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***Sigambra sundarbanensis* sp. nov. (Annelida, Pilargidae) from the Indian sector of Sundarbans Estuarine System, with remarks on parapodial glands**

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Abstract. A new pilargid species, *Sigambra sundarbanensis* sp. nov., is described from the rivers Matla and Thakuran, in the central Indian sector of the Sundarbans Estuarine System. This species is characterized by several characters such as the starting position of the notopodial hooks, the length of the median antenna and the variation in number of the neuropodial chaetae. These characters distinguish the new species from its congeners. Some parapodial glands have been found in individuals of this species. The new species closely resembles *Sigambra parva* (Day, 1963). Additionally, an updated key of genus *Sigambra* is provided, along with a table indicating their morphological variations and a global map showing their type localities.

Keywords. Polychaeta, Pilargidae, parapodial glands, estuaries, Bay of Bengal.

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Introduction

Pilargids are uncommon nereidiform marine annelids; most are free-living, and many are motile burrowers. They are ubiquitous in sediments at various depths in estuarine or oceanic realms, most preferably in coarse to mixed substratum (Jumars *et al.* 2015). They are considered carnivores and

omnivores, but perhaps they intake detritus and microalgae (Day 1967; Dean 1998). The body is often depressed and ribbon-shaped. The integument is smooth or papillated. The pharynx is bulbous, usually papillated, it has rigid structures, sometimes with circlets of marginal papillae. The first dorsal cirri are often longer than the following. Notopodia are always reduced with embedded notoacacula, with or without additional capillary chaetae. Globally, Pilargidae de Saint-Joseph, 1899 comprises about 112 accepted species, under 12 genera (WoRMS 2020). This family has been reviewed several times by Hartman (1947), Pettibone (1966), Salazar-Vallejo (1986) and Licher & Westheide (1997). The phylogenetic affinities of Pilargidae have been questioned over a long time; based on morphological and behavioural similarities. Licher & Westheide (1994) considered the pilargids as a derived group within hesionids. However, further investigations by Pleijel & Dahlgren (1998) and Dahlgren *et al.* (2000) rejected the previous hypothesis of inclusion of pilargids within Hesionidae (Grube, 1850), and recognized them as non-overlapping families.

Sigambra Müller, 1858 is one of the most specious genera in Pilargidae and contains about 27 accepted species globally (Salazar-Vallejo *et al.* 2019). Müller (1858) proposed eight new genera from Santa Catarina Island (Brazil), including *Sigambra*. Later on, Hartman (1947) described some species, but regarded them as *Ancistrosyllis* McIntosh, 1879. A few species of *Ancistrosyllis* were reinstated under *Sigambra*. *Sigambra* has dorsal hooks above the dorsal cirri, resembling *Ancistrosyllis*, but they differ by the size of body appendages, antennae, tentacular cirri and body papillation (Salazar-Vallejo & Rizzo 2009).

In India, taxonomic reports of only two species of *Sigambra* have thus far been published: *S. constricta* Southern, 1921, later recorded by Misra (1995) from Chilka Lake and Hooghly-Matla Estuary, respectively, and *S. tentaculata* (Treadwell, 1941) from the Indian southwest coast (Achari 1975). Even though other species of this genus, such as *S. parva* (Day, 1963) and *S. bassi* (Hartman, 1947), have also been reported in macrobenthic community studies from various estuaries, coasts and tidal creeks, no further taxonomic information was provided. Due to a low number of surveys, our knowledge concerning the taxonomy and ecology of polychaetes from the central sector of the Sundarbans Estuarine System (SES) is minimal (see Mandal & Deb 2018). In this contribution, we describe a new species of *Sigambra* from the rivers Matla and Thakuran in the SES delta. Furthermore, we report on some gland-like structures in parapodial spaces, which have not been reported from any species of this genus.

Material and methods

Study site

Sundarbans Estuarine System (SES) is the largest monsoonal micro-tidal delta comprising hundreds of estuaries located alongside the Indian coast. It is both a World Heritage Site declared by UNESCO in 1997 and a RAMSAR site since 2019 (http://wiienviis.nic.in/Database/ramsar_wetland_sites_8224.aspx). The rivers Matla and Thakuran are two major rivers in the system. Because they are in the central zone, these rivers have been disconnected from freshwater supply and lost their estuarine pattern due to high siltation and neotectonic activity causing tilting of the Eastern Bengal Basin in recent years (Stanley & Hait 2000; Manna *et al.* 2010; Raha *et al.* 2012). Samples of macrobenthos, water and sediment were collected during SES biological surveys under an ongoing project (stations were marked according to that study), in January 2019, August 2019 and December 2019 from both rivers (Fig. 1).

Treatment of specimens

Material was collected in triplicate using a Van Veen grab (0.04 m²). The samples were separately washed in situ through a 0.5 mm sieve. Material retained in the sieve was allowed to relax in a solution of 7 % MgCl₂ in sea water and immediately fixed in a solution of 4% buffered formalin in sea water (for a few samples from January 2019, Rose Bengal was added during fixation). The samples were

