

# The diverse *Grania* fauna (Clitellata: Enchytraeidae) of the Esperance area, Western Australia, with descriptions of two new species

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## Abstract

Seven species of the marine enchytraeid genus *Grania* Southern, 1913 are described from sediments sampled during the 2003 International Workshop on the Marine Flora and Fauna of Esperance Bay and the Recherche Archipelago, on the southern coast of Western Australia. Two species are new to science, the euryhaline Tasmanian *G. dolichura* Rota and Erséus, 2000 represents a new record for the state, and the remaining four species were known from other parts of Western Australia. *Grania quarens* sp. n. is recognized by having a high chaetal index (= short chaetal foot), small coelomocytes, penial apparatus with long whip-like terminal stylets, conspicuous spermathecae with ectally bulbous ducts, and ectally granulated ampullae housing sperm rings in their ental region. *Grania sperantia* sp. n. is readily distinguishable by the complete lack of lateral chaetae, a multiple-banded pattern of the clitellum, extremely long sperm funnels, and the intrasegmental location of the spermathecal pores. The latter new species and four others in the collection (*G. bykane* Coates, 1990, *G. crassiducta* Coates, 1990, *G. dolichura*, and *G. ersei* Coates, 1990) are remarkable in possessing the head organ, a sensory structure unique to *Grania* that was not noted previously in Western Australian species. When considering the whole genus, the geographic pattern of the head organ appears southern-centred: of the 17 species of *Grania* reported to possess it, as many as 13 inhabit the southern latitudes. The seventh species of the Esperance collection, *G. vacivasa* Coates and Stacey, 1993, is notable for the kind of items found in its gut and the unusual appearance of its pygidium.

**Keywords:** *Enchytraeidae*, *Grania*, head organ, new species, taxonomy, Western Australia

## Introduction

The town of Esperance is situated on the south coast of Western Australia, some 725 km east of Perth. Within its bay are around 100 small islands and 1500 islets and exposed reefs forming the Recherche Archipelago. The coastline is a rugged, high-energy coast, with spectacular white beaches between headlands dominated by dome-shaped granite hills of similar origin to the islands. The bay and the archipelago were named after two French

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frigates, *L'Espérance* and *La Recherche*, which sheltered in this area during heavy storms in 1792. The two ships were searching Australian waters for the lost expedition of La Pérouse, while charting the coastline and exploring the new continent.

The rich diversity of habitats and wildlife of the Esperance coastal area is well known and since the 1960s has been conserved by a number of national parks. Likewise, the islands, mostly inaccessible because of their steep sides and frequently extreme weather conditions, feature a variety of unique terrestrial environments and many notable plants, birds, reptiles, and mammals; since 1984 all but one are protected as nature reserves.

Not as much is known of the marine benthic flora and fauna of the area. To improve this knowledge, an international team of 25 marine biologists worked in Esperance Bay and the Recherche Archipelago for 17 days during February 2003, sampling and documenting the local biodiversity. The Esperance marine biology workshop was the seventh in a series organized by the Australian Marine Science Association, in conjunction with the Western Australian Museum and the University of Western Australia, to study marine biology in the western half of the continent.

In previous studies, 14 species of the marine enchytraeid genus *Grania* have been reported from Western Australia (Michaelsen 1907; Coates 1990; Coates and Stacey 1993; Rota et al. 2003), making this state one of the best studied areas in the world with regard to this group of clitellate annelids. Nonetheless, knowledge about the presence of *Grania* along the southern coast is limited to the Albany region (Michaelsen 1907; Coates 1990). The next southern area of Australia for which data are available on *Grania* is Tasmania (Rota and Erséus 2000). The 2003 Esperance workshop provided an opportunity to obtain additional material from southern Western Australia, thus extending the geographical coverage of the continent's southern coast. Tubificidae, also collected at the Esperance workshop, were treated separately (Erséus and Wang 2005).

## Material and methods

A range of intertidal and shallow subtidal sites spanning over 100 km in the Esperance area were visited by the second author (see Appendix 1). At each station, a sediment sample of a few litres was scooped by hand. Each sample was repeatedly (four times or more) stirred in seawater in a bucket, and the suspensions of organic material thus obtained were poured off into a 0.25 mm sieve, after which the sieved material was brought live into the laboratory for further examination. The *Grania* specimens were sorted out under a dissecting microscope. Additional specimens were sorted from subtidal sediment samples (also listed in Appendix 1) collected by various scuba divers. The worms were fixed in Bouin's fluid for 1 or 2 days and then transferred into 75% ethanol.

Later, the individuals were all stained in alcoholic paracarmine, dehydrated through an ethanol/xylene series and mounted whole in Canada balsam. All morphological studies reported herein were performed on these mounted specimens under a DM LB Leica microscope connected to a Coolpix 4500 Nikon digital camera. Drawings were made with the aid of a camera lucida. In the descriptions, specific segments are referred to by Roman numerals. Measurements were obtained by using an eyepiece micrometer. The total length of the chaetae was measured in a straight line from the distal tip to the furthest proximal point. The length of the ental hook (or foot) is meant as the projection of the maximal breadth of the chaeta at its ental end. The "chaetal index" (Rota and Erséus 2003), used to discriminate between different types of L-shaped chaetae, expresses the average ratio between the total chaetal length and the foot length (average calculated on *n* chaetae). The

length of the glandular bulbs in the penial apparatus was measured as their extension parallel to the longitudinal axis of the body. Only the main differential features of the head organ, where present, are given (for an overall description of this sensory structure see Rota and Erséus 1996; Rota et al. 1999).

Types and other reference material are deposited in the Western Australian Museum (WAM), Perth, in the Swedish Museum of Natural History (SMNH), Stockholm, and in the Museo Civico di Zoologia di Roma (MCZR), Italy.

The following abbreviations are used in the figures: a, anus; as, aglandular sac; b, brain; c, chaeta; cc, circumpharyngeal blood commissures; co, circumpharyngeal nerve connectives; cu, cuticle; cy, coelomocytes; dbv, dorsal blood vessel; dl, dorsal lobe of pharyngeal gland; ecd, spermathecal ectal duct; fp, female pore; gb, glandular body of penial bulb; ggc, granular gland cell of clitellum; hgc, hyaline gland cell of clitellum; ho, head organ; hp, hyaline portion of sperm funnel; i, intestine; in, head organ inclusion; l, lateral; mo, mouth; mp, male pore; mu, muscle fibres; nc, nerve cord; p, prostomium; php, pharyngeal pad; py, pygidium; r, rectum; rgc, refringent gland cell of clitellum; sa, spermathecal ampulla; sf, sperm funnel; sh, heads of spermatozoa; sp, spermathecal pore; sr, sperm ring; st, stylet; v, ventral; vd, vas deferens; vl, ventral lobe of pharyngeal gland.

## Descriptions

### *Grania bykane* Coates, 1990

(Figures 1A–G, 2A)

*Grania bykane* Coates 1990, p 21–23, Figures 2, 4A–D.

#### *Material examined*

WAM V 7306, one puberal specimen (spermathecae not fully differentiated) from Stn ES03-22B. SMNH Main Coll. 90226, one fully mature specimen from Stn ES03-5B.

#### *Description*

Body of mature specimen 6.7 mm long, 0.12 mm wide at V, 0.20 mm at XII, comprising 60 segments (puberal specimen 52 segments). Prostomium rounded (Figure 1A), 60–75  $\mu$ m wide, 37–45  $\mu$ m long, epidermis 2.5–3.2  $\mu$ m thick at front side. Chaetae beginning in XIX or XX laterally, in IV or V ventrally. Chaetae L-shaped, shaft straight, proximally bending into a long foot without heel and with low instep (Figures 1D, 2A). Preclitellar chaetae progressively increasing in size towards clitellum, shaft 30–60  $\mu$ m long, 3–5  $\mu$ m thick at mid-point, foot 14–18  $\mu$ m long. Postclitellar chaetae 32–58  $\mu$ m long, 2.5–4.5  $\mu$ m thick, with foot 8–15  $\mu$ m long; minimal size at both ventral and lateral positions recorded within segments XX–XXX. Chaetal index 3.75,  $n=7$ ,  $s=0.538$ . Somatic epidermal gland cells inconspicuous. Clitellum 17  $\mu$ m thick, covering XII and most of XIII; pattern of gland cells as in type material; hyaline cells rectangular, larger than granular gland cells (Figure 1B). A “copulatory gland” seen in XIV. Spermathecal pores in lateral lines, just posterior to 4/5.

Brain posteriorly indented. Head organ present, containing four equally large (ca 3  $\mu$ m in diameter) globular inclusions (Figure 1A) in both specimens. Pharyngeal glands with large ventral lobes (one pair) in IV in both specimens. Gut contents: few medium-sized diatoms.

