5 mm; eleven pairs of radioles with small, filiform tips (Fig. 3l); radioles purple with broad orange band located medially. Funnel with 28–31 radii with blunt tips; verticil with three yellow to hyaline spines, straight; all spines similar in shape and size with pointed tip (Fig. 8a); spines with one to four internal spinules and two to five pairs of lateral spinules without external spinules or wings (Fig. 8a); verticil with central tooth of variable shape and with numerous spinules. Thorax and abdomen cream-coloured. Body length: 13–14 mm, thorax width: 0.7–0.9 mm with seven segments. Collar with bayonet chaetae with two or four pointed-short teeth and proximal rasp, distal blade with many denticles; narrowly limbate chaetae (Fig. 8b). Thoracic membrane with a long apron across the first four abdominal segments; thorax with narrowly limbate chaetae and saw-shaped uncini (Fig. 8c). Abdominal segments 63–68; anterior and mid-abdominal chaetigers with flat-trumpet chaetae, posterior abdominal chaetigers with very elongate, narrowly limbate chaetae; anterior and posterior abdominal uncini saw-shaped.

GROWTH: The small number of individuals did not permit the determination of morphometric correlations.

REPRODUCTION: Gametes were not detected in any of the examined specimens; however, Carpizo-Ituarte and Hadfield (1998) recorded that *H. elegans* is a free-spawner, with planktotrophic development, sperm with a spherical nucleus and eggs with a diameter of 45–53 μm. *Hydroides elegans* is one of the best studied polychaete in terms of reproduction and larval development, in fact, it is an excellent model organism for biofouling experimental research because of its rapid generation time (∼3 weeks) and easy propagation (Nedved & Hadfield, 2008).

REMARKS: *Hydroides elegans* differs from the temperate European *H. norvergicus* (Gunnerus, 1768) in the shape of collar chaetae: with a proximal rasp in *H. elegans*, lacking in *H. norvergicus*. *Hydroides elegans* was described from Port Jackson, Australia and it has been regarded to be an invasive, ship-transported species (Zibrowius, 1994) in its new localities; however, the distribution is generally limited to polluted harbours and lagoons (ten Hove, 1974). It has been recorded for the Caribbean and Gulf of México (Bastida-Zavala & ten Hove, 2002), the Turkish Levantine coast (Çinar, 2006), Hawaii and California (Bastida-Zavala, 2008). This constitutes the first record for Mazatlán port where only five specimens were collected, which suggests that it is not an invasive species in this locality; nevertheless, Bastida-Zavala (2008) examined more than 1000 specimens covering the surface of a PVC plate in 85–90% in Baja California Sur, which is not surprising since *H. elegans* is often the significant animal biofouler on newly submerged surfaces, its calcareous tubes can accumulate rapidly and create serious problems for ships (Nedved & Hadfield, 2008). Under this scenario, it is needed to impel monitoring programs to determine fluctuations on the distribution of *H. elegans* in the Gulf of California.

Hydroides recurvispina Rioja, 1941
Figs 3m, 8d–f

Hydroides recurvispina Rioja, 1941a: 167–169, pl. 1, figs 11–15; text figs 1a–c.
Hydroides recurvispina.– Bastida-Zavala & ten Hove, 2003: 99–101, figs 19A–O, 23.– Bastida-Zavala, 2008: 28, fig. 6P.

MATERIAL EXAMINED: UNAM–ICML Cat. EMU–8521A, Sta. 2 (1 spec.); EMU–8521B, Sta. 14 (11 specs); EMU–8121C, Sta. 15 (19 specs); EMU–8521D, Sta. 16 (2 specs).

