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Sphaerodoridae (Annelida) from Lizard Island, Great Barrier Reef, Australia, including the description of two new species and reproductive notes

MARÍA CAPA[1, 2*] & GREG W. ROUSE[3]
[1]*NTNU University Museum, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway.*
[2]*Australian Museum Research Institute, 6 College Street, Sydney, 2010 NSW, Australia.*
[3]*Scripps Institution of Oceanography, University of California, San Diego, CA 92093-0202, USA.*
[*]*Corresponding author: maria.capa@ntnu.no, capa.maria@gmail.com*

Abstract

Sphaerodorids are scarce at Lizard Island archipelago and other localities in the Great Barrier Reef, Australia. Intensive collections at a variety of habitats within the Lizard Island archipelago over the last four decades have resulted in a total of just 11 specimens. Nevertheless, they represent two new species and a new record for Lizard Island. *Sphaerodoropsis aurantica* n. sp. is characterised by nine longitudinal rows of sessile and spherical dorsal macrotubercles, arranged in a single transverse row per segment; parapodia with around 10 spherical papillae; and compound chaetae with thin shafts and long blades. *Sphaerodoropsis plurituberculata* n. sp. is characterised by more than 12 more or less clearly arranged longitudinal rows of sessile spherical dorsal tubercles (variable in size), in four transverse rows per segment; parapodia lacking papillae; and semi-compound chaetae with distally enlarged shaft and short blades. *Ephesiella australiensis* is reported for the first time in Lizard Island. Laboratory observations of live specimens of *Sphaerodoropsis plurituberculata* n. sp., revealed the use of spermatophores by males. These were found attached externally to the body surface of both sexes, indicating pseudo-copulation.

Key words: *Sphaerodoropsis, Ephesiella*, spermatophore, pseudo-copulation, Australia

Resumen

Representantes de Sphaerodoridae son escasos en el archipiélago de Lizard Island y otras localidades de la Gran Barrera de Coral, Australia. Muestreos intensivos en una variedad de hábitats en archipiélago en las últimas cuatro décadas han contribuido con un total de sólo 11 ejemplares colectados. Sin embargo, estos representan dos nuevas especies y un nuevo registro para Lizard Island. *Sphaerodoropsis aurantica* n. sp. se caracteriza por tener nueve hileras longitudinales de macrotubérculos dorsales sésiles y esféricos, dispuestos en una sola fila transversal por segmento; parápodos con alrededor de 10 papilas esféricas; y sedas compuestas con mangos delgados y artejos largos. *Sphaerodoropsis plurituberculata* n. sp. se caracteriza por tener más de 12 filas longitudinales más o menos evidentes de tubérculos dorsales esféricos y sésiles (variables en tamaño), dispuestos en cuatro filas transversales por segmento; parápodos carentes de papilas; y sedas semi-compuestas con mangos engrosados distalmente y artejos cortos. *Ephesiella australiensis* se cita por primera vez en este archipiélago. E studio de ejemplares vivos de *Sphaerodoropsis plurituberculata* n. sp. en condiciones de laboratorio revela el empleo de espermatóforos por los machos. Estos fueron encontrados adheridos externamente a la superficie del cuerpo de ambos sexos indicando pseudo-cópula.

Introduction

Sphaerodoridae is an uncommon group of benthic marine polychaetes, regarded as part of Phyllodocida (e.g., Fauchald & Rouse 1997; Pleijel & Dahlgren 1998; Capa *et al*. 2015). They are generally smaller than 5 mm long and are characterised by the presence of spherical tubercles over their surface, generally arranged in longitudinal and transverse rows (Ruderman 1911; Fauchald & Rouse 1997; Pleijel & Dahlgren 1998; Capa *et al*. 2015). In

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most sphaerodorids segmentation is not conspicuous and a thick cuticle covers the epithelium providing them with a semi-rigid appearance. They are provided with short prostomial appendages, uniramous parapodia with ventral cirrus but lacking the typical dorsal cirrus present in other Phyllodocida (Ruderman 1911; Reimers 1933; Pleijel & Dahlgren 1998; Fauchald & Rouse 1997; Wilson 2000; Pleijel 2001; Aguado & Rouse 2006; Capa *et al*. 2014).

The group was divided by early workers into short and long forms (e.g., Levinsen 1883; Fauvel 1911), the former being ellipsoid in shape, whereas the long forms can reach up to 20 mm in length, with over a hundred segments and more or less rectilinear bodies. The diversity of number, type and arrangement of tubercles is higher among the short-bodied sphaerodorids, currently grouped in seven genera. This variation includes sessile and stalked tubercles, these may be smooth or with terminal papillae, and be of different sizes (classified as macrotubercles and/or papillae) (e.g., Fauchald 1974; Moreira 2012; Capa *et al*. 2014). The short-bodied sphaerodorids have compound or semi-compound chaetae. In contrast, long-body sphaerodorids, placed in three genera, have a homogenous tubercle pattern, with two dorsal longitudinal rows of large tubercles (macrotubercles) that have terminal papillae; another two rows of microtubercles (smaller and also with terminal papillae) running between the macrotubercles along the dorsum, and several rows of papillae. These long-bodied sphaerodorids can have simple, compound or both type of chaetae (Fauchald 1974; Capa *et al*. 2014). The first phylogenetic hypothesis of Sphaerodoridae has recently been proposed based on DNA sequences, but deep relationships within the family were not strongly supported and reciprocal monophyly of the short and long sphaerodorid could not be assessed with confidence (Capa *et al*. 2015), although morphological data suggests this possibility (Helm & Capa 2015).

Sphaerodorids are mostly reported from muddy sediments from continental shelf and slope environments worldwide (e.g., Fauchald 1974; Kudenov 1993, 1994; Magalhães *et al*. 2011; Moreira *et al*. 2011; Moreira & Parapar 2012) and from bathyal and abyssal depths (e.g., Borowski 1994; Aguirrezabalaga & Cebeiro 2005; Aguado & Rouse 2006; Böggemann 2009; Reuscher & Fiege 2011; Alalykina 2015). Some species described from shallow environments are associated with sediments (Kudenov 1987a, b; Bakken 2002; Magalhães *et al*. 2011, Capa & Bakken 2015) but also with hard substrates such as coral (Hartmann-Schröder 1974a, 1979; Capa & Bakken 2015), or as epibionts of algae (e.g., Fauchald 1974; Hartmann-Schröder 1981; Sardá-Borroy 1987; Moreira 2012; Capa & Bakken 2015).

In Australia, sphaerodorids have only been reported a few times, mainly in tropical waters. The family has just being reviewed in Australia (Capa & Bakken 2015) and the number of nominal species has increased from three to eight, not considering the ones described herein.

The aim of the present study is to describe and illustrate the sphaerodorids found in different shallow water environments within and around Lizard Island archipelago. The material reported in the present paper gathers all the specimens collected after different surveys to this archipelago over the last 40 years by different scientists and research institutions. The paucity of specimens and low diversity reported is evidence of the rarity of sphaerodorids in benthic samples, at least in this tropical coral reef environment. New information about reproductive strategies in one species of *Sphaerodoropsis* is also provided after laboratory observations of live specimens.

Material and methods

Material belonging to the Australian Museum (AM), Sydney and Scripps Institution of Oceanography (SIO), La Jolla, was borrowed and studied in the Norwegian University of Science and Technology University Museum, Trondheim. Specimens from the Zoological Museum, Hamburg (ZMH) were studied on site. Museum Victoria (NMV), Melbourne and Northern Territory Museum (NTM), Darwin, were contacted in search of specimens, but they lack any sphaerodorids from Lizard Island or nearby localities. The most recent surveys to the National Park, where most of the specimens were collected, include the Lizard Island Polychaete Workshop (August 2013), gathering 15 scientists specialised in different polychaetes groups and the three Census of Marine Life CReefs expeditions between 2009 and 2012, where around 20 scientists and assistants combined efforts to collect and document the diversity associated to the coral reefs. Specimens were mostly sorted in the field and either fixed in formalin and preserved in 70–80% ethanol or fixed and preserved in 96–100% ethanol.