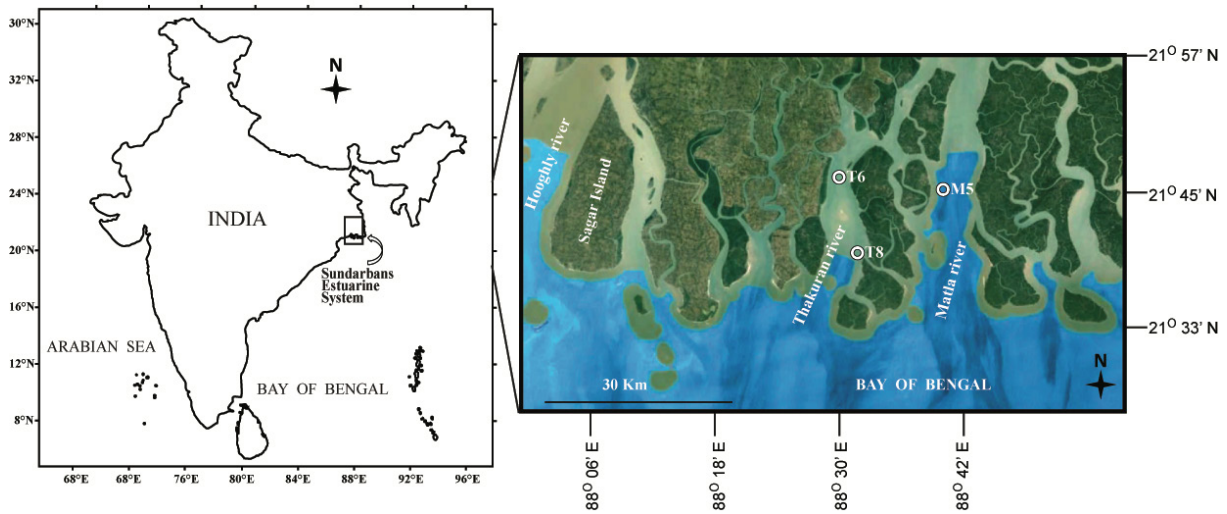


Fig. 1. Study area showing the sampling stations of our ongoing sampling program at SES, indicated by numbers, where M = Matla River and T = Thakuran River.

transported to the laboratory and later sorted and preserved in 70% ethanol. For better observation of the parapodial structures, and to get a clear visualization of the starting position of the notopodial hooks, the marginal papillae and the oocytes, specimens were mounted in a 1:1 solution of glycerin and 70% ethanol. Methyl green staining is often used to examine internal structures such as parapodial glands, as most glands contain phospholipids and the stain is more intensely fixed upon them. Our specimens were first immersed in an oversaturated methyl green solution in 70% ethanol (as samples were preserved in the same concentration of ethanol) for about 1 min; then, they were briefly set on tissue paper and further rinsed in clean ethanol. Samples were scanned and photographed through stereo (Olympus SZX7) and compound (Nikon ECLIPSE Ci) microscopes. For environmental parameters (temperature, pH, salinity, sediment texture and organic content), bottom waters and sediment samples were collected on-board and analyzed using standard protocols (El Wakeel & Riley 1957; Buchanan 1984; Grasshoff *et al.* 1999). The holotype and all paratypes were deposited at the Zoology Museum, Department of Life Sciences, Presidency University, Kolkata, India (PUZ).

Results

Description of new species

Class Polychaeta Grube, 1850
 Order Phyllodocida Dales, 1962
 Suborder Nereidiformia Glasby, 1993
 Family Pilargidae de Saint-Joseph, 1899
 Subfamily Pilarginae de Saint-Joseph, 1899
 Genus *Sigambra* Müller, 1858

Sigambra sundarbanensis sp. nov.

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Figs 2–5; Table 2

Diagnosis

A species of *Sigambra* with median antenna reaching up to chaetigers 3–4, 2–3 times as long as lateral antennae; tentacular segment 3–4 times as wide as long. Pharynx with 14 prismatic projected lobes.

Dorsal cirri larger than ventral ones, largest in chaetiger 1. Ventral cirri absent in chaetiger 2. Notopodial hooks start in chaetiger 8, accompanied by notoacacula; neuropodia with various types of capillary chaetae. Parapodial spaces with glandular, tubular structures.

Etymology

The type locality (river Thakuran) is a tidal estuarine river of the Sundarbans Estuarine System. The epithet of this new species refers to the entire estuarine system, i.e., Indian Sundarbans.

Type material

Holotype

INDIA • complete spec.; river Thakuran, stn T8; 21°39'3.73" N, 88°30'25.17" E; depth 26 m; Aug. 2019; Moumita Bhowmik and Sumit Mandal leg.; in sediment; PUZ 501.

Paratypes

INDIA • 4 complete specs; river Thakuran, stn T6; 21°45'35.90" N, 88°29'8.53" E; depth 10 m; Aug. 2019; Moumita Bhowmik and Sumit Mandal leg.; in sediment; PUZ 502 to PUZ 505 • 3 complete specs; river Thakuran, stn T8; 21°39'3.73" N, 88°30'25.17" E; depth 26 m; Aug. 2019; Moumita Bhowmik and Sumit Mandal leg.; in sediment; PUZ 506 to PUZ 508 • 6 complete specs; river Thakuran, stn T8; 21°39'3.73" N, 88°30'25.17" E; depth 26 m; Dec. 2019; Moumita Bhowmik and Sumit Mandal leg.; in sediment; PUZ 514 to PUZ 519 • 2 incomplete specs; river Matla, stn M5; 21°45'18.20" N, 88°38'25.20" E; depth 11 m; Jan. 2019; Moumita Bhowmik and Sumit Mandal leg.; in sediment; PUZ 490 to PUZ 491.

Sampling site and type locality

Various environmental factors that characterize the sampling sites are in Table 1. Bottom water salinity ranged from 17.0 in August to 23.42 in January 2019. Sediment temperature was found to be at its maximum in August 2019. Organic enrichment in sediment was moderate, ranging from 0.78 to 1.78%. In terms of granulometry, the study sites are mostly silty with comparatively finer and coarser particles that vary seasonally. The lowest proportion of clay was represented in the soil texture during the monsoon (0.15–0.35%). The sediment texture of the type locality was characterized by a high silt percentage and a lower sand percentage that further decreased in the post-monsoon season (Dec. 2019). Bottom water salinity level varied from 17 to 21 (Table 1). Morphological and morphometric data are in Table 2 and the comparison of the new species with all other accepted species of *Sigambra* is in Table 3.

The holotype of *Sigambra sundarbanensis* sp. nov. was collected from the river Thakuran (station T8) and paratypes were collected from both the rivers Thakuran and Matla in January 2019, August 2019 and December 2019. A morphometric analysis was performed for all the collected specimens. Moreover, a global map (Fig. 2) has been presented for all the accepted species of *Sigambra* based on their type locations.

Description

Holotype (PUZ 501)

MEASUREMENTS. Complete, 5.63 mm long, 0.32 mm wide at chaetiger 8–9 (average width 0.28 mm), 64 chaetigers (Fig. 3A).

BODY. Obconic, sub cylindrical along anterior end, depressed thereafter.