CHARACTERISATION: Tube white without peristomes, with transversal and three longitudinal ridges. Branchial crown length 2.39 ± 0.77 mm ($n = 10$; 1.5–3.8 mm); radiolar pairs 15 ± 4 ($n = 10$; 9–19 pairs); radiolar tips digitiform, short (Fig. 3m); branchial basal lamina purple; radioles with narrow purple bands alternating with white narrow bands, each extending over 3–4 pinnules (http://www.morphbank.net/Show/?pop=Yes&id=464025). Operculum amber; peduncle with a well-defined constriction; funnel with 26–29 radii with pointed tips; verticil with 8–10 yellow spines, straight, with tips twisted clockwise (Fig. 8d);
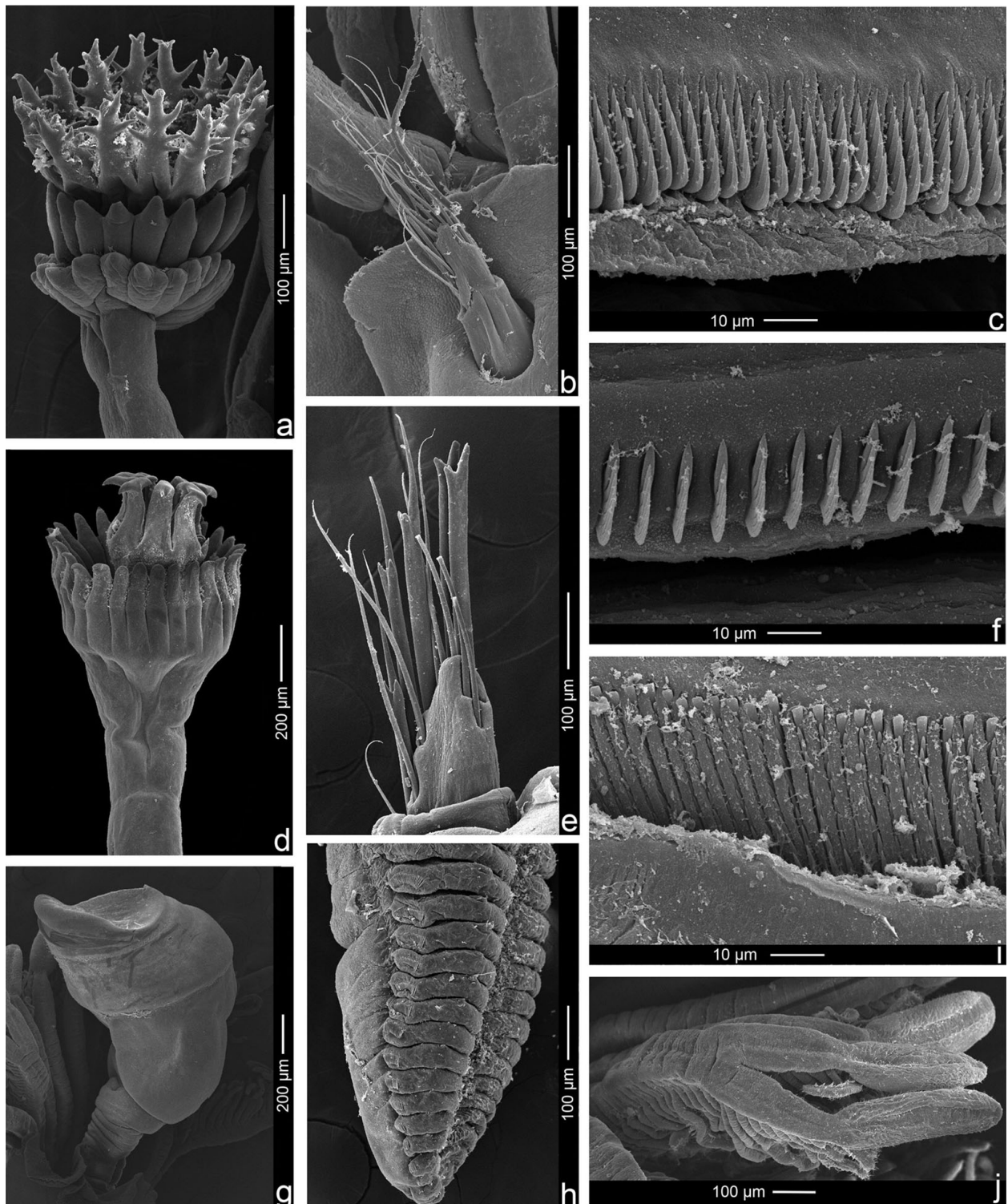
Figure 8 Opercula, chaetae, uncini and other structures. (a, d, g) Opercula, (b, e) chaetae from collar, (c, f, i) thoracic uncini, (h) posterior abdomen, lateral view, (j) radiolar tips. (a–c) *Hydroides elegans*, (d–f) *H. recurvispina*, (g–j) *Vermiliopsis multiannulata*.