Several specimens of *Sphaerodoropsis plurituberculata* n. sp. were maintained for several days in the laboratory, in filtered seawater, and studied alive during this time, and were fixed in ethanol or formalin and then preserved in ethanol.

All specimens were studied under dissecting and compound microscopes. Micrographs were taken with a Leica MZ 8 stereomicroscope or Leica DMR compound microscope with a JVC GC-X3E digital camera. Parapodial papillae and chaetal morphology were studied without dissection, mounting the complete specimen on a microscopic slide with glycerine. Scanning electron micrographs were taken on specimens after dehydrating them in series of mixtures of absolute ethanol and hexamethyldisilazane (HMDS) with the following ratios 2:1, 1:1, 1:2 for 20 minutes each and then into pure HMDS. The prepared samples were mounted on holders, sputter-coated with gold (10 nm thickness). The micromorphology and topography were determined using a Philips FEI INSPECT scanning electron microscope (SEM) at the Museo Nacional Ciencias Naturales (Madrid, Spain) and a JEOL-JSM-6480 SEM at the Cellular and Molecular Imaging Core Facility (CMIC) of the Faculty of Medicine of the Norwegian University of Sciences and Technology (NTNU). The samples were observed with the Back Scattering Electron Detector (BSED) with a resolution at high vacuum of 4.0 nm at 30 kV. The accelerating voltage was 15–30 kV and working distance of 10 mm to the detector.

Locality descriptions of material collected during the August 2013 Lizard Island Polychaete Workshop (MI QLD 2329–MI QLD 2449) are listed as in Ribas & Hutchings (2015, this volume). Number of specimens under each registration number is one unless otherwise specified.

Abbreviations used on figures: ♀co, female copulatory organ; ♂co, male copulatory organ; al, acicular lobe; ch1, parapodia from chaetiger 1; co, copulatory organ; es, early spermatids; la, lateral antenna; ma, median antenna; mi, microtubercle; mo, mouth; mt, macrotubercle; pa, palp; par, parapodium; o, oocytes; pp, parapodial papilla; s, sperm; sp, late spermatids; tc, tentacular cirrus; vc, ventral cirrus.

Taxonomic account

Genus *Ephesiella* Chamberlin, 1919

Type-species. *Sphaerodorum abyssorum* Hansen, 1878

Diagnosis. Body long and slender. Two dorsal longitudinal rows of macrotubercles, one pair per segment, may be absent in first chaetiger. Macrotubercles sessile, with terminal papillae. Two dorsal longitudinal rows of microtubercles, one pair per segment, running parallel between macrotubercles. Additionally, papillae arranged in 3–5 transverse rows on both dorsum and ventrum. Head appendages short, spherical or digitiform. Parapodia from chaetiger 2 with compound chaetae; hooks absent or present.

Ephesiella australiensis Hartmann-Schröder, 1982
(Figs 1, 2A, B)

Ephesiella australiensis Hartmann-Schröder, 1982: 80–81, figs 84–87.

Type material. Holotype: ZMH P.16773, Cervantes, Western Australia, Australia, sandy beach among *Posidonia*, 24 Oct 1975. Paratype: AM W.42693 (on SEM stub), Lizard Island, between South Island and Palfrey Island, 14°41'54"S, 145°26'45"E, dead coral, 17 m, 31 Mar 1995.

Other material examined. AM W.42702 (2, 1 on SEM stub), Western Australia, south west Enderby Island, 20°37'18"S, 116°27'23"E, dead coral encrusted with bryozoans, ascidians and bivalves, 14 m, 8 Aug 2000; AM W.42688 (on SEM stub), Australia, New South Wales, Cape Three Points, south-east of Third Point, 33°31'55"S, 151°24'58"E, sand from around large boulders at edge of rocky reef, 30 m, 6 May 2007.

Diagnosis. Body long and slender. Two longitudinal rows of macrotubercles, one pair per segment, may be absent in first chaetiger. Macrotubercles spherical, sessile, with terminal papillae. Two longitudinal rows of microtubercles, with a collar and a terminal papillae, one pair per segment, running parallel between macrotubercles. Additionally, papillae arranged in three transverse rows on dorsum and in 4–5 transverse rows on ventrum. Head appendages digitiform. Mid-body parapodia with six semi-spherical papillae, all similar in size: one anterior dorsal, one anterior, near the acicular lobe, one anterior ventral two posterior-dorsal, one of the latter distal. Parapodia from chaetiger 2 with compound or semi-compound, shaft provided with a distal spine; hooks not observed.

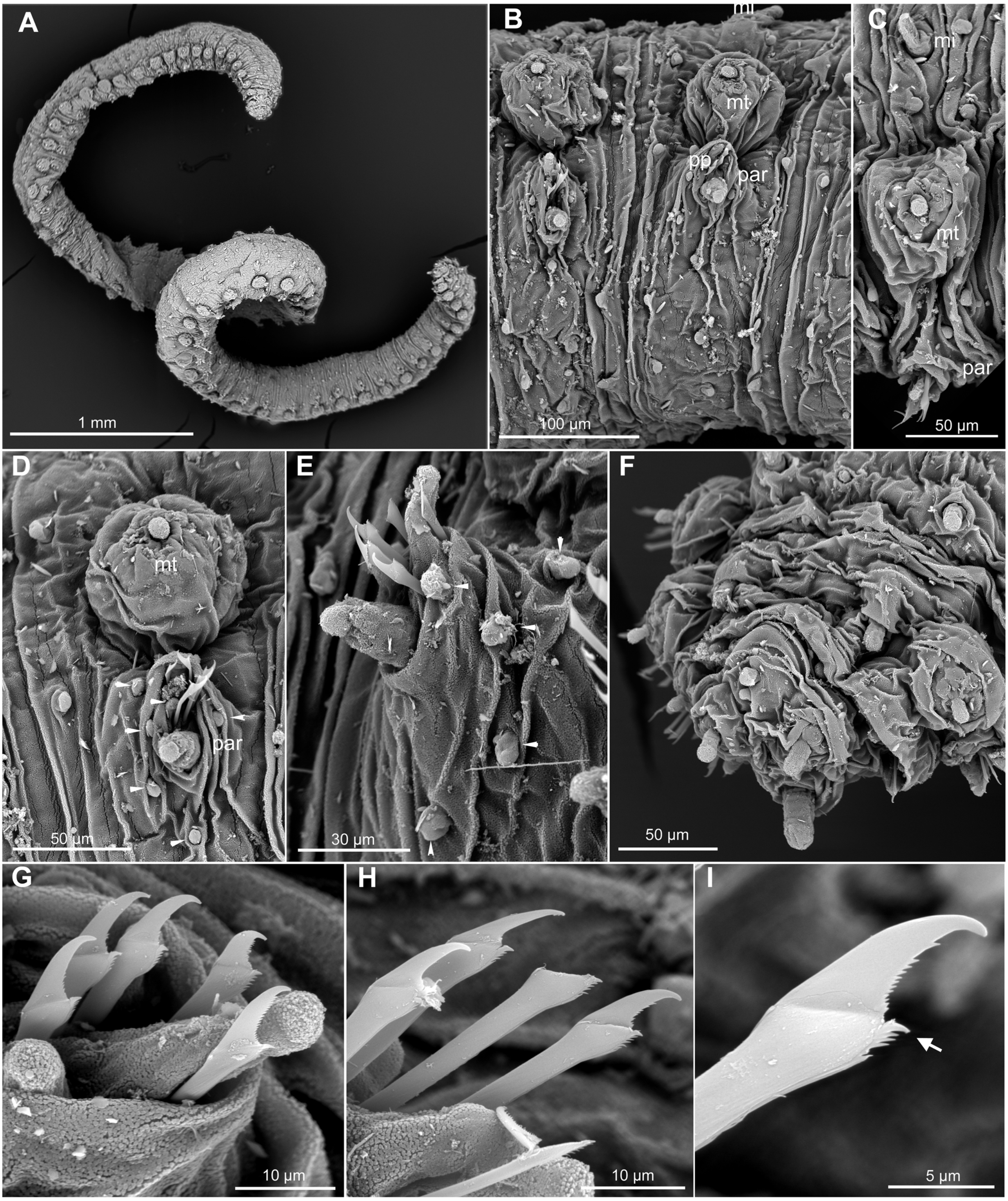

FIGURE 1. *Ephesiella australiensis* SEM images, AM W.42693. A. Whole specimen, anterior end on top; B. Anterior chaetigers, ventro-lateral view, showing microtubercle (mi), macrotubercles (mt) and parapodia (par) with bottle-shaped ventral cirrus and parapodial papillae (pp); C. Same from a dorsal view; D. Mid-chaetiger with macrotubercle (mt) with terminal papillae, and contracted parapodium bearing at least six papillae (arrowheads); E. Mid-body parapodium, anterior view, with five spherical papillae (arrowheads), five compound chaetae and a bottle-shaped ventral cirrus; F. Posterior end showing two terminal macrotubercles, and a digitiform ventral cirrus; G. Compound chaetae of anterior chaetiger; H. Chaetae of mid-body chaetiger; I. Detail of chaetae from posterior chaetiger showing the blade, almost fused to the shaft and the characteristic spinulation of the shaft with a distal-most thicker spine (arrow).