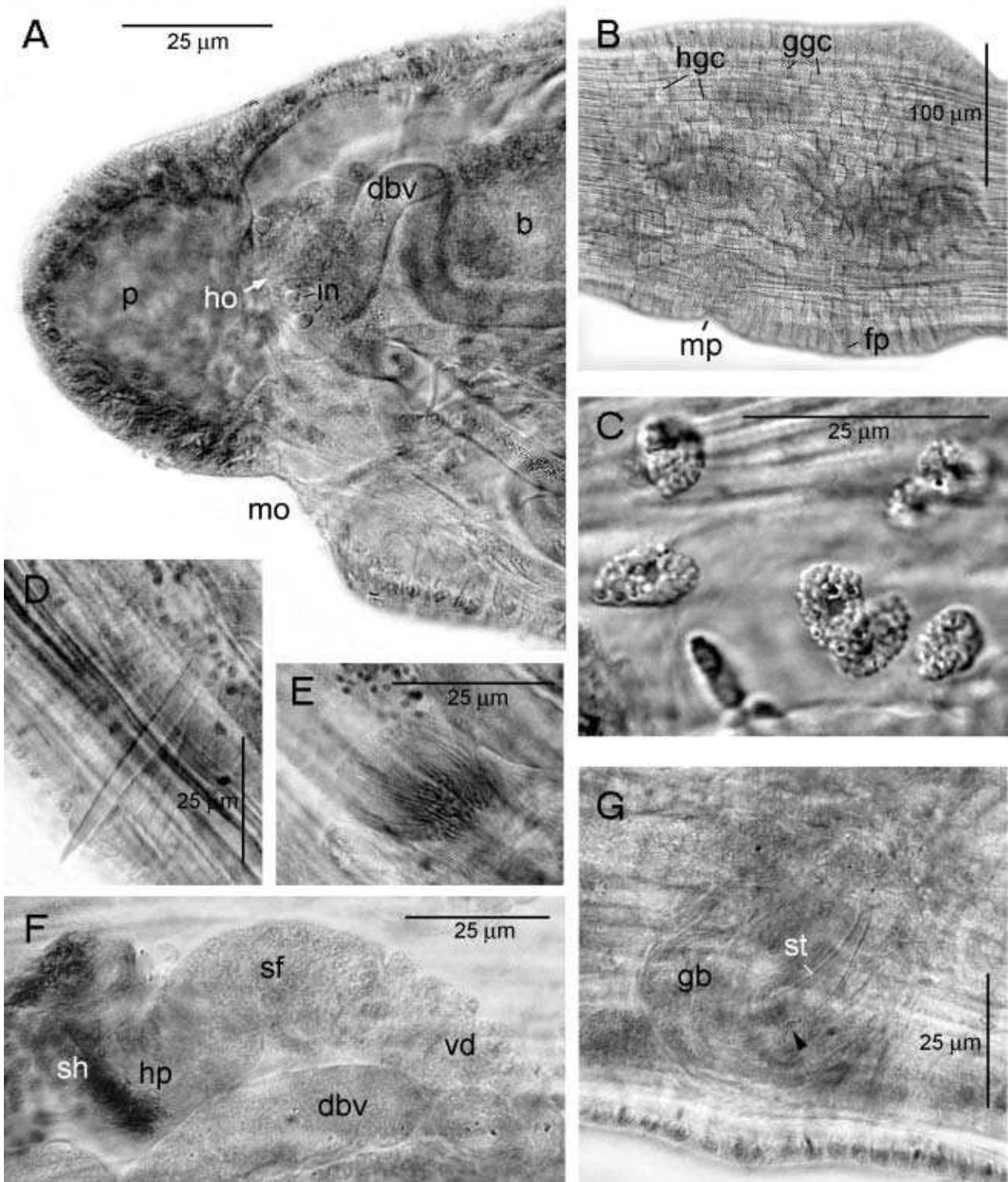


Figure 1. *Grania bykane* Coates, 1990. (A) Cephalic region, dorsolateral view showing the head organ; (B) clitellum (lateral view); (C) coelomocytes; (D) ventral chaeta of segment XIV; (E) late spermatid bundle, showing the spiral structure of the nuclei; (F) sperm funnel; (G) penial bulb with stilet; the arrowhead points to the proximal constriction of the stilet.

Rectal ampulla short, with trapezoidal sagittal section. Nephridia from 7/8, inconspicuous. Coelomocytes oval or drop-shaped, up to 15 µm long, filled with refringent pale globules (Figure 1C). Dorsal blood vessel arising in XXII. Chloragogen cells dense from VII, shallow (maximally 5 µm high above gut). Sperm sac extending into half XV. Sperm

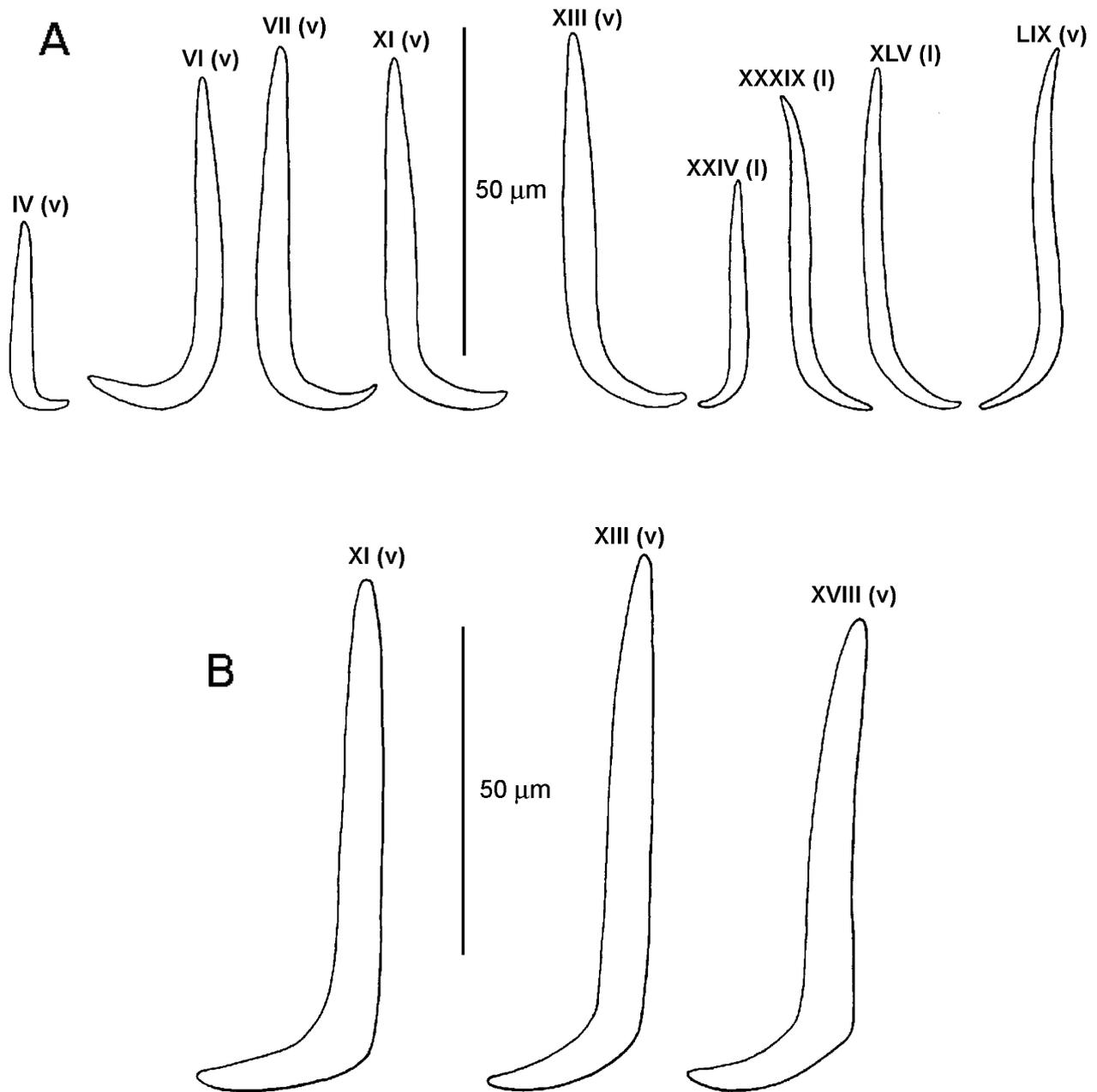


Figure 2. (A) *Grania bykane* Coates, 1990, chaetae from different segments as indicated by Roman numerals; (B) *Grania crassiducta* Coates, 1990, chaetae from different segments as indicated by Roman numerals. l, lateral chaeta; v, ventral chaeta.

funnels with low hyaline portion below collar (Figure 1F). Heads of spermatozoa short (about 9 µm long), showing spiral structure (Figure 1E). Vasa deferentia about 7–9 µm thick, unmodified, showing inner ciliation throughout lengths. Penial stylets (Figure 1G) curved trumpet-like, about 30 µm long, constricted near junction with vas deferens, then soon attaining maximal width (7 µm), to attenuate to 1.3 µm at opposite distal end. Stylets fully developed in puberal specimen. Egg sac extending into XX. Ectal ducts of spermathecae thick-walled, 23 µm in diameter at mid-length, gradually expanding toward ampulla, whereas tapering towards body wall; no glands at ectal pore. Spermathecal ampullae of adult specimen bulb-shaped, 36 µm wide, with up to six sperm rings, 9–11 µm in diameter, arranged in a circle in ectal ampullar portion; some spermatozoa (both coiled and loose) in ectal duct's canal.

*Remarks*

This Western Australian species, originally described from two stations in Princess Royal Harbour, Albany area (Coates 1990), is unmistakably recognized by the morphology of the spermathecae and penial stylets, and by the form and size distribution of the chaetae. The segment number is greater in the present specimens than in the types from Albany, but the holotype was admittedly incomplete (Coates 1990). In light of the new data, *Grania bykane* appears close to *G. crassiducta* Coates, 1990 (see below) as to chaetal shape, segment number and possession of head organ, but it clearly differs in morphometrics (having smaller body size, shorter sperm heads, smaller chaetae, higher chaetal index, shorter sperm and egg sacs), shape of penial stylets (with proximal constriction), chaetal size distribution, and other details. This is the first report of the occurrence of the head organ in *G. bykane*.

*Distribution and habitat*

Southern coasts of Western Australia (Albany and Esperance areas). Intertidal and subtidal to at least 6 m depth, in fine to coarse sand and in sediments under boulders and in seagrass beds (see Coates 1990).

***Grania crassiducta* Coates, 1990**

(Figures 2B, 3A–F)

*Grania crassiducta* Coates 1990, p 20–21, Figures 2, 3A–D; Coates and Stacey 1993, p 404–406, Figure 9A–F.

*Material examined*

WAM V 7307, one fully mature specimen from Stn ES03-39. SMNH Main Coll. 90227, one fully mature specimen from Stn ES03-28E (missing posterior segments).

*Description*

Body of the only complete specimen 7.15 mm long, 0.19 mm wide at V, 0.22 mm at clitellum, comprising 56 segments. Prostomium ogival, only slightly shorter than wide (Figure 3B, C), 72–83 µm wide, 64–72 µm long; epidermis 4.5–8 µm thick at front, cavity of prostomium traversed by horizontal and oblique muscular laminae. Chaetae beginning in XVIII or XX laterally, in IV ventrally. Chaetae L-shaped, shaft straight, bluntly pointed ectally, gradually broadening toward ental end, until bending at 110° into a long, slender foot with indistinct heel, low instep, curved sole and flat toe (Figures 2B, 3A). Preclitellar chaetae 55–80 µm long, with foot increasing in length from 13 to 27 µm; postclitellar chaetae 51–88 µm long, with foot decreasing in length posteriorly from 25 to 17 µm. Size of chaetae maximal in IX–XVIII (here, chaetal index 3.24,  $n=3$ ,  $s=0.432$ ), size gradually decreasing towards posterior body end. Somatic epidermal gland cells visible on segments I–II. Spermathecal pores as conspicuous oval buttons (orientated longitudinally) located in lateral lines, slightly posterior to 4/5.

Brain posteriorly indented. Head organ present, containing four globular inclusions, each 3–5 µm in diameter (Figure 3A, B). Pharyngeal glands with large ventral lobes (one pair) in IV in both specimens. Gut contents: brown organic matter, including some coarse fragments. Rectal ampulla not expanded. Nephridia not seen in front of clitellum.