all spines similar in shape and size, with an external distal knob and pointed tip (Fig. 8d); spines with one basal internal spinule with blunt tip; without external or lateral spinules or wings; verticil without central tooth; pseudoperculum 70% ($n = 10$). Body length 10.30 ± 2.31 mm ($n = 10$; 5–12), thorax width 1.31 ± 0.53 mm ($n = 10$; 0.6–2.3 mm) with 7 ± 0

segments ($n = 10$; 7–7 segments). Collar chaetae bayonet, with two pointed, elongate teeth (Fig. 8e), distal blade denticulate, and narrow limbate chaetae. Thoracic membrane wide with a short apron across the first abdominal segment (http://www.morphbank.net/Show/?pop = Yes&id = 464026); ventral thoracic region with two olive-green, oval areas; thorax

with narrowly hooded chaetae and saw-shaped uncini (Fig. 8f). Abdominal segments 97 ± 19 ($n = 10$; 60–108 segments); anterior and mid-abdomen with flat-trumpet chaetae; posterior abdominal chaetigers with narrowly limbate chaetae; anterior abdominal uncini saw-shaped, posterior uncini rasp-shaped.

GROWTH: Body length was not significantly correlated with the total number of segments or the branchial crown length, although the sample size was low ($n = 10$).

REPRODUCTION: Gonochoric, broadcast spawning species, lacking sexual dimorphism. Fully developed oocyte diameter: 54.0 ± 10.9 μm ($n = 95$; 41.5–66.4 μm). Spermatozoa with spherical nucleus, rounded acrosome and long flagellum.

REMARKS: *Hydroides recurvispina* was described from Acapulco, México. This species resembles *H. trompi* Bastida-Zavala & ten Hove, 2003, described from Panama, in the clock wise twist of the tips of verticil spines, and the basal internal spinules occasionally may be similar to those in *H. trompi*, but all spines of *H. recurvispina* have a pronounced knob, while those in *H. trompi* are smooth. *Hydroides recurvispina* is distributed in the Mexican Pacific (except in the Californian Province), Costa Rica and Panamá (Bastida-Zavala, 2008). This constitutes the first record for Mazatlán port.

Genus *Vermiliopsis* de Blainville, 1818

Vermiliopsis multiannulata (Moore, 1923)
Figs 3n, 8g–j

Metavermilia multiannulata Moore, 1923: 251–253, pl. 18, fig. 48.
Vermiliopsis multiannulata.– Hartman, 1956: 300–301.

MATERIAL EXAMINED: UNAM-ICML Sta. 8 (2 specs).

CHARACTERISATION: Tube unknown. Branchial crown length: 2.9–3 mm; radioles: 11 pairs; radiolar tips paddle-shaped (Figs 3n, 8j). Opercular peduncle smooth, white; operculum with a brown chitinous opercular cap horse hoof-shaped without spine (Fig. 8g) and 12 internal septa. Body length: 11.5 mm. Seven thoracic segments; thoracic membrane extending to fifth thoracic segment. Collar chaetae narrowly limbate with few chaetae per bundle. Thorax with *Apomatus* chaetae starting on second chaetiger; thoracic uncini saw-shaped with 12 teeth and blunt anterior tooth. Abdominal segments: 58–60; number of uncini per row slowly decreases in the anterior two-thirds of the abdomen, then rapidly decreases towards the pygidium (Fig. 8h); all the uncini rasp-shaped with 13–15 teeth visible in profile (Fig. 8i); abdominal chaetae with 2–4 flat narrow geniculate chaetae. Posterior abdomen with a black, dorsal spongy, glandular shield, occupying the last 13 abdominal segments (Fig. 8h).

GROWTH: No morphometric correlations were possible due to a lack of material.

REPRODUCTION: Unknown.