Description. (of Lizard Island specimen) Body elongate, measuring 4.2 mm long, 0.4 mm wide, with 63 segments, slightly narrowing along posterior segments (Fig. 1A). Sub-quadrangular in section, with convex dorsum (Fig. 1A). Tegument with transverse wrinkles and segmentation inconspicuous (Fig. 1A). Preserved material lacking pigmentation. Head externally indistinct. Anterior end bluntly rounded and damaged. Prostomium with five appendages; paired palps and lateral antennae digitiform and three times longer than wide; median antenna, shorter, hemispherical. Prostomial papillae, present but numbers uncertain. Tentacular cirri slightly shorter than palps and lateral antennae. First chaetiger with two sessile and spherical macrotubercles, each provided with a digitiform terminal papillae; microtubercles absent. Rest of chaetigers with two macrotubercles each, arranged in two longitudinal dorso-lateral rows, shape and size of all macrotubercles similar, slightly increasing in size in first segments, and decreasing posteriorly (Fig. 1A–D). A pair of microtubercles on each segment from chaetiger to until last segment, running in two longitudinal rows inside macrotubercles; with terminal papillae longer than collar (Fig. 1C). Spherical and elliptical papillae present over dorsum, arranged in three transverse rows per segment, with around 15–20 papillae per segment on mid body region, including 2–3 papillae between macrotubercles and parapodia (Figs 1A, 2B). Ventral surface with spherical papillae, arranged in 4–5 transverse rows (seemingly a zig-zag in anterio-posterior view), with a total of 20–25 per segment, in mid-body; numbers decreasing towards posterior end. Parapodia sub-conical, increasing in size towards chaetiger 3 and as longer as wide (Fig. 1C–E). Acicular lobe projecting distally anterior to chaetae, resembling other parapodial papillae or slightly longer (Fig. 1E). Ventral cirri bottle-shaped similar in length to acicular lobe (Fig. 1E). Anterior parapodia with four hemispherical papillae: one anterior, one anterio-ventral, one anterior-dorsal and one posterior, in addition to the acicular lobe. Mid-body parapodia with six semi-spherical papillae, all similar in size: one anterior dorsal, one anterior, near the acicular lobe, one anterior ventral, two posterior-dorsal, one of the latter distal (Figs 1D–E, 2B). Compound chaetae, appearing as semi-compound in some chaetigers, arranged in a curved transverse rows around acicular lobe and numbering 4–6 per fascicle (Fig. 1G–I). First chaetiger with blades 5–6 times longer than wide and conspicuous serration along cutting edge. Hooks not seen. Chaetae from chaetiger 3 with shaft distally enlarged and serrated with a main distal tooth; blades showing a slight dorso-ventral gradation (1–2 times longer than wide; except for anterior chaetiger with longer blades) recurved and with smooth or few serration of the cutting edge (Fig. 1G–I). Pygidium terminal, with mid-ventral digitiform anal cirrus and a pair of dorsal anal cirri, similar in shape but slightly smaller than macrotubercles (Fig. 1F). Eyes, muscular pharynx, gonads, gametes or copulatory organs not observed.

Remarks. *Ephesiella* is a cosmopolitan genus that requires revision. It currently groups 15 species supposedly sharing the presence of only compound chaetae from chaetiger 2. Nevertheless, some species have been described as bearing semi-compound chaetae (e.g., Moore 1909, and description above), a feature half way to members of *Sphaerodorum* (with only simple chaetae) and *Ephesiopsis* (with both simple and compound chaetae in all parapodia). Moreover, several species have been described from a single or few specimens (e.g., Desbruyères 1980; Hartmann-Schröder 1982) and consequently, the intraspecific variation has not been addressed. Most specific diagnostic characters rely on the absence or presence of hooks, the number of prostomial appendages, the number and arrangement of parapodial papillae. The types and specimens examined for this study (cited above) all appear to: i) lack hooks and antenniform papillae; ii) have the median antenna distinctly shorter than other prostomial appendages; iii) have three transverse rows of dorsal papillae per chaetiger; iv) number of parapodial papillae range between 4–7; v) bear compound, or semi-compound, chaetae with short blades (2–3 times longer than wide), most of them provided with a distinct spine on the tip of the shaft (not observed in the types, due to their fragile condition for manipulation). Most specimens examined from other Australian localities do share these morphological traits. However, some specimens showed different chaetal morphology (longer blades and/or distal tooth in shaft absent), or different relative position of the macro and microtubercles (Capa & Bakken 2015). *Ephesiella australiensis* is represented elsewhere in Queensland, but only reported from Townsville (Capa & Bakken 2015).

Genus *Sphaerodoropsis* Hartman & Fauchald, 1971

Type-species. *Sphaerodorum sphaerulifer* Moore, 1909

Diagnosis. Body generally short and ellipsoid, some forms slender. Four or more dorsal longitudinal rows of macrotubercles, in one or several transverse rows per segment. Macrotubercles sessile and smooth, without terminal papillae. Microtubercles absent. Papillae over body surface and parapodia. Head appendages short, spherical or digitiform. Parapodia with compound chaetae; hooks absent.

Sphaerodoropsis aurantica **n. sp.**

(Figs 2C, D, 3)

Sphaerodoropsis sp A.—Helm & Capa, 2015.

Type material. Holotype: AM W.44209, MI QLD 2380, on SEM stub. Paratype: AM W.44210, MI QLD 2380, posterior end used for DNA sequencing.

Other material examined. AM W.44218, MI QLD 2390, live photo, further used for confocal microscopy, Helm & Capa 2015; AM W.44220, MI QLD 2387, used for confocal microscopy, Helm & Capa 2015.

Diagnosis. Body ellipsoid, with strongly convex dorsum. Nine longitudinal rows of sessile and spherical dorsal macrotubercles, arranged in a single transverse row per segment row and four transverse rows (with up to 38) of spherical papillae per segment. Parapodia with digitiform acicular lobe, shorter ventral cirrus and around 10 spherical papillae. Over 10 compound chaetae per parapodium with thin shafts, long blades (6–8 times longer than its maximum width), with fine and short spinulation along superior edge and a distal recurved tip.