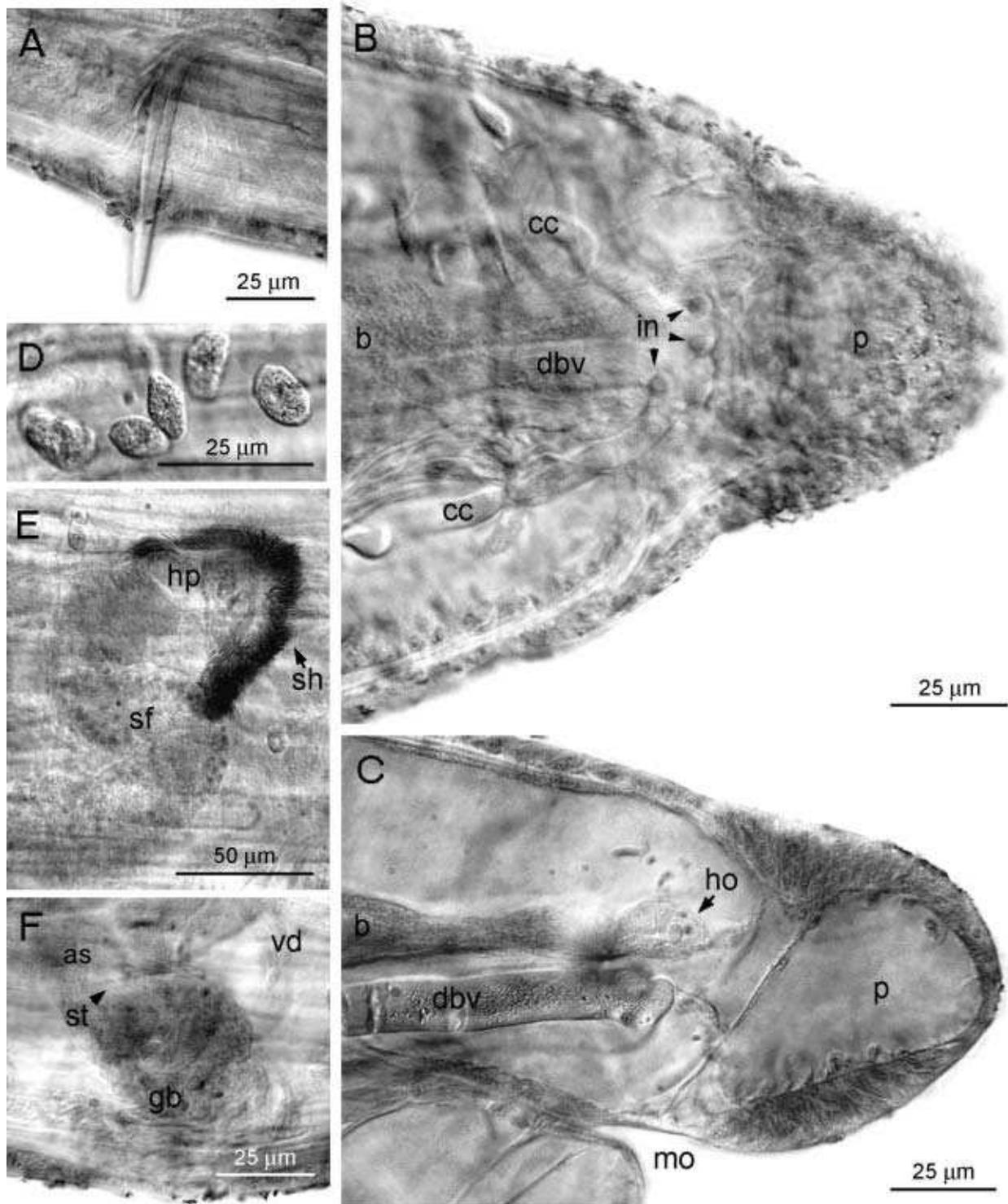


Figure 3. *Grania crassiducta* Coates, 1990. (A) Ventral chaeta of segment XIII; (B) cephalic region, dorsal view (note, in particular, the globular inclusions of the head organ just above the anterior end of the dorsal blood vessel); (C) cephalic region of a different specimen in laterosagittal view, showing the position of the head organ inside the peristomium; (D) coelomocytes; (E) sperm funnel; (F) lateral view of the penial apparatus, showing the terminal tract of stylet inside the aglandular sac.

Coelomocytes few, up to 16µm long, filled with refractile, somehow clotted granules (Figure 3D). Dorsal blood vessel arising in XX–XXIV. Chloragogen tissue mostly shallow, but some cells reach 8–9µm above gut in posterior segments. Sperm sac extending into XVI–XVII. Sperm funnels narrow, cylindrical, with tall hyaline portion below collar

(Figure 3E). Heads of spermatozoa about 15  $\mu\text{m}$  long. Vasa deferentia (Figure 3F) showing conspicuous inner ciliation, about 10–11  $\mu\text{m}$  thick for most of their course, narrowing to 6–8  $\mu\text{m}$  ectally. Penial stylets spiral horn-shaped, 21–30  $\mu\text{m}$  long, 5–7  $\mu\text{m}$  wide at junctions with vasa deferentia, terminating in a very thin tip inside large aglandular sac. Glandular bulb 50  $\mu\text{m}$  wide (Figure 3F). Egg sac extending into XX. Spermathecal ampullae housing about 10 sperm rings, 10–12  $\mu\text{m}$  in diameter, embedded in walls around equator of ampulla.

#### Remarks

The morphology and morphometrics of the Esperance specimens of this taxon are in line with the original description from Princess Royal Harbour, Albany (Coates 1990). Conspecifics reported later from Rottneest Island (Coates and Stacey 1993), having shorter bodies, penial stylets almost twice as long as those of the types and a marked variation in width along the vas deferens, belong perhaps to an allied unnamed species. The occurrence of the head organ in *G. crassiducta* is noted here for the first time. The species appears now also remarkable for the low chaetal index (= long ental foot), the bulbous shape of the spermathecal ducts (maximum diameter as great as or greater than maximum width of ampullae) and the thin horn-shaped penial stylets.

#### Distribution and habitat

Southern (Albany and Esperance) and western (Rottneest Island) coasts of Western Australia. Characteristic of lower intertidal to shallow subtidal habitats; in Esperance found in muddy coarse sand and in mixed sand with pebbles and coral.

#### *Grania dolichura* Rota and Erséus, 2000

(Figure 4A–C)

*Grania dolichura* Rota and Erséus 2000, p 249–252, Figure 3A–H.

#### Material examined

WAM V 7308, one subadult from Stn ES03-28B and WAM V 7309, one puberal specimen (spermathecae not fully differentiated) from Stn ES03-35B.

#### Description

Body 9.7–10.5 mm long, 0.17 mm wide at V, 0.20 mm at XII, comprising 84, 85 segments. Prostomium small, bluntly conical, 60–80  $\mu\text{m}$  wide and 48–55  $\mu\text{m}$  long, epidermis 5.5–6.0  $\mu\text{m}$  thick at front (Figure 4B). Chaetae (Figure 4C) beginning in XVII–XVIII, in IV ventrally. Preclitellar chaetae up to 55  $\mu\text{m}$  long, postclitellar chaetae up to 57  $\mu\text{m}$  long. Epidermal gland cells conspicuous on anteriormost segments. A “copulatory gland” seen midventrally in XIV in puberal specimen. Spermathecal pores in lateral lines, slightly posterior to 4/5.

Head organ containing two large (5–6  $\mu\text{m}$ ) inclusions in both specimens (Figure 4B); other inclusions may be present but coelomocytes partly impede observation of the region. Anterior septa 7/8–8/9 thickened. Pharyngeal glands showing no ventral lobes in IV, nor any extra pairs in VII. Gut contents: brown organic matter and diatoms. Rectal ampulla

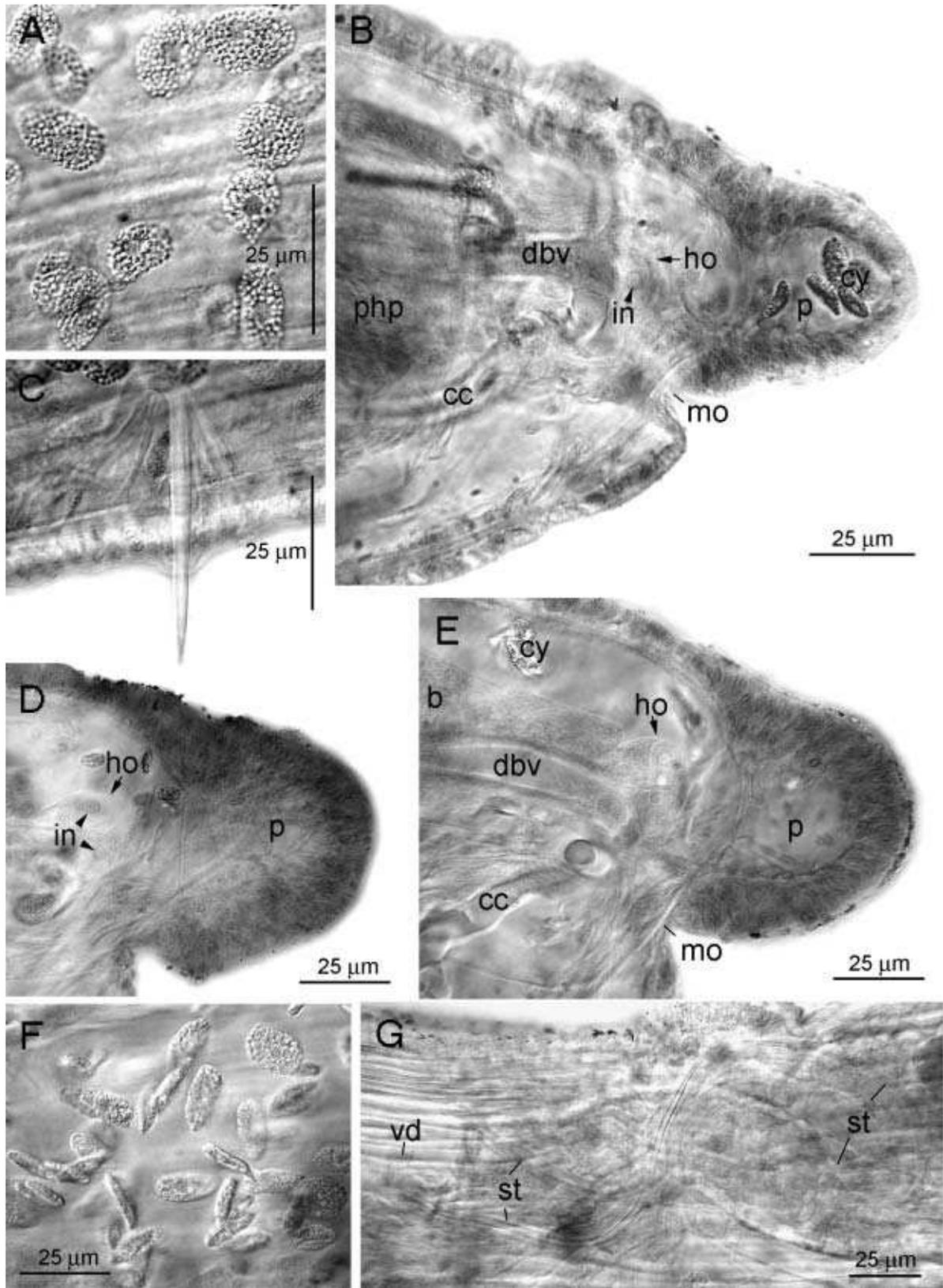


Figure 4. (A–C) *Grania dolichura* Rota and Erséus, 2000: (A) coelomocytes; (B) cephalic region, dorsolateral view; (C) ventral chaeta of segment LXVII. (D–G) *Grania ersei* Coates, 1990: (D) tip of cephalic region in dorsolateral view, showing a shallow optical section of the prostomium and the typical bilobed outline of the head organ; (E) cephalic region of a different specimen. Deeper optical section through the head organ showing the location of inclusions inside the “empty” compartments; (F) coelomocytes; (G) terminal tract of the vas deferens and the enclosed penial stylet in an unusual loose state; the stylet length is more than twice the length of segment XII.

spacious, bowl-shaped, filling most of pygidium, ending in a broad anus. Coelomocytes numerous, rather large (16–19 µm long), filled with small, non-transparent, round granules (Figure 4A). Dorsal blood vessel originating in L. Sperm sac reaching XXV. Sperm funnels three to four times longer than wide (130–170 × 38–45 µm), cylindrical, with tall hyaline portion below collar. Sperm heads 20 µm long, with evident helical structure. Vasa deferentia unmodified, showing conspicuous inner ciliation, 11 µm thick near funnel, then narrowing to about 6–8 µm thick. Penial apparatus with bipartite aglandular sacs and trumpet-like, entally funnel-shaped stylets, latter 21–25 µm long, 7 µm wide at junctions with vasa deferentia, terminating in a 1.5 µm wide tip. Stylets fully developed in puberal specimen. Each stylet housed in anterior portion of aglandular sac. Egg sac not developed. Spermathecal ampullae bulb- or pear-shaped, with small but evident inner cavity, empty (both specimens precopulatory). Ectal ducts narrow (18 µm), ectally bent, slightly expanded but devoid of glands at orifice.