PROSTOMIUM. Blunt, bilobed, three times as wide as long. Palps biarticulated directed ventrally; palpophores large, palpostyles small. Pharynx exposed with 14 prismatic marginal papillae, tips distinct

Table 1. Environmental parameters of studied stations.

| Sampling period | Jan. 2019 | Aug. 2019 | Dec. 2019 |
|-----------------------------|-----------|-----------|-----------|
| Station name | M5 | T6 | T8 |
| Depth (m) | 11 | 10 | 26 |
| Bottom water salinity (PSU) | 23.42 | 19 | 17 |
| Sediment temperature (°C) | 21 | 31 | 31.5 |
| Organic matter (%) | 1.78 | 0.9 | 0.78 |
| Sand (%) | 2.78 | 35.95 | 33.23 |
| Silt (%) | 83.82 | 63.7 | 66.62 |
| Clay (%) | 13.4 | 0.35 | 0.15 |

(Fig. 3C). Antennae cirriform, lateral antennae subdistally located, smaller than median one (Fig. 3B). Median antenna 2.3 times as long as laterals, reaching up to chaetiger 4.

TENTACLES. Tentacular segment 3–4 times as wide as long; two pairs of tentacular cirri, dorsal tentacular cirri slightly larger than ventral ones.

CIRRI. Parapodial cirri triangular, tapered, foliose, longer than wide. Dorsal cirri longer than ventral cirri throughout, largest in chaetiger 1, reaching up to chaetiger 5 (Fig. 3D). Chaetiger 2 with smallest dorsal cirri, without ventral cirri. Parapodia with reduced notopodia and well developed neuropodia.

NOTOPODIA. Include distally curved dorsal hooks from chaetiger 8 (Fig. 3D), head of hook not exposed outside body wall to chaetiger 22, fully exposed from chaetiger 23, continued along body (Fig. 3E) up to last 2 pre-pygidial chaetigers (Fig. 3G). From chaetiger 8 onwards, hooks accompanied with acicula (Fig. 5A–B). Neurochaetae include 2–4 short wide pectinate chaetae with variable number of spinulose or serrated capillaries (Figs 3F, 5A).

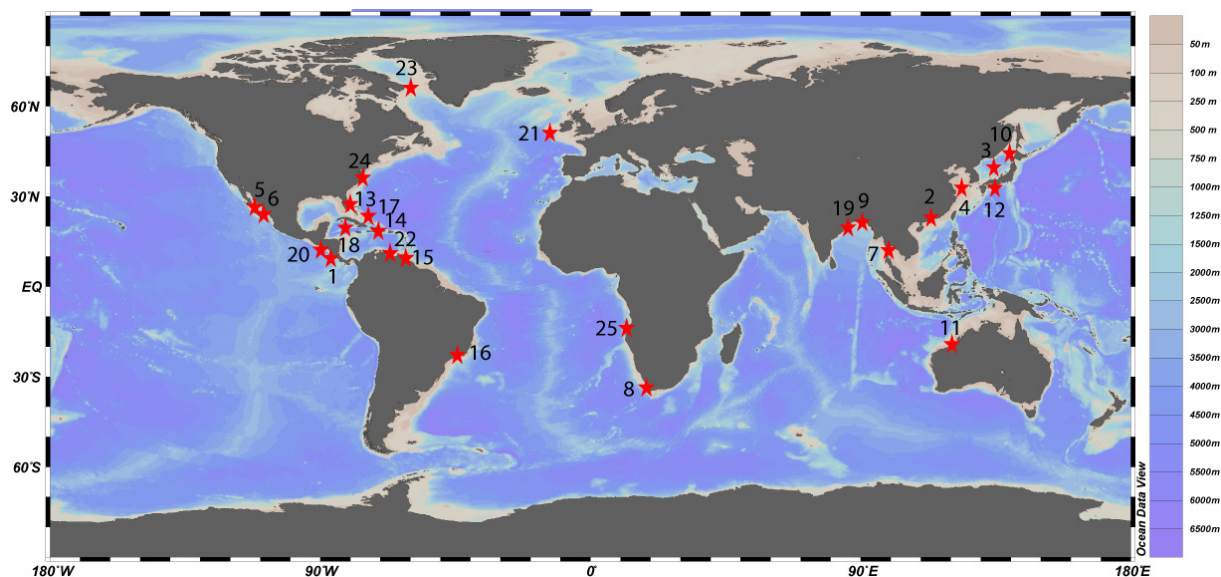


Fig. 2. Type localities of the accepted species of *Sigambra* Müller, 1858, names of the species are denoted with the serial numbers from Table 3.

Table 2. Morphometric data of holotype and paratypes of *Sigambra sundarbanensis* sp. nov.

| | Holotype | Paratypes (n=15) |
|-------------------------------------|---------------------------------------|--|
| Length (mm) | 5.63 | 2.18–8.91 mm (5.09 ± 2.29) |
| Width (mm) | 0.28 | 0.08–0.41 (0.15 ± 0.08) |
| No. of chaetiger | 64 | 32–79 |
| No. of marginal papillae | 14 | 14 |
| Length of median antenna (mm) | 0.36 | 0.2–0.57 (0.36 ± 0.11) |
| Right lateral antenna (mm) | 0.172 | 0.06–0.35 (0.18 ± 0.07) |
| Left lateral antenna (mm) | 0.15 | 0.08–0.38 (0.19 ± 0.08) |
| Tentacular segment (L:W) | 1:4 | 1:4 |
| Tentacular cirri (right) (mm) | 0.18 | 0.09–0.22 (0.17 ± 0.04) |
| Tentacular cirri (left) (mm) | 0.18 | 0.09–0.26 (0.17 ± 0.04) |
| Dorsal cirri:Ventral cirri | Dorsal > Ventral (0.87 times as long) | Dorsal > Ventral (0.5–0.9 times as long) |
| First appearance of notopodial hook | Chaetiger 8 | Chaetiger 8 |
| Size of notopodial hook (mm) | 0.13 | 0.12–0.18 (0.14 ± 0.01) |
| Diameter of oocyte (µm) | NA | 12–36 (23.33 ± 6.90) |
| Parapodial gland length (µm) | 19–50 (29 ± 16.38) | 14–74 (43.88 ± 17.69) |
| Parapodial gland width (µm) | 8–11 (9 ± 1.41) | 8–18 (2.38 ± 10.23) |

GLANDS. Parapodial glands starting from chaetiger 5, developed gradually up to chaetiger 60. Each gland with 2–6 large tubular cells, varying in shape and size (Fig. 4B, 5D). These tubular structures converge ventrally from wide base of coelomic ramus. Tubular structures rudimentary (L: 19 µm, W: 11 µm) or fully developed (L: 50 µm, W: 8 µm); inner features unknown.