Description. Holotype 1.8 mm long after fixation, 0.6 mm maximum width; with 20 chaetigers. Body ellipsoid (Fig. 3A–B); with convex dorsum and flattened ventrum. Tegument with transverse wrinkles, segmentation inconspicuous (Fig. 3A–B). Head externally indistinct (Fig. 3A–C). Anterior end bluntly rounded (Fig. 3B–C). Prostomium with five appendages, including a pair of palps, in ventral most position, sub-conical and slightly wrinkled; a pair of lateral antennae, similar in shape and size to palps; and a median antenna, shorter (two thirds) and wider than lateral antennae and with a rounded distal end (Fig. 3B–C). Antenniform papillae cannot be unequivocally recognised (Fig. 3C). Around 30 digitiform small papillae confined by prostomial appendages and mouth in frontal view (Fig. 3C). A pair of tentacular cirri, similar in shape and size to lateral antennae and palps, and several scattered papillae similar to prostomial. Macrotubercles, sessile, rounded or provided with an incipient rounded terminal papillae (Fig. 3B, G–H), arranged in longitudinal rows along dorsum, and single transversal rows per segment. First and following chaetigers with nine macrotubercles, decreasing to eight in posterior chaetigers. Macrotubercles with two different sizes, following pattern in Fig. 2C; provided with pores arranged on groups (Fig. 3G–H), some of them with incipient terminal papillae or at least pear-shaped (Fig. 3H). Spherical papillae over dorsum, arranged in four transverse rows per segment; digitiform in anterior-most chaetigers and spherical in following (Fig. 3C–D). Ventral surface with similar spherical papillae, arranged in about 5–6 irregular transverse rows, with a total of around 50 papillae per segment, in mid-body (Fig. 3B). Parapodia sub-conical, increasing in size towards chaetiger 5 and around 1–2 times longer than wide, wrinkled (Fig. 3C–D). Acicular lobe anterior to chaetal fascicle, projecting distally (Fig. 3D–E, J). Ventral cirri sub-conical to pear-shaped, shorter than acicular lobe (Fig. 3D–E, J). Mid-body parapodia with around 10 small spherical papillae, slightly different in size: one or two on dorsal surface, three on anterior surface, three on ventral surface and three on posterior surface (Fig. 2D). Compound chaetae present in all chaetigers, arranged in a curved transverse fascicle around acicular lobe and numbering 10–22 per parapodium. Shaft with similar width all along, slightly widened distal end with delicate almost inconspicuous spinulation. Blades similar in length within fascicles (6–8 times longer than its maximum width), with fine and short spinulation along superior edge and a distal recurved tip (Fig. 3J–L). Pygidium terminal, with mid-ventral digitiform anal cirrus and a pair of dorsal anal cirri, similar in shape to macrotubercles (Fig. 3F). Mouth located ventrally near base of palps (Fig. 3C). Gut visible by transparency with muscular pharynx occupying about four segments. Eyes and copulatory organs or gametes not seen.

Colour pattern. Live specimens white, with a bright orange transverse band on dorsum of chaetigers 12–13. Lateral most and dorsal most macrotubercles of all except for anterior and posterior two chaetigers also partially pigmented (Fig. 3A). Colour lost in preserved material.

Variation. Paratype with 21 chaetigers. Number of epithelial tubercles and papillae matches those described in holotype. Parapodia of mid-body chaetigers with higher number of chaeate and papillae, within the range described in holotype. Pigmentation pattern varied slightly among described specimens and the orange band was more or less evident in some specimens, and within chaetigers 10–13 but the dorsolateral macrotubercles, were in all cases partially bright orange. Copulatory organs or gametes not observed in any specimen.

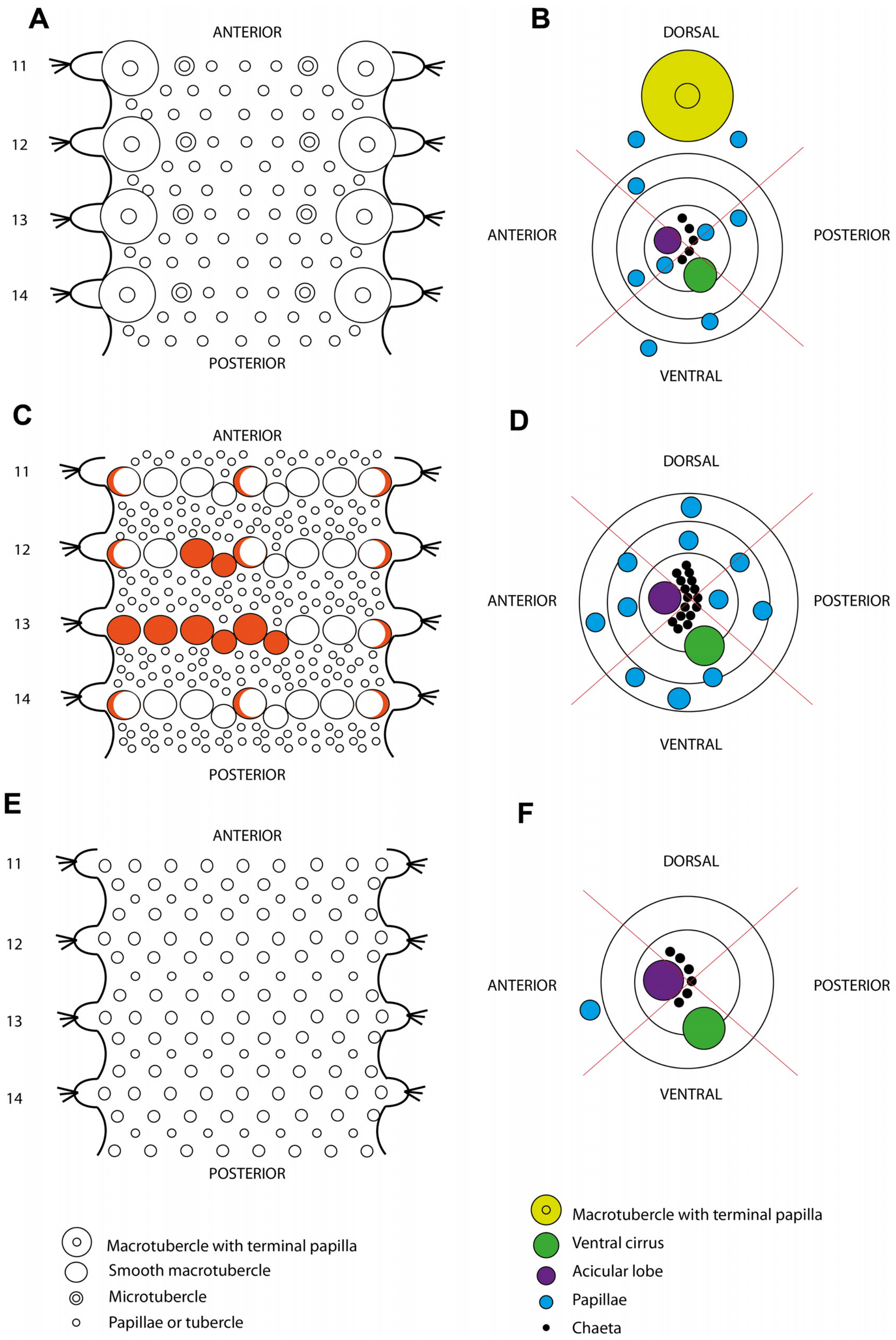

FIGURE 2. Stylised drawings. A, B. *Ephesiella australiensis*. A. Dorsal tubercles of chaetigers 11–14; B. Parapodial papillae and appendages including ventral cirrus, acicular lobe, papillae and nearby macrotubercle; the concentric circles represent the volume of the parapodium (larger ones indicate basal and smaller distal areas) and the red axis its four sides; C, D. *Sphaerodoropsis auranticus* n. sp.; C. Dorsal tubercles of chaetigers 11–14, and pigmentation pattern; D. Arrangement of parapodial appendages and papillae; E, F. *Sphaerodoropsis plurituberculata* n. sp.; E. Dorsal tubercles of chaetigers 11–14; F. Arrangement of parapodial appendages and papillae.