#### Remarks

Neither of the Esperance specimens of *G. dolichura* is fully mature but both are consistent with the original description (Rota and Erséus 2000) from Tasmania in diagnostic details of somatic (large size of head organ inclusions, long dorsal vessel, large chloragogen cells, thickening of anterior septa) and reproductive characters (clitellar pattern, penial bulb construction, stylet shape and size, length of sperm heads). From present observations on Tasmanian material (in E. R. collection), the two Australian populations are also consistent in the morphology of the rectum, a detail not noted previously. As concerns the pharyngeal glands, the Esperance specimens differ from the Tasmanian ones in lacking ventral lobes in IV and the extra glands in VII, while their sperm sacs extend more posteriorly. The new morphological information reported herein for *G. bykane* (head organ with four small globular inclusions, entally constricted penial stylets, etc.; see above) does not strengthen the possibility of a close relationship between the two species advanced by Rota and Erséus (2000).

#### Distribution and habitat

Originally reported from estuaries around Tasmania, where it is abundant and widespread (about 70 specimens from six stations) and covers a salinity range of 11–35psu, *G. dolichura* now appears to be a “southern Australian element” with a distribution possibly spanning across the Great Australian Bight and the South Australian Gulfs. Previously known as intertidal, in Esperance it is found in shallow subtidal (0.5–1.5 m) coarse sand colonized by *Posidonia* and in shelly heterogeneous sand.

#### ***Grania ersei* Coates, 1990**

(Figures 4D–G, 5A)

*Grania ersei* Coates, 1990 p 17–20, Figures 1A–D, 2; Coates and Stacey 1993, p 406–408, Figure 10A–F.

#### Material examined

WAM V 7310–7314, five specimens numbered in this order: two from Stn ES03-5B, two from Stn ES03-34B, and one from Stn ES03-39. SMNH Main Coll. 90228-90236, nine specimens: one from Stn ES03-4B, two from Stn ES03-5B, one from Stn ES03-21C, and

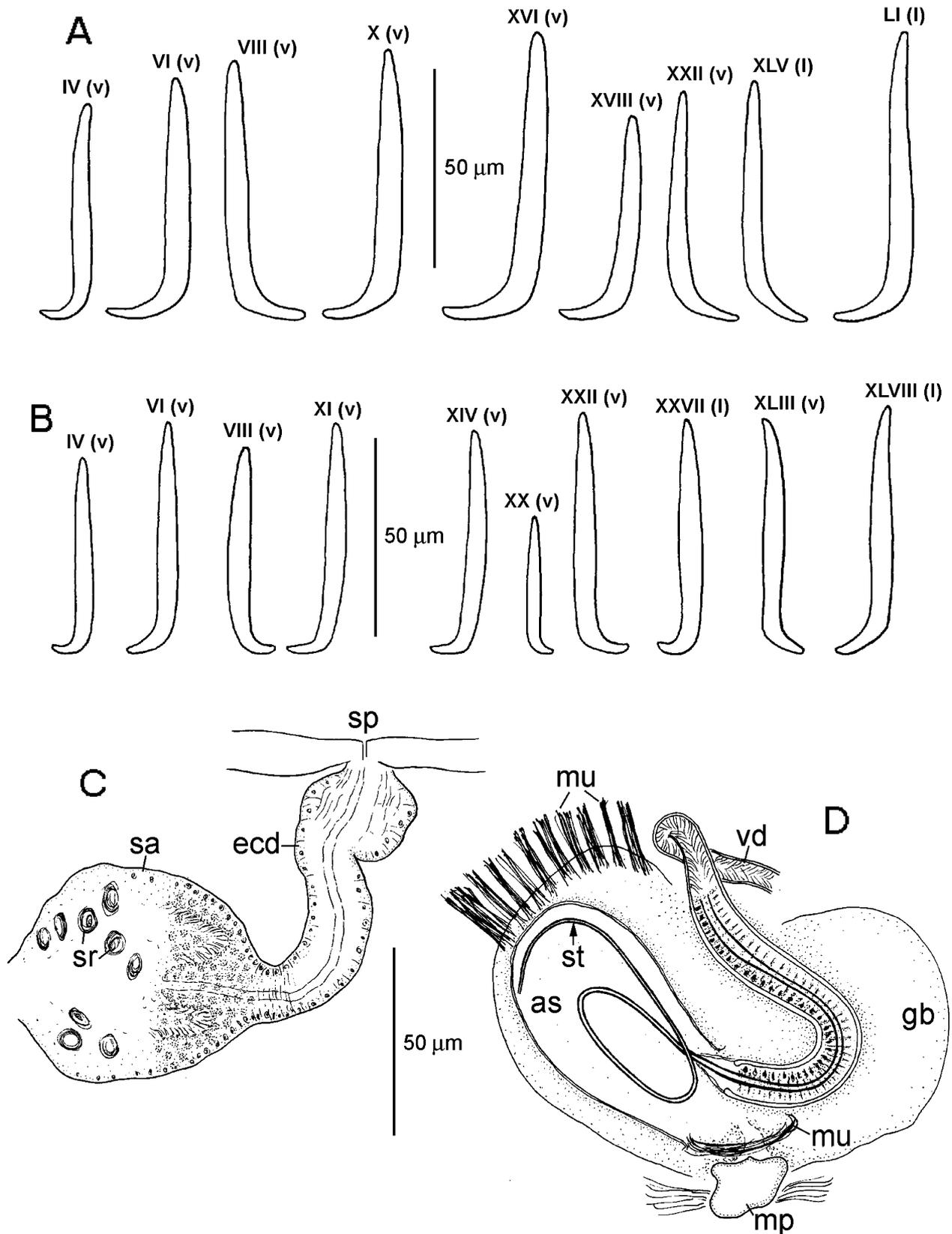


Figure 5. (A) *Grania ersei* Coates, 1990, chaetae from different segments as indicated by Roman numerals. (B–D) *Grania quaerens* sp. n.: (B) chaetae from different segments as indicated by Roman numerals; (C) spermatheca; (D) lateral view of the penial apparatus. (C) and (D) shown to the same scale. l, lateral chaeta; v, ventral chaeta.

five from Stn ES03-34A. MCZR Oligochaeta 0140–0145, six specimens: two from Stn ES03-1B, two from Stn ES03-5B, and two from Stn ES03-15C. All specimens fully mature, except those from Stns ES03-1B and ES03-39, and one from ES03-15C (puberal to precopulatory).

### Description

Body 6.1–8.1 mm long ( $n=12$ ), 0.15–0.24 mm wide at V, 0.17–0.29 mm at XII ( $n=16$ ). Segments of adults 53–61 ( $n=12$ ). Prostomium dome-shaped (Figure 4D, E), 72–104  $\mu\text{m}$  wide at 0/1, 56–85  $\mu\text{m}$  long ( $n=7$ ), epidermis not always reduced at front (5–9.5  $\mu\text{m}$ ). Lateral chaetae beginning in XIV–XV, more rarely in XVI–XIX. Chaetal shaft straight, stout, 3.5–6  $\mu\text{m}$  thick at mid-point, proximally bent into an oblique, rather long, narrow foot with indistinct heel and low instep; tip of foot straight (Figure 5A). Preclitellar chaetae 50–70  $\mu\text{m}$  long, with foot 13–19  $\mu\text{m}$  long; postclitellar chaetae 54–75  $\mu\text{m}$  long, with foot 16–23  $\mu\text{m}$  long. Chaetal index 3.65,  $n=14$ ,  $s=0.303$ . Maximal length of shaft around XVI and in caudal segments (72–75  $\mu\text{m}$ ), thickness greatest in anterior body region. In the two specimens from ES03-34B, chaetae smaller, shaft length by thickness ranging within 40–56 by 2.5–5  $\mu\text{m}$ . Epidermal gland cells inconspicuous.

Brain indented posteriorly. Head organ present, containing up to four equal- or unequal-sized globules (Figure 4D, E). Head organ not always detectable, partly because specimens on fixation had either everted their foregut or ejected refringent coelomocytes from head pore. Pharyngeal glands never extending into VII, always with ventral lobes in IV (one pair). Gut contents heterogeneous: both fine and coarse organic matter, undigested algal filaments, diatoms, fragmented sponge spicules. Rectal ampulla not or just enlarged at mid-length (olive-shaped). Nephridia not seen before clitellum. Coelomocytes numerous, narrow oval to drop-shaped, finely granular, refractile, up to 16  $\mu\text{m}$  long (Figure 4F). Dorsal blood vessel arising in XXV. Sperm sac extending into XVI–XIX ( $n=16$ ). Sperm heads 15–18  $\mu\text{m}$  long. Penial stylets (Figure 4G) originating in posterior portion of penial apparatus, about 394–500  $\mu\text{m}$  long ( $n=4$ ), fully formed also in puberal specimens devoid of spermathecae. An adult specimen from ES03-5A had two detached stylets at bottom of egg sac. Egg sac extending into XX–XXII ( $n=16$ ). Ectal ducts of spermathecae very long, coiled, 13–14  $\mu\text{m}$  thick, occasionally bearing a distinct, sessile ectal gland (ES03-4B, ES03-5B). Sperm rings, 13–18  $\mu\text{m}$  in diameter, embedded in agranular walls of ental ampullar portion.

### Remarks

The Esperance material gives the opportunity to complete the original and subsequent accounts of this Western Australian taxon (Albany: Coates 1990; Rottnest Island: Coates and Stacey 1993) with respect to the occurrence of coelomocytes, the different texture of the walls in the ectal and ental portions of the spermathecal ampulla, and the presence of a head organ (although not always detectable). The latter observation rectifies what was stated previously (Rota and Erséus 2000, p 249; based on material in C. E. collection). Apparently, there is considerable variation in chaetal size among populations from different geographic areas (Albany: 42–112  $\mu\text{m}$ ; Rottnest: 40–68  $\mu\text{m}$ ; Esperance: 50–75  $\mu\text{m}$ ), but the values of the chaetal index are likely to be typically low, due to the proportionally long ental foot (see Coates 1990, Figure 1B; Coates and Stacey 1993, Figure 10A, B). As noted in other species, the penial stylets (extremely long in *G. ersei*) appear fully developed before complete differentiation of the spermathecae has taken place.