PYGIDIUM. Laterally expanded with 2 ventral cirri, as long as 3–4 median chaetigers (Fig. 3G).

OOCYTES. Not seen.

Paratypes

A total of 13 complete and 2 incomplete paratypes show a minor characteristic variation. They were 2.18–8.91 mm long (5.09 ± 2.29 mm), 0.08–0.41 mm wide (0.15 ± 0.08 mm); median antennae were 0.2–0.57 mm long (0.36 ± 0.11 mm) reaching up to chaetigers 3–4. Oocytes (Figs 4A, 5C) 12–36 µm in diameter (23.33 ± 6.90 µm). Glandular structures in parapodial spaces have been found in most paratypes, they were 14–74 µm long (43.88 ± 17.69 µm) (Table 2). Large tubular glandular cells in chaetigers 47–49 of paratype PUZ 506 are shown in Fig. 4C–D. In other parapodia (chaetigers 12 and 13), tubular cells invade into coelomic space (Fig. 4E–F).

Remarks

Following the redescription of *S. parva* by Moreira & Parapar (2002), it can be stated that *S. sundarbanensis* sp. nov. resembles *S. parva* Day, 1963. They have similar characteristics, such as median antenna longer than lateral ones, reaching chaetigers 3–4, and pharynx with 14 marginal papillae. However, they differ in several features, the most notable ones being the starting point of the dorsal hooks and the absence of capillary chaetae in the notopodia. In *S. sundarbanensis* sp. nov., the first appearance of dorsal hooks from chaetiger 8 remains constant in all 16 specimens, irrespective of specimen size. The hooks are accompanied by a single acicula, and the last two chaetigers are hookless. The notopodia are devoid of any capillary chaetae, neuropodia with 2–4 short pectinate chaetae with a variable number of spinulose or serrated capillaries, and the relative size of the median antenna is 2.3 times as long as the lateral ones. In comparison with *S. parva*, the median antenna is 1.5 times as long as the lateral ones, the notopodial hook starts from chaetigers 4–5 and is accompanied by single capillary chaetae in

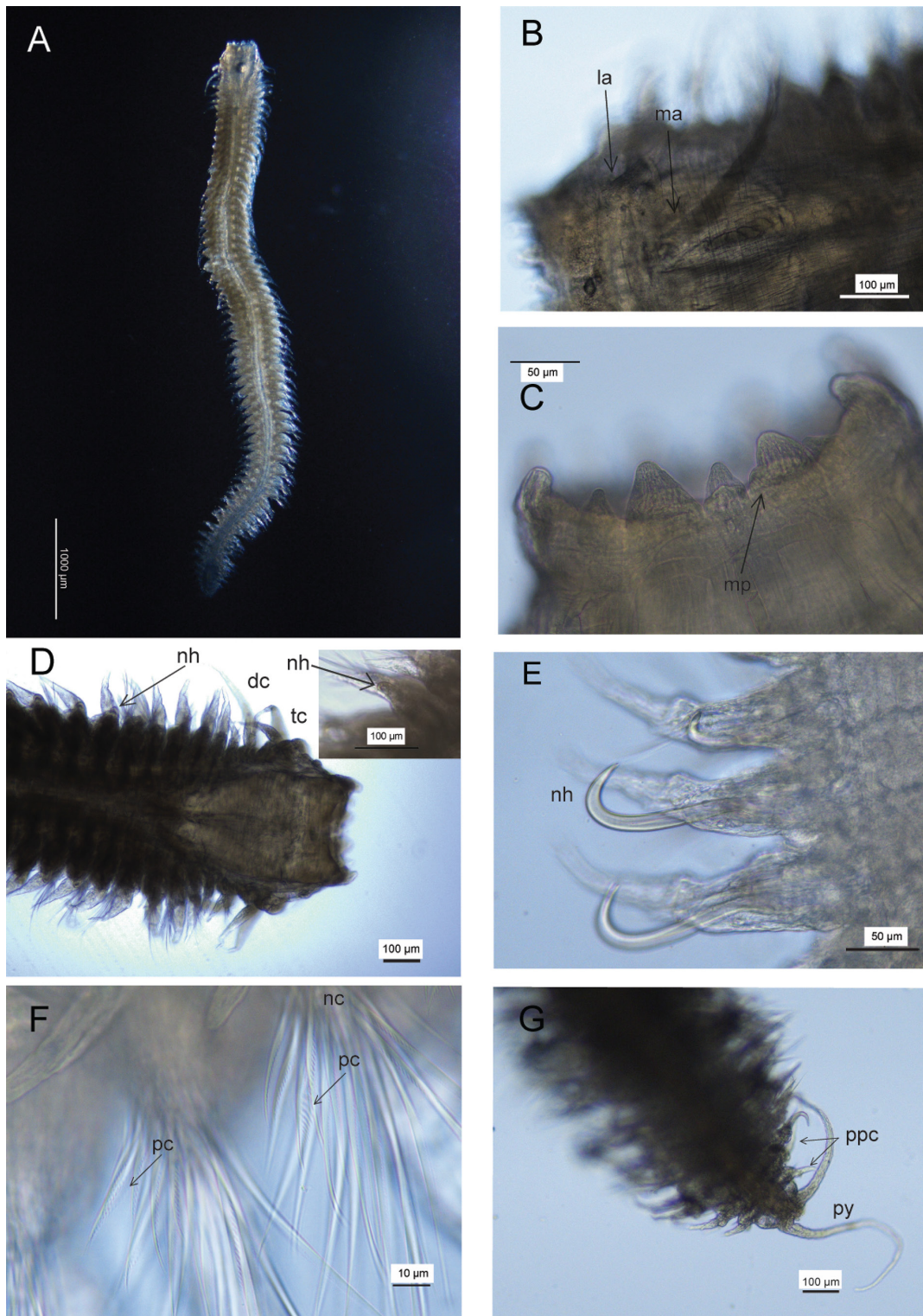


Fig. 3. *Sigambra sundarbanensis* sp. nov., holotype. **A.** Dorsal view (PUZ 501). **B.** Anterior end (dorsal view), lateral antenna (la) and median antenna (ma) in dorsal view. **C.** Pharynx, 7 among 14 marginal papillae (mp), dorsal view. **D.** First appearance of notopodial hook (nh, inset) from chaetiger 8, dorsal cirri (dc) longest at chaetiger 1; tc = tentacular cirri. **E.** Median chaetigers, continuous notopodial hooks (nh). **F.** Neuropodial chaeta (nc) with four short pectinates (pc). **G.** Pygidium (py) with last 2 prepygidial chaetigers (ppc) without hook.