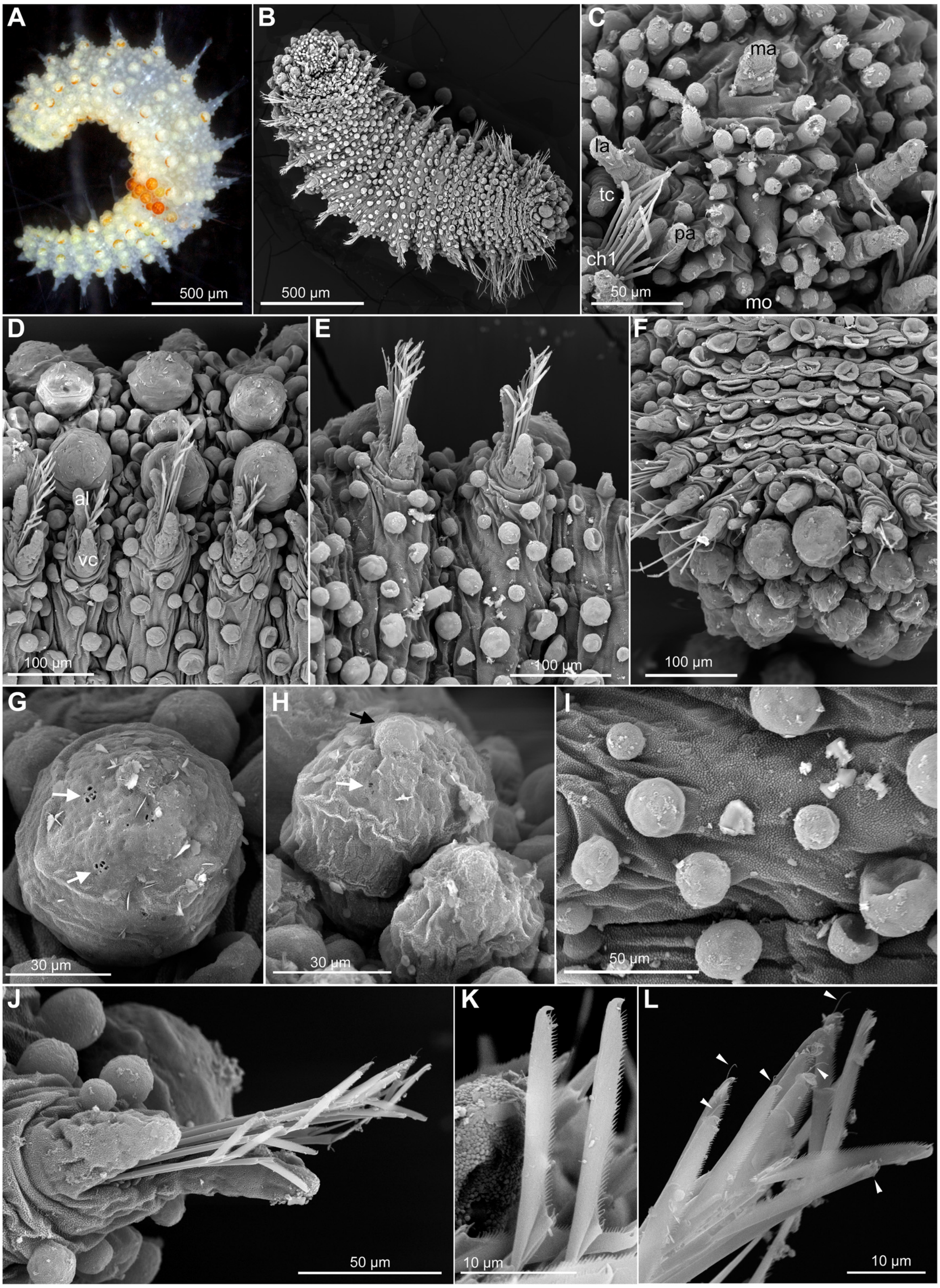

FIGURE 3. *Sphaerodoropsis aurantica* n. sp., AM W.44218 (A), AM W.44209 (B). A. Live specimen, micrograph taken with a dissecting microscope, dorsal view; B–L. SEM images. B. Whole specimen, ventral view, anterior end on top; C. Anterior end, frontal view, with median antenna (ma), lateral antennae (la), palps (pa), tentacular cirri (tc) and parapodia from first chaetiger (ch1); D. Mid-chaetigers in lateral view, showing large macrotubercles and dorsal papillae, ventral papillae, and parapodia with acicular lobe (al), ventral cirri (vc) and compound chaetae; E. Parapodia of chaetiger 6 and 7, ventral view (lacking copulatory organs), ventral view; F. Posterior end, ventral view, showing pygidial papillae and mid-ventral cirrus; G. Detail of dorsal macrotubercle with pores (arrows); H. Posterior macrotubercles with incipient terminal papillae (black arrow); I. Different size ventral papillae of mid-chaetigers; J. Mid-body parapodium, anterior view showing acicular lobe (al), ventral cirrus (vc) (behind chaetae) and parapodial papillae; K. Detail of compound chaetae of posterior chaetigers with long blades and thin shafts; L. Mid-chaetiger chaetal fascicle. Some of the chaetae have distal spine over blades (arrowheads).

COI Barcode (Paratype, AM W.44210).

AAAATCAAAACAAATGTTGAAATAAAATAGGATCTCCTCCTCCTGCCGGATCAAAAAACCTAGTATTT
AGATTACGATCAGTTAATAATATAGTAATTACACCTGCCAATACAGGCAAAGCTAATAATAATAAAATAG
CTGTAATCAATACAGATCAAGTAAATAAAGGAATACGCTTAAACTTCATACCCACTACATGATCAAATA
TAATAGTAACAATAAAATTAATAGCACCTAAAATAGAAGAAACACCAGCTATATGTAATGAAAAAATAG
CTATATCAACAGAAGGCCCCGAATGAGTTATATTACTTGATAAAGGAGGATAAACTGTTCATCCTGTAC
CAGCACCTTTCTCTACTAATGTAGATCCCAATAATAATATTAAAGAAGGAGGCAAAAATCAAAACCTTA
TATTATTTAATCGAGGAAAAGCTATATCAATAGCACCTAACATTAAAGGAACTAATCAATTACCAAAAC
CACCCATTATAACTGGTATTACAAGAAAAAAAATTATTAAAAAAGCATGACCAGTAACAATAGTATTAT
ATAATTGATCTCTACCTAATAAACTACCTGGTTGACCTAATTCAGCACGAATCAACAAACTTATAGATGT
ACCTAAAAATCCAGATCATATACCAAAAATAAAATACAAAGTACCAATATCTT

Remarks. Even though some macrotubercles were observed with distal papillae, this is not a constant attribute of all tubercles or present in all specimens of *Sphaerodoropsis aurantica* n. sp. examined and may be an artefact due to the collapse of some of these structures. Nevertheless, and as indicated previously (Capa *et al.* 2015; Capa & Bakken 2015), distinguishing *Sphaerephesia* and *Sphaerodoropsis* is confusing at present because there are species within each genus presenting pear-shaped macrotubercles that lack terminal papillae. This species would belong within the Group 2 proposed by Borowski (1994), together with other *Sphaerodoropsis* species with more than four longitudinal rows of macrotubercles arranged in a single transverse row per segment. There are nine other species in the group (Borowski 1994; Aguirrezabalaga & Cebeiro 2005; Moreira & Parapar 2011), considering that *S. minuta* (Webster & Benedict, 1887) and *S. polypapillata* Hartmann-Schröder & Rosenfeldt, 1988, have recently been synonymised with other genera (Moreira & Parapar 2011; Capa *et al.* 2015). Species distinguished from *S. aurantica* n. sp. due to the lower (<9) number of longitudinal rows of macrotubercles are *S. amoreuxi* Aguirrezabalaga & Cebeiro, 2005, *S. benguellarum* (Day, 1963), *S. octopapillata* (Hartmann-Schröder, 1965), *S. sphaerulifer* (Moore, 1909) and *S. uzintunensis* Kudenov, 1987. Of the remaining species, *S. aestuarum* Averincev, 1990 is distinguished from *S. auranticus* n. sp. because it has two transverse rows of additional papillae per segment in addition to the 8–10 macrotubercles and compound chaetae with blades around three times longer than wide; *S. balticum* (Reimers, 1933) also has two transverse rows of papillae per segment in addition to the 7–9 rows of macrotubercles and short chaetal blades (less than twice as long as wide); *S. gudmunduri* Moreira & Parapar 2012, lacks dorsal papillae among the nine macrotubercles and has short chaetal blades (around three times longer than wide); and *S. katchemakensis* Kudenov, 1987 bears two transverse rows of papillae in addition to the 8–9 macrotubercles and chaetae with blades ranging 3–4 times as long as wide (Reimers 1933; Hartmann-Schröder 1996; Kudenov 1987a; Moreira & Parapar 2012).