*Distribution and habitat*

South (Albany, Esperance) and west (Rottneest Island) coasts of Western Australia. In intertidal and subtidal sands down to 26 m (new depth record), often among boulders and pebbles, with algal debris. This species can be locally very abundant: both previous accounts were based on rich collections (Albany material: 112 specimens from 26 stations; Rottneest material: 101 specimens from 25 stations).

***Grania quaerens* sp. n.**  
(Figures 5B–D, 6A–I)

*Type material*

Holotype: WAM V 7315, whole-mounted specimen, fully mature, from north of New Island, 34°0.84'S, 122°8.52'E, rocky shore, lower intertidal, medium to coarse sand under rocks, 6 February 2003 (Stn ES03-5A). Paratypes: WAM V 7316–7319, four specimens numbered in this order: three from type locality (V 7318 missing posterior segments), and one from Stn ES03-28D. SMNH Type Coll. 6803–6808, six specimens: five from type locality (two missing posterior segments), and one from Stn ES03-36. MCZR Oligochaeta 0146–0149, four specimens from type locality (one missing posterior segments). All but one specimen fully mature.

*Description*

Body 5.8–7.2 mm long ( $n=5$ ), 0.19–0.22 mm wide at V, 0.22–0.26 mm at XII ( $n=8$ ). Segments of complete adults 49–53 ( $n=7$ ). Prostomium small, rounded (Figure 6C, D), 62  $\mu$ m long, widening out bell-wise at 0/1 (80–88  $\mu$ m) ( $n=2$ ) to meet twice as broad peristomium; epidermis not notably reduced at front tip (5–8  $\mu$ m thick). Lateral chaetae from XIV (13 specimens) or XV (two specimens), ventral chaetae from IV. Chaetal shaft straight, 3.2–5.6  $\mu$ m thick at mid-point, proximally bent into a short, thin, oblique (110–125° to the shaft) foot with low instep and receding heel; tip of foot straight (Figures 5B, 6B). Preclitellar chaetae 35–62  $\mu$ m long, with foot 7–9.5  $\mu$ m long; postclitellar chaetae 35–67  $\mu$ m long, with foot 7–13  $\mu$ m long. Chaetal index 5.21,  $n=10$ ,  $s=0.644$ . Shaft length and thickness slightly increasing towards posterior body end; shortest and thinnest lateral and ventral chaetae recorded near XX. Epidermal gland cells inconspicuous, except in a poorly preserved specimen from ES03-36 which from XVIII to posterior end shows a complete row of deep-staining, large (6.5–8  $\times$  19–22  $\mu$ m) rectangular cells per segment at chaetal level. Clitellum (Figure 6A, E) extending over XII and most of XIII, maximally 13–17.5  $\mu$ m thick, comprising small gland cells arranged in about 35 regular transverse rows; granular type interspersed with hyaline cells except lateral to and, ventrally, posterior to male pores where dense granular fields occur; both types absent midventrally between male pores (Figure 6E). A small “copulatory gland” midventrally in XIV. Spermathecal pores in lateral lines, immediately posterior to 4/5 (Figure 6G).

Brain indented posteriorly. Head organ absent. Pharyngeal glands at 4/5–6/7, not united dorsally; ventral lobes in IV–VI. Ventral lobes of IV twice as long as dorsal lobes (Figure 6C). Gut contents characterized by large amounts of coarse, thin-walled organic matter, some diatom shells, and spicule fragments. Rectal ampulla short, with trapezoidal

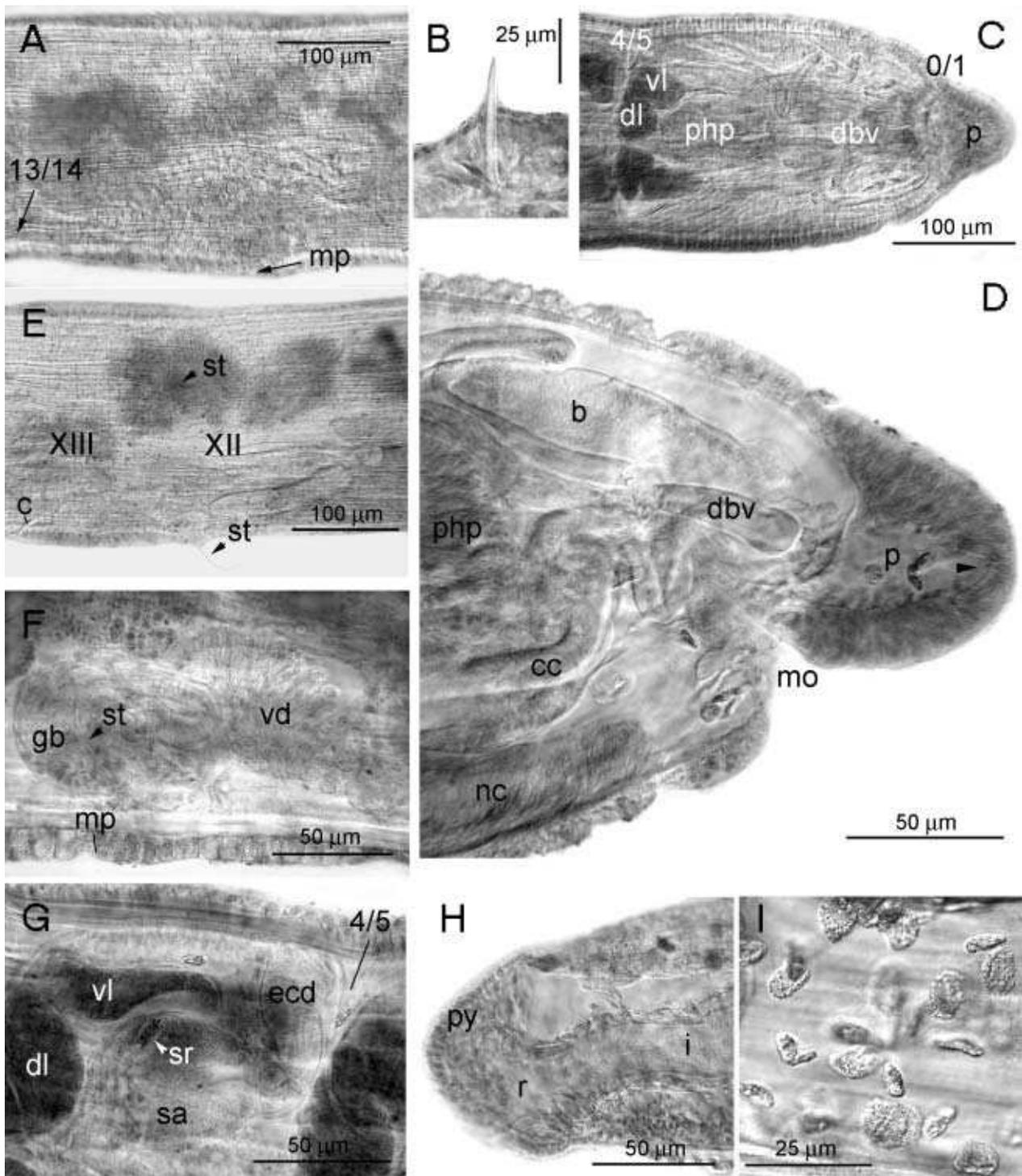


Figure 6. *Grania quaerens* sp. n. (A) Clitellum, dorsolateral view; (B) dorsal chaeta of segment XX; (C) dorsal view of prostomium and anterior segments (I–IV); (D) cephalic region, laterosagittal view (the arrowhead points to the inner cavity at the tip of prostomium); (E) ventrolateral view of clitellum, with stylet protruding from male pore; (F) vas deferens and penial apparatus; (G) spermatheca; (H) lateral view of caudal region, showing rectal ampulla; (I) coelomocytes.

sagittal section (Figure 6H). First nephridia at 7/8. Dorsal blood vessel arising in XVIII or XIX. Coelomocytes numerous, small, with irregular oval or round outline, up to 13 μm long; cytoplasm with refractile, fine granulation thinning out around cell nucleus (Figure 6I). Sperm sac extending into XIV–XVI. Sperm funnels four to five times longer

than wide (192–200 × 40–48 μm), as long as inner body diameter at clitellum, cylindrical with a short hyaline portion below collar. Heads of sperm 16–18 μm long. Each vas deferens 8–9 μm wide, coiled in tight spirals in XII (Figure 6F), or extending backwards as far as XIV inside sperm sac, showing thin ciliated walls all the way to penial apparatus. Latter comprising an elongated glandular body (125 μm) centred at male pore, which is joined by vas from posterior dorsal aspect, and a long whip-like stylet (V 7318 missing posterior segments) (Figure 5D). Inside penial apparatus, vas thicker (12 μm), muscular and unciliated, forming a stiff curve in the anterior part of glandular body; here vas cells endowed with large nuclei all along enclosed section of stylet (Figures 5D, 6F). Stylet totally about 210–258 μm long ( $n=7$ ), diameter constantly 4 μm in initial one-third (located inside vas deferens), then gradually attenuating to 1 μm at distal end; free part of stylet coiled into one and a half perpendicular loops located inside deep male invagination and aglandular sac, but in fixed specimens distal end often protruding through male pore (Figure 6E). Stylets fully developed in subadult specimen. Egg sac extending into XVII–XIX. Spermathecal ducts not notably muscular, 90–100 μm long, ectally bulbous (25 μm thick), 15 μm thick at midcourse, not thinning entally; inner canal maintaining uniform diameter throughout duct's length, joining ciliated ampullar cavity through conspicuous, short-conical intrusion (Figures 5C, 6G); ampullae oval, 55–75 μm long, 43–55 μm wide, granulated ectally; 8–12 sperm rings, 7.5–12.5 μm in diameter, embedded in clear ampullar walls of ental portion (Figures 5C, 6G). No separate glands at ectal pores of spermathecae.

#### *Etymology*

The specific name is Latin for “seeker, searcher”, in reference to its occurrence in the Recherche Archipelago.

#### *Remarks*

Diagnostic for this new species is the combination of a high chaetal index (= short chaetal foot), small coelomocytes, long penial stylets forming loops inside the deep epidermal invaginations at male pores, conspicuous spermathecae with ectally bulbous ducts, and ectally granulated ampullae housing sperm rings in their ental region. The named features of the spermathecal ampullae (ectal granulation of walls and ental location of sperm rings), as well as the unusual length of the penial stylets, are reminiscent of the Western Australian *G. longistyla* Coates and Stacey, 1993 and *G. ersei*. In fact, at first sight one may have the impression that *G. quaerens* is but a small-sized version of *G. ersei*, with the shorter reproductive organs (spermathecal ducts and penial stylets are about one-half the length of those of *G. ersei*) being simply related to the smaller body size, but this is not so. The body size of *G. ersei* and *G. quaerens* largely overlap. Moreover, both *G. ersei* and *G. longistyla* have a different chaetal shape from *G. quaerens* (low chaetal index at least in *G. ersei*, see above) and lack preclitellar nephridia. Finally, as *G. vacivasa*, *G. quaerens* differs from *G. ersei* and the other species identified in the Esperance area by the lack of the head organ.