Table 3 (continued on next page). Main distinguishing characters of accepted species of *Sigambra* Müller, 1858.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|--|---|--|------------------------------------|---|---|---|---|--|---|--|--|
| Species | <i>S. vargasii</i> Dean, 1999 | <i>S. papagayu</i> Bamber in Muir & Bamber, 2008 | <i>S. bidentata</i> Britayev & Saphronova, 1981 | <i>S. pingatensis</i> Licher & Westheide, 1997 | <i>S. rugosa</i> Fauchald, 1972 | <i>S. setosa</i> Fauchald, 1972 | <i>S. phuketensis</i> Licher & Westheide, 1997 | <i>S. parva</i> (Day, 1963) | <i>S. sandar-</i> <i>banensis</i> sp. nov. | <i>S. elegans</i> Britayev & Saphronova, 1981 | <i>S. perithonene</i> Hartmann Schröder, 1979 | <i>S. hanaokai</i> (Kitamori, 1960) | <i>S. bassi</i> (Hartman, 1947) |
| Body size : Length (L), width (W) and no. of chaetigers | L: 5.2, W: 1 Chaetiger: 60 | L: 22.81, W: 1.5 Chaetiger: 122 | – | L: 2.3, W: 0.38 Chaetiger: 22 | L: 14, W: 2.5 Chaetiger: 80 | L: 14, W: 3 Chaetiger: 60 | L: 4.5, W: 0.55 Chaetiger: 46 (Holotype) | L: 6.75–10, W: 0.35–0.8 Chaetiger: 56–75 | L: 5.63, W: 0.28 Chaetiger: 64 | L: 16, W: ? Chaetiger: ? | L: ? W: ? Chaetiger: ? | L: 5–15, W: 0.5–1 Chaetiger: ? | L: 24, W: 1.9, Chaetiger: 146 |
| Relative size of dorsal and ventral cirri | Dorsal > Ventral | Dorsal > Ventral | Dorsal > Ventral | Dorsal > Ventral | Dorsal > Ventral | Dorsal > Ventral Dorsal cirri at median segment is 5 times longer than wide | Dorsal > Ventral dorsal cirri of median segments 3 times longer than wide | Dorsal > Ventral | Dorsal > Ventral | Dorsal > Ventral | Dorsal > Ventral | Dorsal > Ventral | Dorsal > Ventral |
| Ventral cirri (chaetiger 2) | Absent | Absent | Absent | Absent | Absent | Absent | Absent | Absent | Absent | Absent | Absent | Absent | – |
| No. of marginal papillae | 8 | 8 | 8 | 8 | – | – | 14 | 14 | 14 | 13 | 13 | 14 | 14 |
| Length of median antenna compared to lateral antennae | 3 times longer | 1.75 times longer | Barely longer | 2 times longer | Subequal | Similar length | 2 times longer | 1.5 times longer | 2.3 times longer | 2 times longer | Slightly longer | 2 times longer | 2 times longer |
| Median antenna reaching up to chaetiger | 7 | 5 | – | 3 | 1 | – | 1 to 2 | – | 3 to 4 | – | 4 to 6 | 8 to 10 or extending beyond | 2 |
| First appearance of dorsal hook from chaetiger | 15–17 | 3–5 | 3–8 | 3–8 | 43–66 | 3–4 | 3 | 4–5 | 8 | 12–18 | 7–10 | 7–8 | 14–15 (holotype) |
| Notopodial capillaries | Present (1 or 2) | Absent | Present (2) | Present | Absent | Present (2–3) | Present (may be lacking in some anterior and posterior chaetigers) | Present | Absent | – | – | Present | Present |
| Remarks | Median antenna three times longer than lateral antenna | No notochaete adjacent to dorsal hook | Neurochaete with bifid tips, notochaete with 2 capillaries | – | – | Notochaete in all parapodia | Presence of tooth like proboscoidal papillae and their arrangement | The first segment with hook is fixed at chaetiger 8 | – | – | – | – | Presence of notopodial straight spines |
| Reference | Dean 1999 | Muir & Bamber 2008 | Licher & Westheide 1997 | Licher & Westheide 1997 | Fauchald 1972 | Fauchald 1972 | Licher & Westheide 1997 | Moreira & Parapar 2002 | Present Study | Nishi <i>et al.</i> 2007; Salazar-Vallejo <i>et al.</i> 2019 | Licher & Westheide 1997 | Nishi <i>et al.</i> 2007 | Licher & Westheide 1997 |

Table 3 (continued). Main distinguishing characters of accepted species of *Sigambra* Müller, 1858.

| | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|--|---|---|---|---|---|---|--|----------------------------------|
| Species | <i>S. tentaculata</i> (Treadwell, 1941) | <i>S. diaz</i> Salazar-Vallejo, Rizzo, León-González & Brauko, 2019 | <i>S. grabii</i> Müller, 1858 | <i>S. hernandezii</i> Salazar-Vallejo, Rizzo, León-González & Brauko, 2019 | <i>S. olivai</i> Salazar-Vallejo, Rizzo, León-González & Brauko, 2019 | <i>S. constricta</i> (Southern, 1921) | <i>S. ocellata</i> (Hartmann Schröder, 1959) | <i>S. magnuncus</i> Paterson & Glover, 2000 | <i>S. ligneroi</i> Salazar-Vallejo, Rizzo, León-González & Brauko, 2019 | <i>S. aedynae</i> Gagev, 2008 | <i>S. wasasi</i> Pettibone, 1966 | <i>S. robusta</i> (Ehlers, 1908) |
| Body size : Length (L), width (W) and no. of chaetigers | L: 11, W: 0.62 Chaetiger: 95 | L: 7.5, W: 1.5 Chaetiger: 41 | L: 11.5, W: 2 Chaetiger: 82 | L: 9, W: 2 Chaetiger: 76 | L: 20, W: 2.8 Chaetiger: 152 | L: 19, W: ? Chaetiger: 105 or more | L: 1.5, W? Chaetiger: 25 | L: 3.7, W: 0.73 Chaetiger: 33 | L: 17, W: 4 Chaetiger: 49 | L: ? , W: 0.7 Chaetiger: ? | L: 45-70, W: 4-5 Chaetiger: 107-192 | L: 54, W: ? Chaetiger: 182 |
| Relative size of dorsal and ventral cirri | Dorsal > Ventral | Dorsal > Ventral | Dorsal > Ventral | Dorsal > Ventral | Dorsal > Ventral | Dorsal > Ventral | Subequal | Subequal | Dorsal > Ventral | Dorsal > Ventral | Dorsal > Ventral | Dorsal > Ventral |
| Ventral cirri (chaetiger 2) | Absent | Absent | Absent | Absent | Absent | Absent | Absent | Absent | Present | Present | Present | Present |
| No. of marginal papillae | 14 | 13-16 | 14 | 14 | 15 | 14 | 8 | 8 | 8 | 8 | 8 | 15 or 16 |
| Length of median antenna compared to lateral antennae | 1.5-2 times longer | Twice | Longer | Twice | Twice | Nearly 2 times longer | 2 times longer | Barely longer | Twice | 1.5 times longer | Slightly longer | - |
| Median antenna reaching up to chaetiger | - | 5 to 7 | 2 | 2 to 3 | 2 to 3 | 1 to 2 | - | 3 to 4 | 1 to 2 | ? | - | - |
| First appearance of dorsal hook from chaetiger | 4-5 | 4-5 | 20 | 28 | 38 | 30-40 | 6-7 | 3 | 26-28 | 4 | 27 | 43-70 |
| Notopodial capillaries | Present | Present | Absent | Absent | Absent | Present in posterior chaetigers | - | Present 1 in anterior and 2 in posterior segments | Absent | Present from chaetiger 20 | Absent | Absent |
| Remarks | Presence of tooth like peristomial papillae | Dorsal cirri tapered without basal enlargement, ventral cirri in median and posterior chaetiger are long as neurochaetal lobe | Median antenna is medium sized and 4-6 hookless posterior chaetiger | Median antenna shorter, two hookless chaetiger in the end of the body | No constriction on chaetiger 4, no capillaries in the posterior chaetiger | Body with a constriction at chaetiger 4 | The smallest species of this genus | Only species from deepest zone | Median antenna is twice as long as laterals, dorsal cirri is three times longer than ventral ones on chaetiger 1, 8 regular papillae on pharynx | Two types of acicula in the notopodia, segmentation of the prostomium | - | Notopodia without capillaries |
| Reference | Moreira & Parapar, 2002 | Salazar-Vallejo <i>et al.</i> , 2019 | Salazar-Vallejo 1990 | Salazar-Vallejo <i>et al.</i> , 2019 | Salazar-Vallejo <i>et al.</i> , 2019 | Southern 1921 | Licher & Westheide 1997; Nishi <i>et al.</i> , 2007 | Paterson & Glover 2000 | Salazar-Vallejo <i>et al.</i> , 2019 | Gagev 2008 | Pettibone 1966; Salazar-Vallejo <i>et al.</i> , 2019 | Nishi <i>et al.</i> , 2007 |

the posterior parapodial segments, neuropodia with 1–2 pectinate chaetae, but the number of hookless chaetigers is not mentioned in the literature (Day 1963; Moreira & Parapar 2002).

Distribution

Sigambra sundarbanensis sp. nov. is only known from the rivers Matla and Thakuran of the Indian Sundarbans.