REMARKS: *Vermiliopsis multiannulata* was described by Moore (1923) as *Metavermilia* from off Point Pinos Lighthouse, in Monterey Bay, Southern California, but the cotypes belong to *Pseudovermilia conchata* ten Hove, 1975. Hartman (1956) transferred the taxon to the genus *Vermiliopsis* and synonymised both *Vermiliopsis hawaiiensis* Treadwell, 1943, and *Vermiliopsis torquata* Treadwell, 1943 from Hawaii with *V. multiannulata*. However, *V. hawaiiensis* was synonymised with *Pseudovermilia occidentalis* by ten Hove (1975), while *V. torquata* is a *Vermiliopsis*, very similar to *V. multiannulata* (ten Hove, pers. comm.).

The records of *V. multiannulata* by Hartman (1961) from central and southern California, (1966) from Hawaii and (1969) from Point Pinos, California, are confused and at least partly belong to *Pseudovermilia occidentalis* and *P. conchata* (see ten Hove 1975: 88–92). Rioja recorded *V. multiannulata* from several localities of the Mexican Pacific: Acapulco (1941b), Mazatlán (1942), Zihuatanejo, Puerto Vallarta, Topolobampo and Guaymas (1962) but these records should be referred to *Pseudovermilia occidentalis* due to their black operculum and triangular tube with strong mid-dorsal and weaker lateral ridges (ten Hove, pers. comm.). ten Hove and Kupriyanova (2009) regarded *V. multiannulata* to be a member of the *Vermiliopsis infundibulum/glandigera* complex. This *Vermiliopsis infundibulum/glandigera* complex was recognised by Imajima (1976). The group has a circum (sub) tropical distribution and has been recorded for the Mediterranean, Red Sea, India, Southern Japan, Australia, Micronesia, Hawaii (Imajima, 1976; Imajima & ten Hove, 1984) and in the Mexican Pacific (Bastida-Zavala, 2008). However, a detailed revision is needed to state the possible affinities found among species comprised in this complex. Çinar (2006) restricts the use of the name *Vermiliopsis infundibulum* (Philippi, 1884) to the Mediterranean-Atlantic region; similarly, for our material we use the locally available name *V. multiannulata* (not *sensu* Hartman, nor Rioja), that identifies the taxon as Pacific American.

Our specimens were collected on concrete dock pilings and differ from those recorded by Bastida-Zavala (2008) from Oaxaca and Baja California Sur by having a horse hoof-shaped opercular cap without a spine, with 12 internal septa and a thoracic membrane extending to the fifth segment (conical cap with or without spine, with up to 14 internal septa and a thoracic membrane extending to the third segment in Bastida-Zavala's material). The sporadic presence of this species in Mazatlán port indicates that it is not an invasive species.

In one specimen a single radiole is dichotomously branched (Fig. 9j). This aberration is not common in serpulids; however, in the sabellid genera *Schizobranchia* Bush, 1905, or *Eudistylia* Bush, 1905, dichotomous radioles are common in large individuals (Fitzhugh, 1989).

Concluding remarks

This study recognises nine fouling sabellids and serpulids in the southeastern Gulf of California, and provides information about the reproductive biology of these species, integrating the taxonomic accounts with the World Wide Web through

Morphbank. It highlights the discovery of the sabellid tube-worm *B. bairdi* on ship hulls and harbour structures, and the serpulid tubeworm *F. miamiensis* on shrimp farms and mangrove roots in the southern Gulf of California, both taxa of Caribbean origin. It provides further evidence of the relevance of hull fouling and aquaculture practices as ongoing vectors in the translocation of non-indigenous marine species. The distribution patterns and number of individuals of the studied species allowed the establishment of their status as invasive species in the port of Mazatlán. For the moment, only *B. bairdi* and *F. miamiensis* are considered as invasive species, while the status of *H. elegans* as invasive species has not been confirmed. The rest of the species are native in the Panamic and Californian provinces. Hopefully, the information generated here could facilitate monitoring programmes to determine fluctuations on the distribution of these and other species and to evaluate the impacts on biodiversity and ecosystem functioning by non-native tubeworms.

Acknowledgements

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