#### *Distribution and habitat*

South coast of Western Australia (Esperance). Exclusively found in lower intertidal, medium to coarse sand.

***Grania sperantia* sp. n.**  
(Figures 7A–H, 8A, B)

*Type material*

Holotype: WAM V 7320, whole-mounted specimen, fully mature, from southeast of Cowerie Bay at Cheyne Point, 33°56.91'S, 122°31.27'E, subtidal, 0.5 m, heterogeneous sand with pebbles and coral, 19 February 2003 (Stn ES03-39). Paratypes: WAM V 7321–7326, six specimens numbered in this order: one from type locality, one from Stn ES03-25C, one from Stn ES03-28A, one from Stn ES03-28C, and two from Stn ES03-35A. SMNH Type Coll. 6809–6817, nine specimens: six from Stn ES03-28C and three from Stn ES03-35A (two missing posterior segments). MCZR Oligochaeta 0150–0155, six specimens: three from Stn ES03-28C (two missing posterior segments) and three from Stn ES03-35A (two missing posterior segments). All fully mature except three just puberal from ES03-25C, ES03-28A, and ES03-35A, and two subadult from ES03-28C and ES03-35A.

*Description*

Body 11.8–15.4 mm long ( $n=13$ ), 0.30–0.35 mm wide at V, 0.38–0.42 mm at clitellum ( $n=20$ ). Segments of complete adults 66–78 ( $n=14$ ). Prostomium rounded (Figure 7A, B), 80–108  $\mu\text{m}$  long, 133–175  $\mu\text{m}$  wide at 0/1 ( $n=20$ ), epidermis just thinning at front (to 10–15  $\mu\text{m}$ ). Chaetae beginning in VII ventrally, absent throughout laterally. Chaetal length 125–163  $\mu\text{m}$  in preclitellar segments, 105–160  $\mu\text{m}$  in postclitellar segments, larger in (VII) IX–XXV (XXX), then gradually decreasing towards tail. Chaetae (Figures 7F, 8A) stout, L-shaped, ectal tip blunt, shaft straight, progressively expanding entally (from up to 11  $\mu\text{m}$  thick at mid-point to up to 14  $\mu\text{m}$  across ankle), then curving into a short, slender foot with low instep and indistinct heel. Chaetal index 4.84,  $n=10$ ,  $s=0.424$ . Sole of foot flat, tip of foot upturned. Epidermal gland cells inconspicuous. Thick layer of longitudinal body wall muscle fibres. Clitellum as much as 32.5  $\mu\text{m}$  thick when fully developed, extending from the chaetae of XI to the whole of XIII, sometimes covering part of XIV (Figure 7C, D); gland cells distributed into three main bands around body: a wider “middle band” of small (8–11  $\mu\text{m}$  across), polygonal cells with two granulation types, hyaline and pale granular, interspersed in an irregular pattern—this middle band starts in the first half of XII; and an anterior and a posterior “border band”, each of 14–16 regular transverse rows of cells, dominated by large rectangular (10  $\times$  16–24  $\mu\text{m}$ ) hyaline cells. In closer view, the “border bands” indeed consist each of two sub-bands: one located at the (anterior or posterior) boundary of clitellum and comprising about 10–12 rows of merely hyaline cells, and the other, adjacent to the middle clitellar band, consisting of four to five rows of hyaline cells intermingled with few, very small (3–7  $\times$  6  $\mu\text{m}$ ), refringent granular cells (Figure 7D). Clitellum absent midventrally between male pores (Figure 7C). Male pores ventrolateral in middle of XII. A small “copulatory gland” midventrally in XIV. Spermathecal pores (Figure 8B) located in lateral lines at one-third of V.

Brain indented posteriorly. Head organ housing four to six globular inclusions of uniform (4.8  $\mu\text{m}$ ) or different (2.5–6.4  $\mu\text{m}$ ) diameter (Figure 7A, B); inclusions often showing a central hole (some specimens from ES03-28C and ES03-35A). Pharyngeal glands paired at 4/5–6/7, with ventral lobes in IV–VI; ventral lobes larger than dorsal ones in

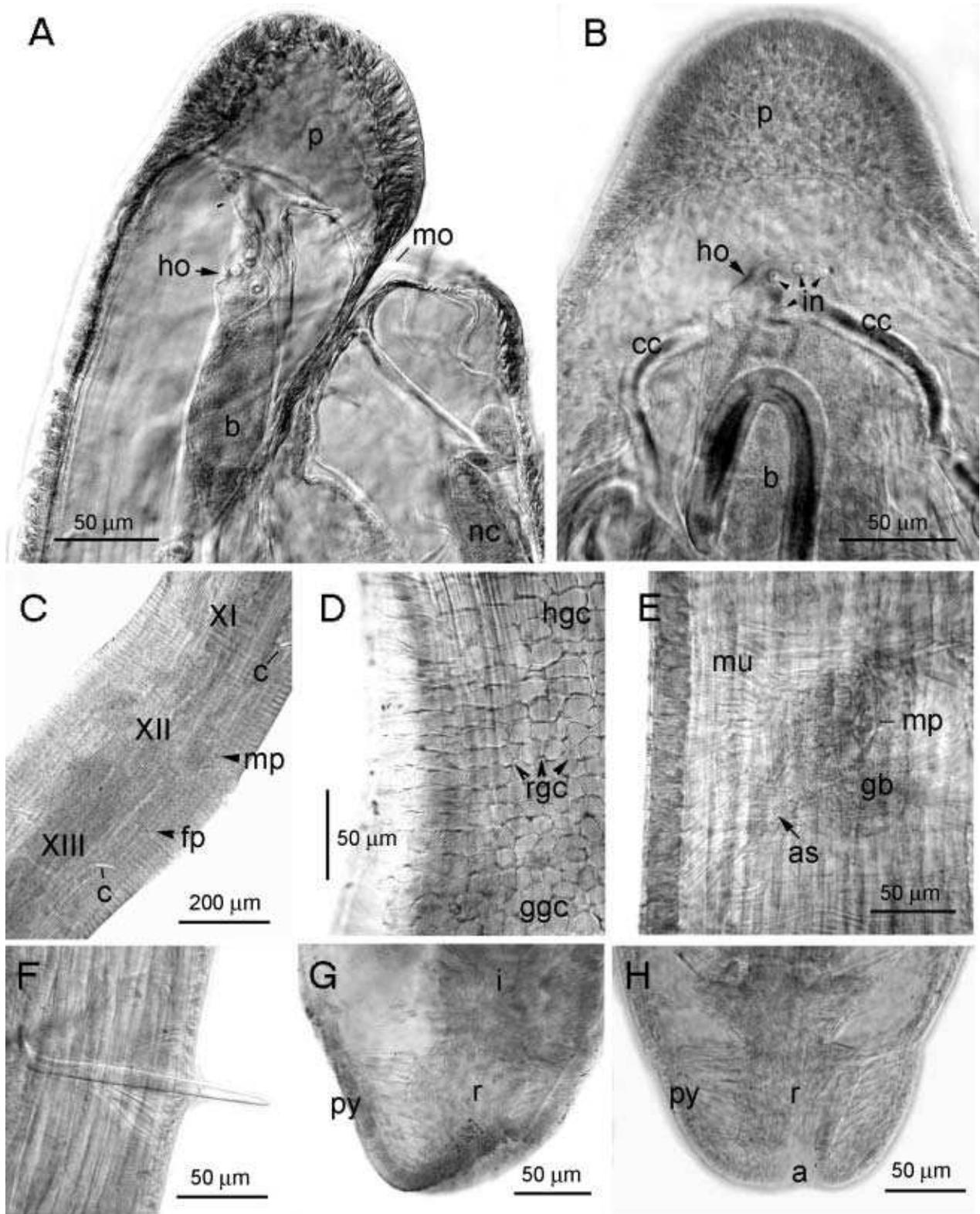


Figure 7. *Grania sperantia* sp. n. (A, B) Cephalic region in lateral (A) and dorsal (B) views, showing the head organ and its hollowed inclusions; (C) ventral view of clitellum; (D) detail of the anterior part of clitellum, showing (above) the two anterior sub-bands of rectangular hyaline cells, intermingled or not with small refringent cells, and (below) the middle band made of hyaline and pale granular, polygonal cells; (E) ventrolateral view of penial bulb; (F) ventral chaeta of segment XXXVII, turned somewhat frontally; (G, H) pygidium in lateral (G) and ventral (H) views, showing rectal ampulla.

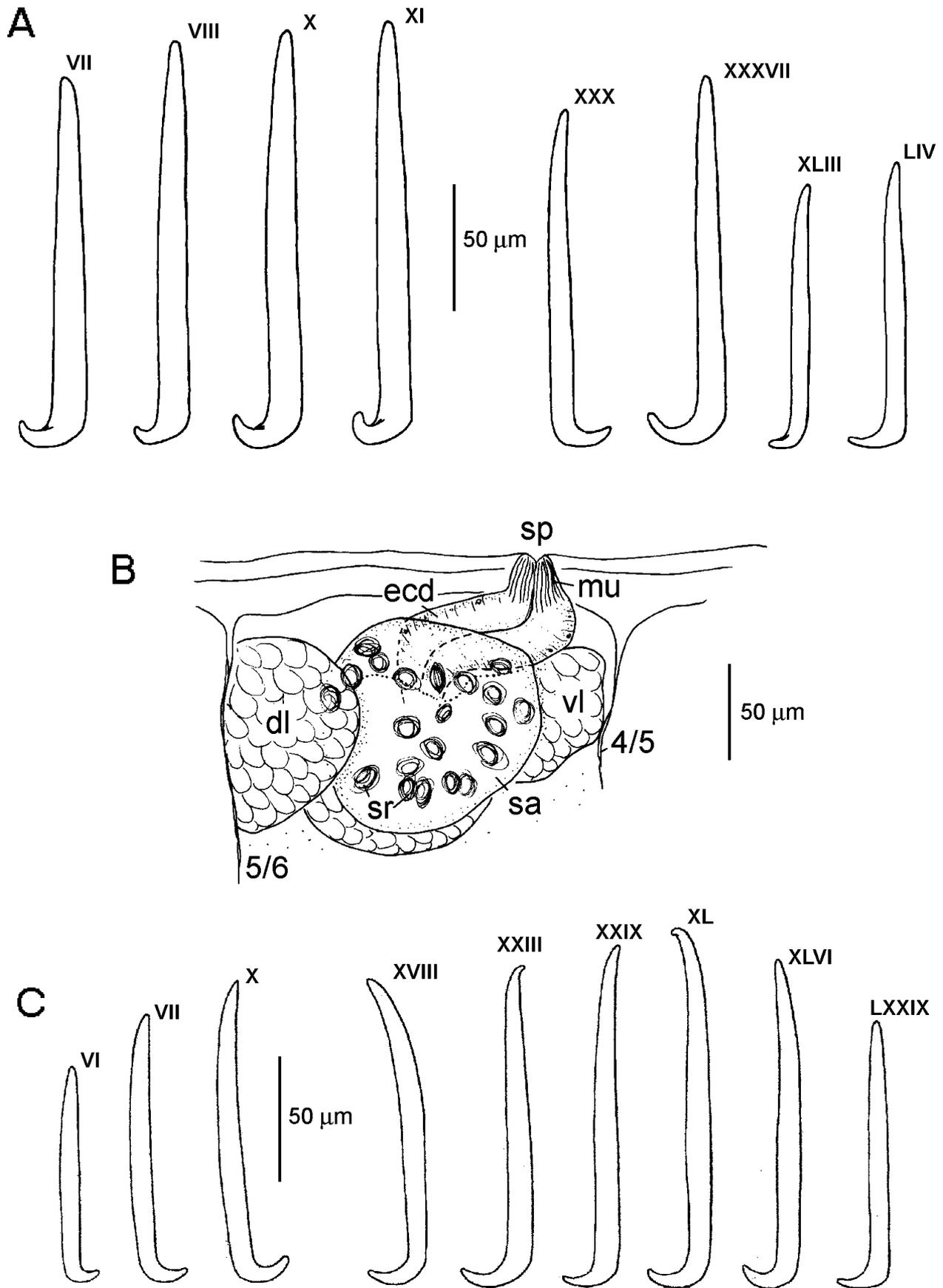


Figure 8. (A, B) *Grania sperantia* sp. n. (A) Chaetae from different segments as indicated by Roman numerals (all ventral chaetae); (B) dorsal view of the spermatheca and pharyngeal glands of segment V; (C) *Grania vacivasa* Coates and Stacey, 1993, chaetae from different segments as indicated by Roman numerals (all ventral chaetae).