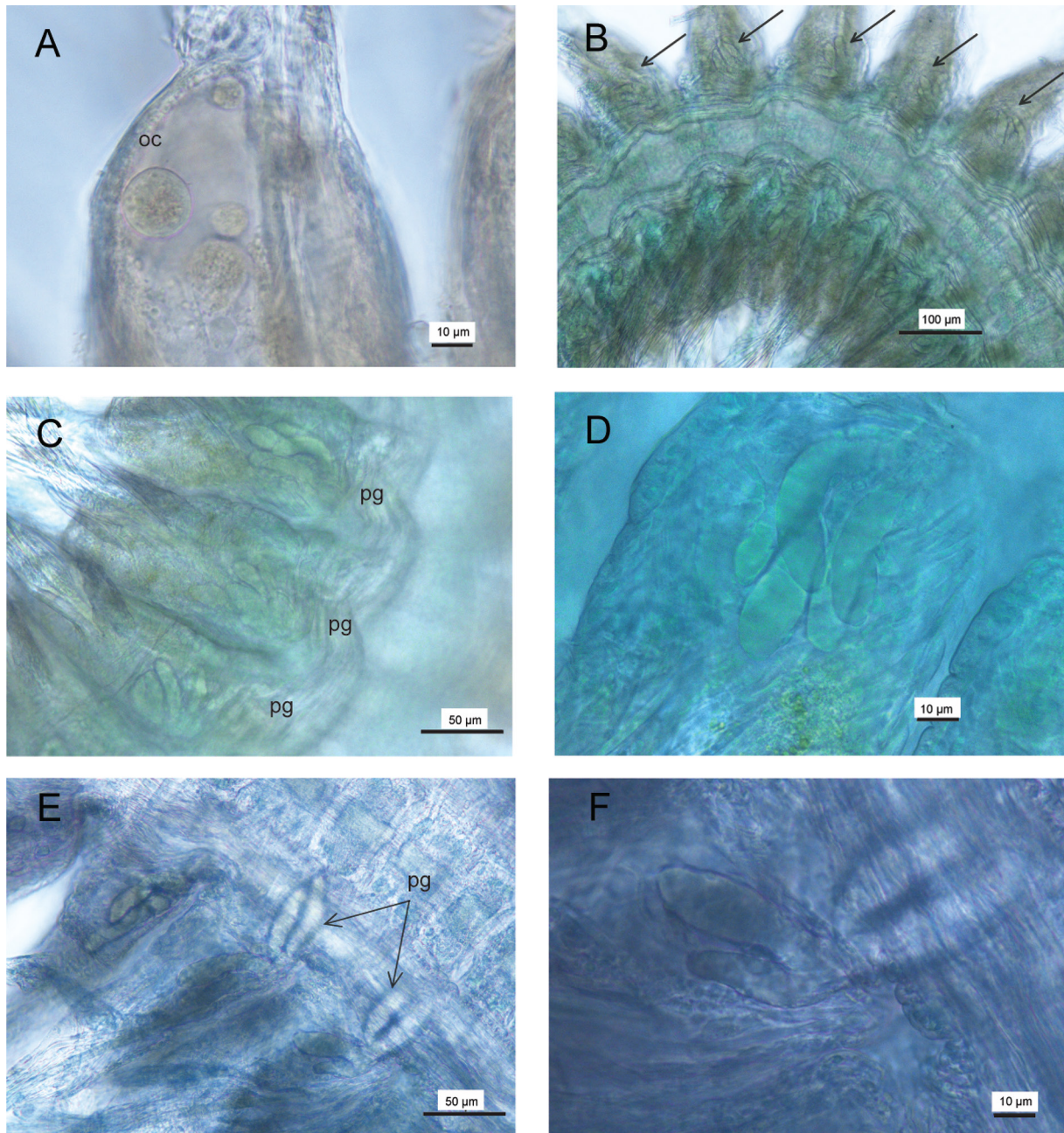


Fig. 4. *Sigambra sundarbanensis* sp. nov. **A.** Paratype (PUZ 503), oocytes inside parapodial spaces. **B.** Paratype (PUZ 506), arrows showing parapodial glands. **C.** Chaetigers 47–49 with parapodial glands (pg). **D.** Parapodial gland in 100 × magnification. **E–F.** Paratype (PUZ 515), parapodial glands in chaetiger 12–13 invaded into coelomic space.

Ecology

All specimens of this new species were found in mangrove habitats with silty sand sediments, in depths of 11 to 26 m. Mature specimens, with developed oocytes, were recorded in August and December 2019 from Thakuran River. Among all the abiotic factors, salinity plays a pivotal role in ecology and

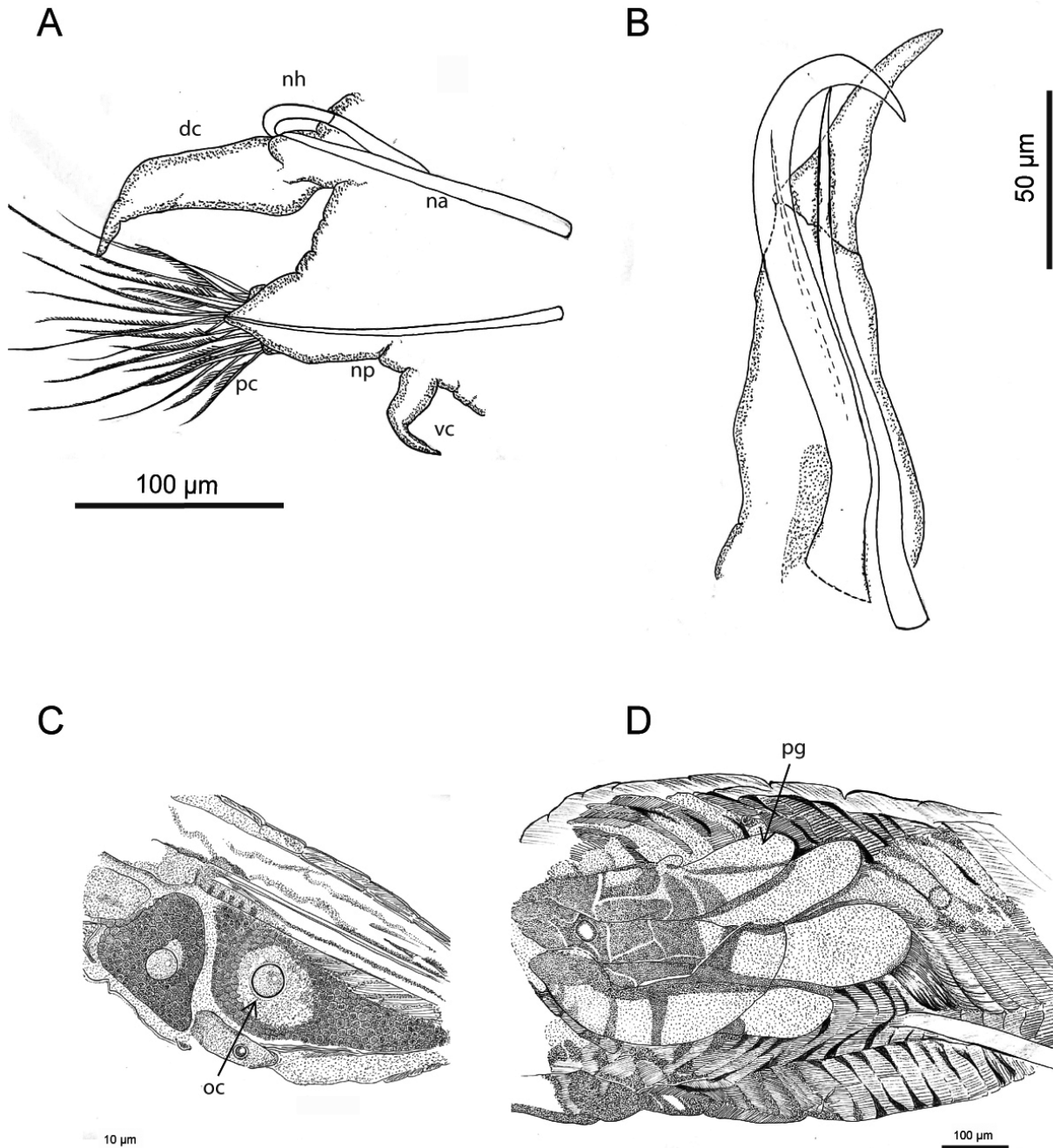


Fig. 5. *Sigambra sundarbanensis* sp. nov. **A.** Holotype (PUZ 501), parapodia with notopodial hook and neurochaetae. **B.** Paratype (PUZ 507), notopodium with hook, acicula and cirrus. **C.** Paratype (PUZ 514), oocytes inside parapodia. **D.** Holotype (PUZ 501), a bunch of large gland cells in parapodium. Abbreviations: dc = dorsal cirrus; vc = ventral cirrus; np = neuropodium; pc = pectinate chaeta; na = notoacacula; nh = notopodial hook; oc = oocyte; pg = parapodial gland.