Sphaerephesia gesae Moreira & Parapar, 2011 is the only species in that genus with more than four longitudinal rows of macrotubercles (Moreira & Parapar 2011; Alalykina 2015). It can be distinguished from *S. aurantica* n. sp. by the presence of two transverse rows of macrotubercles per segment, instead of only one found in the new species and the chaetal morphology with short blades (maximum twice as long and wide) in comparison to those described in *S. aurantica* n. sp.

Etymology. The species name refers to the bright orange pigmentation (orange in Latin=*auranticus*) present in mid body tubercles.

Distribution. Species only known from type locality.

***Sphaerodoropsis plurituberculata* n. sp.**

(Figs 2E, F, 4, 5, 6)

Type material: Holotype: AM W.47516, Australia, Queensland, Great Barrier Reef, beach near research station, 14°40'43"S, 145°26'50"E, intertidal, coarse sand, 5 Nov 2002. Paratypes: AM W.47517 (1 spec.), AM W.47518 (1 spec, on SEM stub), SIO-BIC A3645 (2 males and 2 females, in resin blocks), SIO-BIC A 3647 (2 specs), all same collection information as holotype.

Comparative material examined. Holotype of *Sphaerodoropsis multipapillata heteropapillata* Hartmann-Schröder, 1987, ZMH P.18875, Australia, Victoria, Geelong, Point Lonsdale, Abrasion terrace near lighthouse, on coralline algae, 24 Dec 1975. Holotype of *Sphaerodoridium multipapillata* Hartmann-Schröder, 1979, ZMH P.14336, Tanzania, Mtwara, fine sand near coral reef south to the entrance of the harbour, 13 Nov 1967.

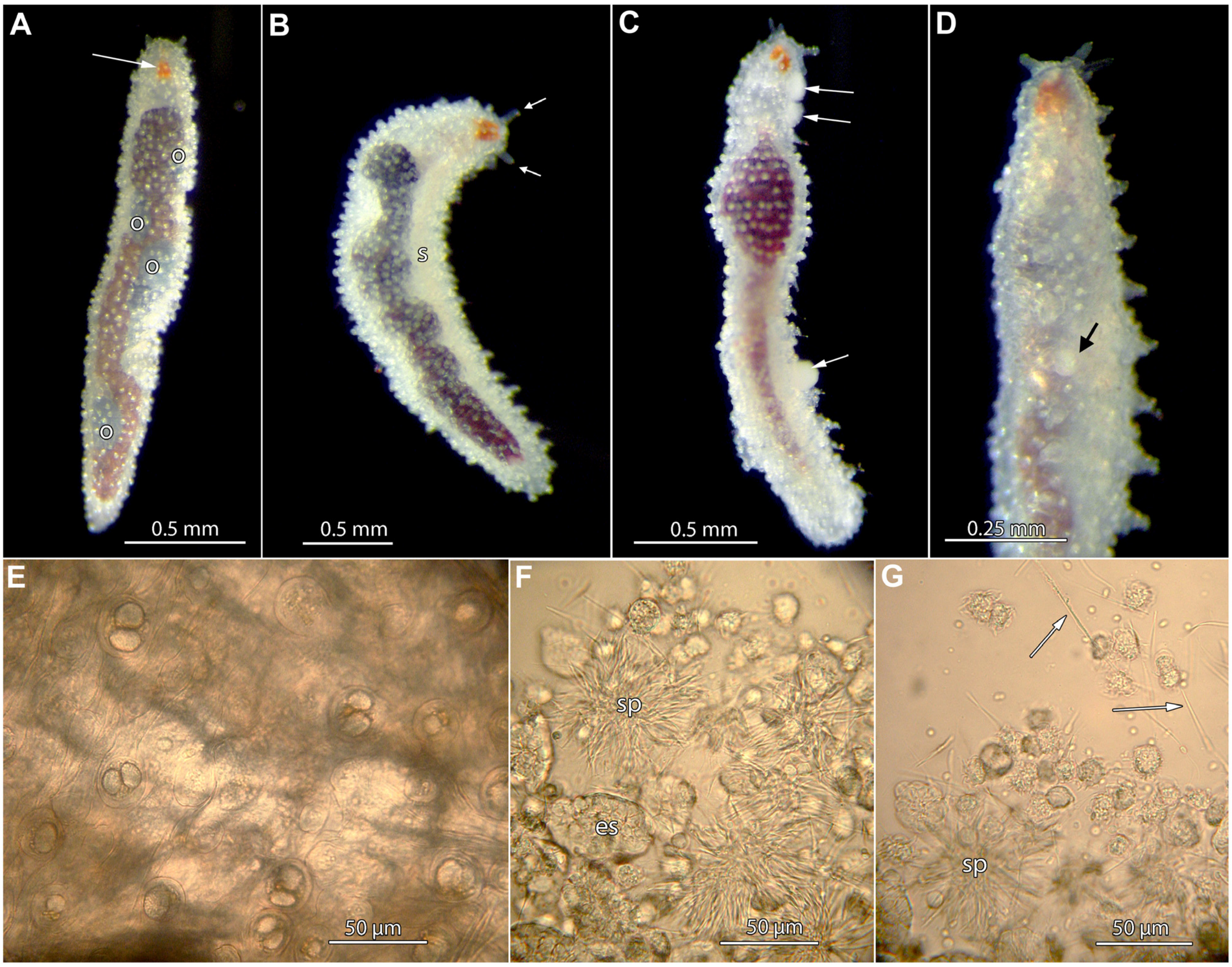

FIGURE 4. *Sphaerodoropsis plurituberculata* n. sp. live specimens. A–D. Micrographs taken with a dissecting microscope. A. Female, dorsal view, with a pair of orange subdermal eyes (arrow), brown gut and bluish oocytes (o); B. Male filled with sperm (s); lateral antennae marked with arrows; C. Male with spermatophores on dorsum (arrowheads); D. Male, ventro-lateral view, with copulatory organs on chaetiger 6 (arrow) and spermatophore visible through body wall; E–G. Micrographs taken with a compound microscope; E. Ventral papillae, containing paired transparent granules and a small orange one; F. Early (es) and late (sp) spermatids attached to central cytophore and other coelomic cells; G. Spermatids with some free swimming sperm (arrows).

Diagnosis. Body ellipsoid, with strongly convex dorsum. Over 12 more or less clearly arranged longitudinal rows of spherical, variable in size, and sessile dorsal tubercles, in four transverse row per segment. Parapodia with digitiform acicular lobe similar in shape and size to ventral cirrus, lacking papillae. Around six semi-compound chaetae per parapodium with distally enlarged shaft and short blades (up to twice longer than wide), serrated, with distal long spines; shaft with conspicuous spinulation. Male with enlarged, bottle-shaped and porous copulatory organ present in chaetiger 6 ventral to each parapodia instead of the normal ventral cirri. Females with oval and flat tubercle with a porous surface also ventral to parapodia of chaetiger 6.