IV. Gut contents: small to large diatoms, fragments of thick sponge spicules, organic material mostly decomposed. Rectal ampulla not expanded (Figure 7G, H). First nephridia at 7/8; nephridia conspicuous in posterior body half. Coelomocytes not seen. Dorsal blood vessel commencing in XXXIX–XLIX ( $n=12$ ). Chloragogen cells reaching 16  $\mu\text{m}$  above gut in anterior segments, more flattened (11  $\mu\text{m}$  at most) behind clitellum. Sperm sac extending to XXII–half XXIX ( $n=6$ ). Sperm funnels elongate, 62.5  $\mu\text{m}$  wide, about 19 times longer than wide, occupying 3.5 segments [XIII–XV(XVI)], with a short (16–19  $\mu\text{m}$ ) hyaline portion below collar. Heads of sperm reaching 22–24  $\mu\text{m}$  above collars. Vasa deferentia not very long, always less deep than sperm funnels inside sperm sac (coils only seen as far back as XIV); vas unmodified, ciliated throughout, proximally 17.5  $\mu\text{m}$  wide, ectally narrowing to 10  $\mu\text{m}$  as approaching penial apparatus from posterior side. Penial apparatus, a compact glandular bulb, oval in lateral view, 96–112  $\mu\text{m}$  long, slightly off-centred to the rear of the male pore, flanked laterally by an aglandular sac pointing posteriorly; all parts of apparatus anchored by robust muscles to body wall (Figure 7E). No stylets present (penial type “3” sensu Coates 1984). Egg sac extending into XXIX–XXXII ( $n=4$ ). Spermathecal ampullae large, oval, 88–112  $\mu\text{m}$  wide, 104–128  $\mu\text{m}$  long, with agranular walls, separately attached to oesophagus in posterior of V (Figure 8B); about 30 sperm rings, maximally 19  $\mu\text{m}$  wide, embedded in each ampulla. Ectal ducts 100–128  $\mu\text{m}$  long, 32  $\mu\text{m}$  wide at midcourse, narrowing at both ends; ducts S-shaped, proximally curved medially to enter ampullae laterally, distally bent at angle to reach external pores. Latter portion of ducts showing distinct muscle fibres.

#### *Etymology*

Named using the late Latin equivalent of “Espérance” (the French name for “Hope”).

#### *Remarks*

This new species is easily distinguished by the complete lack of lateral chaetae, the multiple-banded pattern of the clitellum, the extremely long sperm funnels, and the intrasegmental location of the spermathecal pores. Remarkable also is the high number (and the hollowness) of the inclusions that can be found in the head organ of some specimens. The lack of coelomocytes, consistently observed in material from four stations, could be an artefact due to loss of these cells on fixation (thus representing at least a behavioural, if not physiological, trait of the species). The body size, the chaetal characters (size, shape, and distribution) and the proportions of the sperm funnels are strongly reminiscent of *G. conjuncta* Coates and Stacey, 1993, another Western Australian species described (on a single specimen) from Rottneest Island, characterized by dorsally merging spermathecae and the lack of penial aglandular sacs. *Grania sperantia*, however, does not share such aberrant structure of the spermathecae and penial apparatus, and is also readily distinguished from *G. conjuncta* by its regular number of pharyngeal glands, the occurrence of nephridia at 7/8, and a more posterior origin of the dorsal vessel.

#### *Distribution and habitat*

South coast of Western Australia (Esperance). In lower intertidal to shallow subtidal (2 m), medium to coarse sand.

*Grania vacivasa* Coates and Stacey, 1993  
(Figures 8C, 9A–E)

*Grania vacivasa* Coates and Stacey 1993, p 400–402, Figures 5A–D, 6A–D.

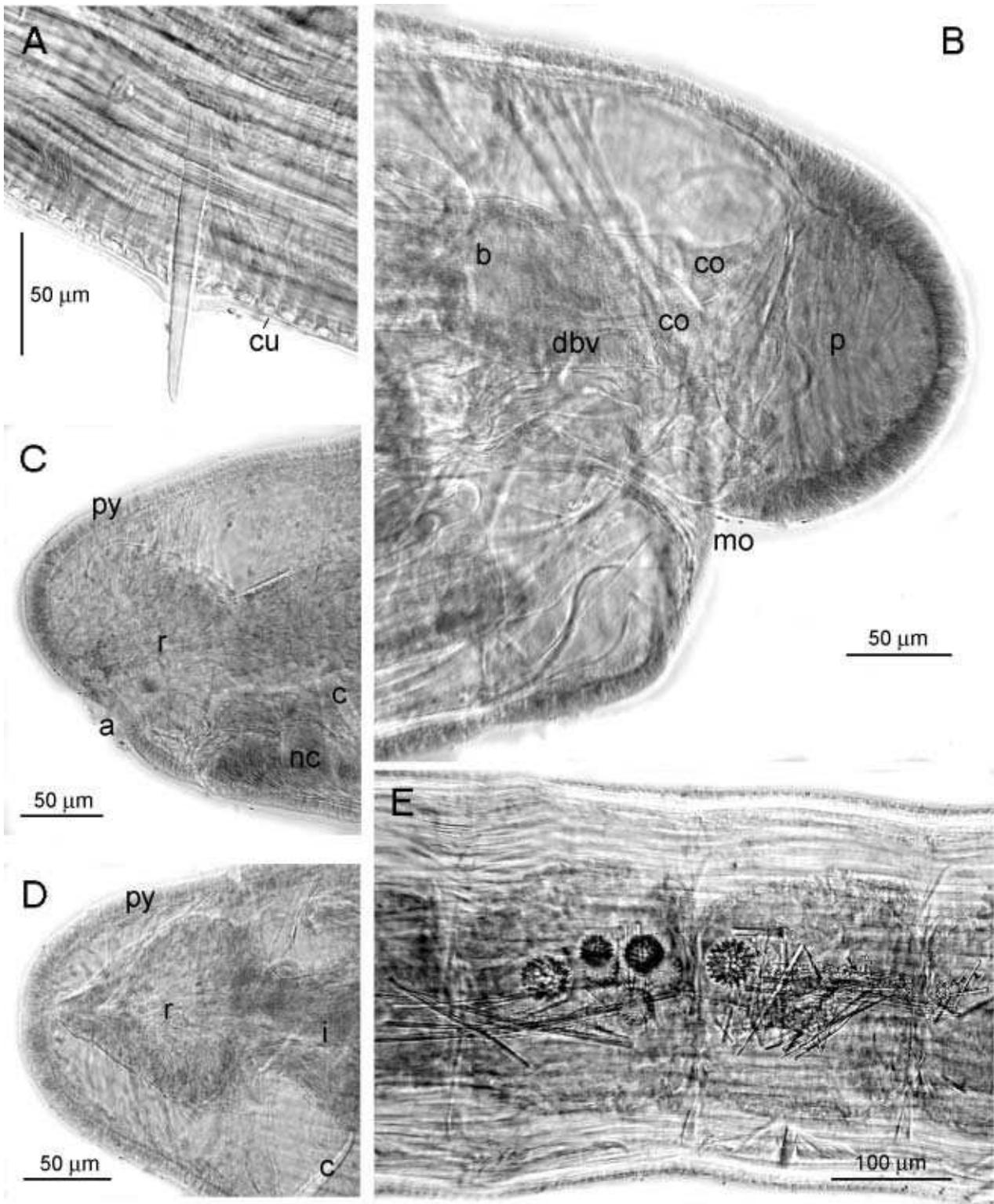


Figure 9. *Grania vacivasa* Coates and Stacey, 1993. (A) Ventral chaeta of segment XXIX; (B) dorsolateral view of cephalic region; (C, D) pygidium in lateral (C) and ventral (D) views, showing expanded rectal ampulla; (E) caudal segments showing large sponge spicules inside gut lumen.

*Material examined*

WAM V 7327–7329, three specimens, one of which (V 7329) missing posterior segments. SMNH Main Coll. 90237–90238, two specimens, one of which missing posterior segments. MCZR Oligochaeta 0156–0157, two specimens. All from Stn ES03-4A and fully mature.

*Description*

Body 14–18 mm long ( $n=5$ ), 0.32–0.36 mm wide at V, 0.32–0.37 mm at clitellum ( $n=7$ ), comprising 70–87 segments ( $n=5$ ). Prostomium dome-shaped (hemispherical) (Figure 9B), 175–200  $\mu\text{m}$  wide at base and 100–120  $\mu\text{m}$  long ( $n=5$ ), epidermis 7.5–15  $\mu\text{m}$  thick at front. Posterior margin of pygidium rounded (Figure 9C, D). Chaetae lacking laterally, beginning in V (three specimens) or VI (four specimens) ventrally. Preclitellar chaetae 80–130  $\mu\text{m}$  long, postclitellar chaetae 90–147  $\mu\text{m}$  long. Size of chaetae reaching maximum at mid-body (around XXX–XL), progressively decreasing towards anterior and posterior body ends. Chaetae L-shaped or hooked, with shaft straight or slightly bent ectally (without preferential direction), thickest at mid-point, entally curving into a short foot with curved sole and slightly upturned toe (Figures 8C, 9A). Chaetal index 5.70,  $n=11$ ,  $s=0.523$ . Body cuticle always thin (1  $\mu\text{m}$ ), or tightly adhering, over prostomium, peristomium, and pygidium; it may reach up to 4  $\mu\text{m}$  over mid-body segments (Figure 9A). Epidermal gland cells inconspicuous. Clitellum maximally 23–27  $\mu\text{m}$  thick, absent between male pores; both granular and hyaline gland cells small, irregularly shaped, intermingled; only granular cells occurring midventrally behind male pores and laterally to male pores. Spermathecal pores as conspicuous oval buttons in lateral lines, somewhat posterior to 4/5.