Description. Male holotype. Body more or less ellipsoid, anterior end bluntly rounded and posterior end tapering (Figs 4A–D, 5A–B), measuring 1.5 mm long, 0.5 mm wide, with 18 chaetigers. Strongly convex dorsum and flat ventrum; segmentation inconspicuous (Figs 4A–D, 5A–B). Live colour transparent with brown gut, milky white coelom; dark brown after preservation. Bright orange subdermal eyes (Fig. 4A–D). Tegument with microscopic oblong granules. Head externally indistinct (Fig. 5A–C). Prostomium with five appendages; a pair of ventral-most palps, digitiform and about three times as long as wide; a pair of lateral antennae similar in shape and size to palp; and a spherical median antenna (Figs 4A–D, 5A). Around 10 small and spherical papillae confined by these appendages. A pair of tentacular cirri, shorter than palps and lateral antennae. Body surface covered in tubercles of two different sizes arranged in more or less 16–18 longitudinal rows in mid-body, four rows per segment, adding a total of around 30 in mid-chaetigers (Figs 2E, 4A–D, 5B). Microtubercles absent. Ventrum with papillae similar in shape and size to dorsal, arranged in about 10 longitudinal rows, four transverse rows per segment and a total of about 20 papillae per chaetiger in mid-body (Fig. 5A). Ventral papillae containing different type of granules (Fig. 4E). Parapodial sub-conical, increasing in size towards chaetiger 3 and decreasing in last three chaetigers, as long as wide in mid-chaetigers (Fig. 5A–E, G). Acicular lobe, digitiform, three times longer than wide, similar in shape as size as ventral cirrus (Fig. 5D–E). Parapodia lacking parapodial papillae; but one spherical papilla located close to anterior base of each parapodia (Figs 2F, 5D). Bottle-shaped copulatory organ present in chaetiger 6 ventral to each parapodia, which lack ventral cirri (Figs 4D, 5A, 6A), suggesting these structures are transformed ventral cirri. Usually six chaetae arranged in a more or less curved transverse line behind the acicular lobe (Fig. 5D–E). Hooks in anterior segments not observed. All chaetae simple (Fig. 5F), appearing semi-compound in some cases, denoting that shaft and blade have probably fused. Distal end enlarged, three times longer than wide, with spinulation in cutting edge and a conspicuous distal projection (Fig. 5F), similar along body and within fascicles. Chaetae showing a thin groove running parallel to edge, in distal end. Pygidium terminal, with inconspicuous spherical single anal cirrus (Fig. 5G). Brown gut seen by transparency, coiled in some parts (Fig. 4A–D) without a distinct muscular structure.

Variation. Paratypes range from 0.6 to 1.5 mm long, and 12–20 segments, showing two different body shapes, more or less elongated, probably due to contraction. The length of the anterior appendages also varies, being contracted in one paratype and resembling prostomial papillae (Fig. 5B), while in rest of paratypes they are digitiform and conspicuous. Number and size of epithelial tubercles vary slightly along chaetigers but they are constantly arranged in about four dorsal and ventral more or less evident transverse rows per segment. Longitudinal rows range between 13–18, however numbers are often difficult to count due to the different size of tubercles and their zigzag arrangement. Papillae seem absent of parapodia in all specimens, however and as mentioned in the holotype, an anterior ventral papillae can be considered part of the parapodia when these are relaxed and enlarged. Chaetae often broken but those that are intact are as those described in holotype, simple with spinulation along cutting edge and a distal spine. All specimens (live and preserved) lack external pigmentation.

Male paratypes share the presence of copulatory organs as described in holotype, and ventral to parapodia of chaetiger 6 (Fig. 6A). Females bear an oval and flat tubercle with a porous surface also ventral to parapodia of chaetiger 6 (Fig. 6B). Females, instead, show ventral cirri on the parapodia of this chaetiger (Fig. 6B).

Remarks. The present species agrees with the diagnostic features attributed to those *Sphaerodoropsis* species with macrotubercles in more than two transverse rows per chaetigers (Group 3, according to Borowski 1994), but also with other genera considered to lack macrotubercles and with large papillae instead, such as *Amacrodoum* Kudenov 1987, *Commensodoum* Lützen, 1961 and *Euritmia* Sardá-Borroy, 1987. Distinguishing papillae and macrotubercle is imprecise since they are currently defined according to their size (Fauchald 1974) and this is continuous character. Consequently, the species sharing the presence of more than 10 longitudinal rows of tubercles (more or less similar in size) in around four transverse rows per chaetiger need revision to enlighten their relationships and address their correct classification (Capa & Bakken in prep.).

There are two other species of *Sphaerodoropsis* in Borowski's Group 3, *S. multipapillata* (Hartmann-Schröder, 1974), from Tanzania, and *S. mutipapillata heteropapillata* Hartmann-Schröder, 1987, from Victoria, Australia, recently given a species rank (Capa & Bakken 2015). *Sphaerodoropsis plurituberculata* n. sp. is most similar to *S. heteropapillata* because both species are covered with dissimilar dorsal tubercles, while in *S. multipapillata* these are of similar size (Hartmann-Schröder 1974b; Hartmann-Schröder 1987; Capa & Bakken, 2015). Differences between *S. heteropapillata* and the new species include the length of the prostomial appendages (inconspicuous in *S. heteropapillata* and digitiform in *S. plurituberculata* n. sp., at least when not contracted); the number and of ventral papillae (around 50 per segments in *S. heteropapillata* and 30 in *S. plurituberculata* n. sp.); and the number of parapodial papillae (*S. heteropapillata* bears one at anterior surface while *S. plurituberculata* n. sp. lacks parapodial papillae).

Amacrodorum bipapillatum Kudenov, 1987, from Alaska, is distinguished from the new species by the morphology of the antennae, with spurs in *A. bipapillatum* and apparently smooth in the new species; the presence of one pair of black eyes in *A. bipapillatum,* absent in the new species; and having chaetae with strongly recurved tips (Kudenov 1987b: Fig. 1J) instead of straight but provided with a long and thin distal spine. Moreover, *A.*

bipapillatum was described with the apparently atypical attribute of bearing two different types of tubercles, elliptical and hemispherical while in *S. plurituberculata* n. sp. all papillae seem spherical.