Brain indented posteriorly. Head organ absent (Figure 9B). Septa 7/8–9/10 somewhat thickened. Gut contents: conspicuous sponge spicules (large needles, fragmented or entire, and spherical bodies) and coarse organic matter (Figure 9E). Rectal ampulla distinctly dilated, occupying most of pygidial lumen (Figure 9C, D). Nephridia not seen. Coelomocytes not seen. Dorsal blood vessel arising in XXXIV–XLVI ( $n=4$ ). Chloragogen cells rounded, finely granular, forming a thin layer above gut in all segments. Sperm sac extending into XXV–XXXI. Heads of spermatozoa about 15  $\mu\text{m}$  long. Vasa deferentia unmodified, showing conspicuous inner ciliation, about 11.0–15.5  $\mu\text{m}$  thick. Egg sac extending into XXXII–XXXVII. Spermathecae attached to oesophagus in posterior half of V. About 20 sperm rings, 16–22  $\mu\text{m}$  in diameter, scattered throughout walls of each ampulla; spermatozoa often present (uncoiled) also inside canal of ectal duct.

*Remarks*

This large species, known so far from one station at Rottneest Island, is easily identified by the lack of lateral chaetae, the location of the largest chaetae at midbody, the midventral papillae in XIV and XV, the long sperm funnels (11–15 times longer than broad), and the unarmed penial apparatus (Coates and Stacey 1993; personal observation). Three additional diagnostic features, noted herein for the first time and essential to clearly separating it from the otherwise similar *G. sperantia*, are: the high chaetal index (the highest value recorded so far in the genus), the lack of head organ, and the characteristic external and internal appearance of the pygidium. The dorsal blood vessel appears longer in the specimens from Esperance than in the types from Rottneest Island. The lack of coelomocytes, a feature not specified in the original description, could be due to a recurrent behavioural artefact (loss of

these cells on fixation). Coates and Stacey (1997) noted a strong similarity between *G. vacivasa* and the northwestern Australian *G. integra* Coates and Stacey (1997), to the point that they suspected the two species might be identical other than in the presence of the penial stylet (in *G. integra*). Our own observations on the two species (Rota et al. 2003; and present paper) confirm this discrepancy and add others: e.g. presence of abundant coelomocytes, confinement of the spermathecal ampullae to the anterior half of V, and no expansion of the rectal ampulla in *G. integra*. (The latter feature is possibly correlated with the kind of items found in the gut in *G. vacivasa*.) For the time being, however, the hypothesis of a close relationship between the two species should not be discarded.

#### *Distribution and habitat*

South (Esperance) and west (Rottnest Island) coasts of Western Australia. Subtidal to at least 11.5 m (new depth record), in medium to coarse sand.

### **Discussion**

#### *Head organ*

Five of the seven *Grania* species described herein from Esperance possess the head organ, a multicellular vesicular structure housing a number of solid inclusions, which is believed to act as a georeceptor in the peristomium (Rota et al. 1999). First discovered in five Antarctic and one deep-Atlantic *Grania* species (Rota and Erséus 1996), the head organ has subsequently been recorded in another five congeners scattered across the Atlantic, from the subantarctic South Georgia (Rota and Erséus 1997) up to Bermuda (Locke and Coates 1999), Bahamas (Rota et al. 1999), and the Canary Islands (Rota and Erséus 2003). Having been recognized elsewhere only in two Tasmanian species (Rota and Erséus 2000), the head organ was so far thought to be rare in species from the Indian Ocean and the Pacific. Our observations of its presence also in three known species of Western Australia (*G. bykane*, *G. crassiducta*, and *G. ersei*), one of which (*G. ersei*) had always been studied on abundant material, testify that this structure has been previously overlooked and could be widespread among the Australian fauna.

Today, the total of 60 species described worldwide in the genus are nearly equally distributed between the northern (30) and the southern (29) hemispheres; only the deep-sea amphi-Atlantic *G. atlantica* crosses the equator, occurring between 48°N and 10°S (Coates and Erséus 1985; Rota and Erséus 2003). Interestingly, the presently known geographic pattern of the head organ appears southern-centred: of the 17 species reported to possess the head organ, as many as 13 inhabit the southern latitudes. The relevance of this character to unravelling the evolution and biogeography of the genus has still to be investigated.

#### *Biogeography*

The *Grania* collection described above is comprised of only 70 specimens sampled at 20 stations in the Esperance area. The seven species differentiated in the samples testify to a high local diversity, even by comparison with earlier fruitful efforts exerted in Western Australia: about 125 *Grania* specimens belonging to six or seven species were yielded by sampling 33 stations during both the Albany and Rottnest Workshops (Coates 1990; Coates and Stacey 1993).

Of the recorded species, *G. ersei* was found at eight of the Esperance sites, spanning across the whole area explored, thus confirming it to be the most common species of *Grania* in Western Australia. This species and *G. crassiducta* live in all three marine areas surveyed in this state, whereas *G. bykane* is reported only from Albany and Esperance, and *G. vacivasa* is recorded from Rottnest and Esperance. None of these four species, however, is yet reported from outside Western Australia. Conversely, *G. dolichura* is known to occur all around Tasmania, thus representing one exception to the typically narrow geographical ranges noted in the genus. The dispersal capability of *G. dolichura* is possibly enhanced by its peculiar somatic traits and by its eurythermal and euryhaline nature (Rota and Erséus 2000). A similar case is represented in Europe by *G. postclitellochaeta* (Knöllner, 1935) (see Rota and Erséus 2003).

The observed species richness at Esperance and the occurrence of a Tasmanian species in southern Western Australia are not surprising. Esperance is located at the western border of the Great Australian Bight, and in biogeographical classifications of marine coastal areas of Australia (e.g. IMCRA 1996) it often marks the eastern limit of species proper to the South Western Province (a major region extending to Perth in the north) and the western limit of a suite of species reaching the Great Australian Bight from eastern regions, including the cold temperate Tasmanian Province. The combined presence of western and eastern elements can be attributed to the influence of the south-flowing Leeuwin Current that transports warm temperate fauna down the west coast and then eastwards into the Great Australian Bight, and vice versa the dispersal of eastern species in the opposite direction by the deeper Flinders Current, which flows from the southern tip of Tasmania to Cape Leeuwin (Cirano and Middleton 2004). Interestingly, a survey of the patterns of distribution of southern Australian echinoderms and decapods has revealed a minimal representation of narrow-range species near Esperance, whereas such species appear abundant near Perth, the South Australian Gulfs and at the southeastern tip of the continent (O'Hara and Poore 2000).

With the addition of the two new species described here, a total of 17 species of *Grania* have been recorded from Western Australian marine waters, representing 85% of all named *Grania* species reported from Australia, and 28% of all species described in the genus to date.

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## Appendix 1

All stations are located in the vicinity of Esperance, Western Australia, from Nine Mile Beach 15 km west of the town, to Nares Island in the Duke of Orleans Bay. The *Grania* species found at each station are also listed. Seven additional stations were successfully sampled for tubificids (Erséus and Wang 2005) but did not yield any *Grania* material, probably due to poor oxygen supply in the sediments.

*ES03-1B*. Southwest end of Wylie Bay, 33°50.18'S, 121°59.04'E, rocky shore, barely subtidal to lower intertidal, heterogeneous sand with sea stars, 5 February 2003. *Grania ersei*.

*ES03-4A*. North tip of Long Island, 34°02.67'S, 121°58.10'E, subtidal, 11.5 m, medium to coarse sand (coll. A. Longbottom), 6 February 2003. *Grania vacivasa*.

*ES03-4B*. Same as *ES03-4A*, but fine to medium sand (coll. A. Longbottom), 6 February 2003. *Grania ersei*.

*ES03-5A*. North of New Island, 34°0.84'S, 122°8.52'E, rocky shore, lower intertidal, medium to coarse sand under rocks, 6 February 2003. *Grania quaerens* sp. n.

- ES03-5B. Close to ES03-5A, lower intertidal, mainly medium sand (coll. J. McDonald), 6 February 2003. *Grania bykane*, *Grania ersei*.
- ES03-15C. Southeast tip of Little Wharton Bay, 33°56.94'S, 122°34.14'E, barely subtidal to lower intertidal, very coarse sand, 10 February 2003. *Grania ersei*.
- ES03-21C. South of New Island, 34°01.35'S, 122°08.33'E, subtidal, 26 m, medium to coarse sand (coll. F. Wells), 12 February 2003. *Grania ersei*.
- ES03-22B. North of New Island, 34°0.832'S, 122°8.54'E, subtidal, 5.9 m, fine sand with dead grass (coll. A. Brearley), 12 February 2003. *Grania bykane*.
- ES03-25C. Southwest of Lucky Bay, 33°59.68'S, 122°13.25'E, subtidal, 2 m, coarse sand (coll. S. Shepherd), 13 February 2003. *Grania sperantia* sp. n.
- ES03-28A. South of Duke of Orleans Bay, near Nares Island, 33°56.16'S, 122°35.44'E, barely subtidal to lower intertidal, medium to coarse sand, 14 February 2003. *Grania sperantia* sp. n.
- ES03-28B. Same as ES03-28A, but subtidal, 0.5 m, coarse sand with soil-like sediment in *Posidonia* grass-mat, 14 February 2003. *Grania dolichura*.
- ES03-28C. Same as ES03-28A, but subtidal, 1.5 m, coarse sand, 14 February 2003. *Grania sperantia* sp. n.
- ES03-28D. Same as ES03-28A, but about 10 m away, lower intertidal, medium to coarse sand, 14 February 2003. *Grania quaerens* sp. n.
- ES03-28E. Same as ES03-28B, but muddy coarse sand, 17 February 2003. *Grania crassiducta*.
- ES03-34A. Limestone flat southeast of Nine Mile Beach, 33°54'S, 121°46'E, lower intertidal, fine sand, with coarse sand and pebbles, 16 February 2003. *Grania ersei*.
- ES03-34B. Same as ES03-34A, but fine sand with bigger pebbles and fine organic matter, 16 February 2003. *Grania ersei*.
- ES03-35A. Southwest cove of Nares Island, 33°56.2'S, 122°35.4'E, subtidal, 0.5 m, shelly coarse sand, 17 February 2003. *Grania sperantia* sp. n.
- ES03-35B. Same as ES03-35A, but 1.5 m, shelly heterogeneous sand, 19 February 2003. *Grania dolichura*.
- ES03-36. South of Duke of Orleans Bay, immediately north of road end to Nares, 33°56.16'S, 122°35.44'E, lower intertidal, coarse sand (coll. I. Bartsch), 17 February 2003. *Grania quaerens* sp. n.
- ES03-39. Southeast of Cowerie Bay at Cheyne Point, 33°56.91'S, 122°31.27'E, subtidal, 0.5 m, heterogeneous sand with pebbles and coral, 19 February 2003. *Grania crassiducta*, *Grania ersei*, *Grania sperantia* sp. n.