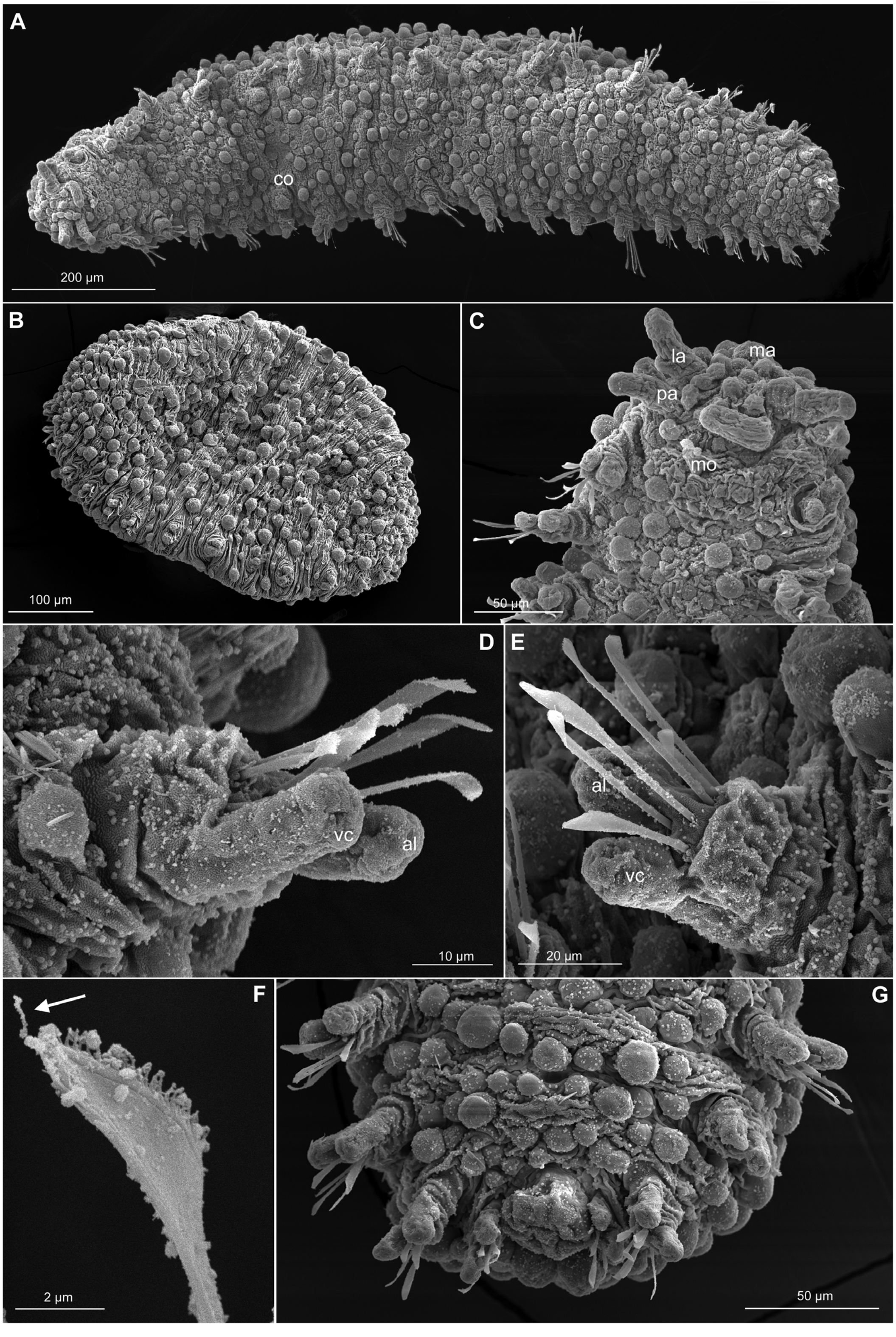

FIGURE 5. *Sphaerodoropsis plurituberculata* n. sp. SEM images. A. Male, ventral view, anterior end on left side, with copulatory organs on chaetiger 6 (co); B. Whole specimen, lateral view, anterior end on left side; C. Anterior end, ventral view; digitiform palps (pa) and lateral antennae (la), hemi-spherical median antenna (ma); mouth (mo) anterior to first chaetiger; D. Anterior chaetiger, ventral view with six chaetae, and digitiform ventral cirrus (vc) and acicular lobe (al); E. Mid-body chaetiger, posterior view; F. Detail of chaetae with conspicuous serration and distal spine (arrow); G. Posterior end with terminal pygidium.

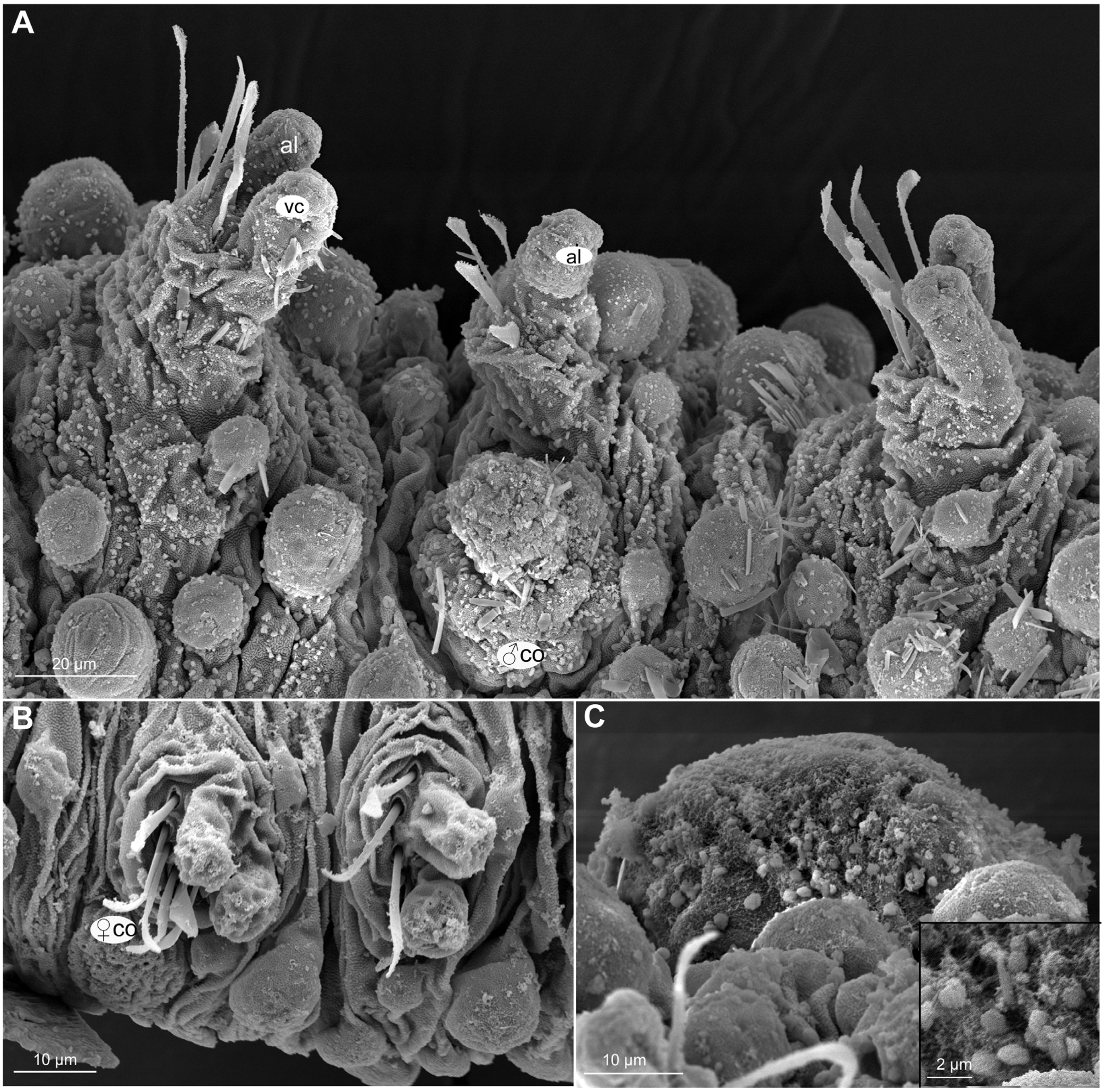

FIGURE 6. *Sphaerodoropsis plurituberculata* n. sp., reproductive features, SEM images. A. Male, detail of copulatory organ of chaetiger 6 (♂co); (al) acicular lobe, (vc) ventral cirrus; B. Female, copulatory organ on chaetiger 6 (♀co); C. Spermatophore attached to a male with detail (small window) of surface.

Euritmia hamulisetosa Sardá-Borroy, 1987 described from the south of Spain, differs from the new species in the chaetal morphology. *Euritmia hamulisetosa* bears simple chaetae, of different widths in all chaetigers all provided with a distal spine bent rearward to the cutting edge (Sardá-Borroy 1987) while *S. plurituberculata* n. sp. bears semi compound chaetae, all similar in width and with an erected thin spine. The other congener, *Euritmia capense* (Day, 1963) is provided with two defined rows of papillae of different size each, but they are not distributed in an apparently random pattern as in *S. plurituberculata* n. sp.

Commensodorum commensalis Lützen, 1961 is distinguished from the new species in the presence of four longitudinal rows of papillae along the dorsum (Lützen 1961).

Reproductive notes. Live specimens of *Sphaerodorpsis plurituberculata* n. sp. maintained in aquaria were studied during several days. White masses were observed attached to the body surface of both sexes during this time. These were found to be spermatophores when examined with a compound microscope (image not shown).

On several occasions males were seen to be pseudo-copulating with females, or other males, for less than a minute and on detaching were seen to have left one or two spermatophores on the body surface (Fig. 4C). Masses that corresponded to the size and colour of these spermatophores could be seen ventrally in chaetiger 6 (Fig. 4D), suggesting this segment is indeed the location of copulatory papillae. Structures attributed to be copulatory organs have been described for several other sphaerodorids in *Sphaerodoropsis* and *Sphaerodoridium* (Moreira *et al*. 2004; Böggemann 2009; Reuscher & Fiege 2011; Moreira & Parapar 2012, 2015; Capa & Bakken 2015). Males of *Sphaerodoropsis plurituberculata* n. sp. were observed to have various stages of spermiogenesis in their coelom. Sperm developed in cluster attached to a large central cytophore (Fig. 4F–G). The sperm heads were elongate at ~35 µm long (Fig. 4G) with what appeared to be a free flagellum of similar length. Free sperm were visible in the coelom (Fig. 4B) and it is not known how the sperm were packaged in the spermatophores. Males could be easily distinguished from females by having milky white coelomic contents surrounding the dark gut. Females had bluish/gray oocytes at various stages of development, with up to 10 oocytes at what appeared to be a late stage of development (Fig. 4A). Some females were observed to have free sperm in the coelom that had presumably come from the spermatophores (not shown). The largest eggs observed inside a female were about 150 µm in diameter suggesting development is lecithotrophic, similarly to conclusions reached by Christie (1984).

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