distribution of species across the globe, as this acts as a physiological barrier for both stenohaline and euryhaline species. *Sigambra parva* was recorded from Cape Province, South Africa (Day 1963) and the Mediterranean coast of Spain (Moreira & Parapar 2002), where the water salinity remains higher than 30%, whereas the localities of *S. sundarbanensis* sp. nov. had a salinity of 17–23.42%. Additionally, *S. parva* had a comparatively higher range of depth variation from 2 to 97 meters (Day 1963; Moreira & Parapar 2002).

Key to species of *Sigambra* Müller, 1858

(modified after Salazar-Vallejo *et al.* 2019)

1. Dorsal cirri larger than ventral cirri 2
 - Dorsal and ventral cirri subequal 26
2. Chaetiger 2 without ventral cirri 3
 - Chaetiger 2 with ventral cirri 22
3. Pharynx with 8 marginal papillae 4
 - Pharynx with 13–16 marginal papillae 7
4. Dorsal hooks from chaetigers 3–8 5
 - Dorsal hooks from chaetigers 15–17 (5–18 mm long; up to chaetiger 30?); median and posterior notopodia with 1 capillary; median antenna long, reaching chaetiger 7 *S. vargasi* Dean, 1999
5. Median and posterior notopodia with capillaries 6
 - Notopodia without capillaries; all neurochaetae with tips entire; median antennae reaching chaetiger 5 (17–23 mm long) *S. papagayu* Bamber in Muir & Bamber, 2008
6. Some neurochaetae with bifid tips; median antenna barely longer than laterals, reaching chaetiger 2; median and posterior notopodia with 2 capillaries *S. bidentata* Britayev & Saphronova, 1981
 - All neurochaetae with entire tip; median antenna markedly longer than laterals, reaching chaetiger 3; median and posterior notopodia with 1 capillary *S. qingdaoensis* Licher & Westheide, 1997
7. Dorsal hooks from anterior chaetigers (4–18) 8
 - Dorsal hooks from median chaetigers (30–40); median antenna twice as long as lateral ones or longer 21
 - Dorsal hooks from posterior chaetigers (42–66), or beyond that (14 mm long); median antenna as long as lateral ones, barely reaching chaetiger 1 *S. rugosa* Fauchald, 1972
8. Tentacular segment about twice as wide as long 9
 - Tentacular segment 4 times as wide as long 11
9. Tentacular segment with anterior margin with rounded projected lobes, external to lateral antennae *Sigambra* sp. indet.* (Brazil)
 - Tentacular segment with anterior margin smooth, without projected lateral lobes; dorsal hooks from chaetiger 3–4 (14 mm long) 10
10. Antennae of similar length; dorsal cirri of median segments 5 times as long as wide
 - *S. setosa* Fauchald, 1972
 - Median antenna almost twice as long as lateral ones; dorsal cirri of median segments 3 times as long as wide *S. phuketensis* Licher & Westheide 1997

| | |
|--|--|
| 11. Tentacular segment with rounded projected lobes in anterior margin; median antenna slightly longer than lateral ones, reaching chaetigers 3–4 | 12 |
| – Tentacular segment with anterior margin smooth, without rounded projected lobes | 13 |
| 12. Dorsal hooks from chaetigers 4–5 (6–12 mm long) | <i>S. parva</i> (Day, 1963) |
| – Dorsal hooks from chaetiger 8 (2–9 mm long) | <i>S. sundarbanensis</i> sp. nov. |
| 13. Median and posterior notopodia with capillaries | 14 |
| – Notopodia without capillaries | 20 |
| 14. Median antenna short, reaching up to chaetigers 3–4 | 15 |
| – Median antenna medium-sized, reaching chaetigers 5–7 | 16 |
| – Median antenna long, reaching chaetigers 9–12; dorsal hooks of chaetigers 11–15 (40 mm long); lateral antennae without lateral depressions | <i>S. bassi</i> sensu Blake, 1994 |
| 15. Dorsal hooks from chaetiger 4 (15 mm long); median antenna slightly longer than lateral ones; first dorsal cirri slightly longer than dorsal tentacular ones | <i>S. tentaculata</i> sensu Blake, 1994 |
| – Dorsal hooks from chaetiger 12–18 (16 mm long); median antenna twice as long as lateral ones; first dorsal cirri markedly longer than dorsal tentacular ones | <i>S. elegans</i> Britayev & Saphronova, 1981 |
| 16. Median antenna slightly longer than lateral ones, reaching chaetigers 4–6; dorsal hooks from chaetigers 7–10 (5.5 mm long) | <i>S. pettiboneae</i> Hartmann-Schröder, 1979 |
| – Median antenna twice as long as lateral ones | 17 |
| 17. Median antenna reaching chaetigers 7–8 | 18 |
| – Median antenna reaching up to chaetigers 5–6; dorsal hooks from chaetigers 4–5 | 19 |
| 18. Dorsal hooks from chaetigers 3–9 (5–20 mm long) | <i>S. hanaokai</i> (Kitamori, 1960) |
| – Dorsal hooks from chaetigers 12–18 (24 mm long) | <i>S. bassi</i> (Hartman, 1947) |
| 19. All parapodia with ventral cirri shorter than neuropodial lobes; dorsal cirri basally wider | <i>S. tentaculata</i> (Treadwell, 1941) |
| – Median and posterior parapodia with ventral cirri long, reaching tip of neuropodial lobes; dorsal cirri tapered, not wider basally | <i>S. diazi</i> Salazar-Vallejo <i>et al.</i> , 2019 |
| 20. Median antenna medium-sized, reaching chaetigers 3–4; posterior region with 4–6 hookless chaetigers; body papillae large in proportion | <i>S. grubii</i> Müller, 1858 |
| – Median antenna short, reaching chaetigers 2–3; posterior region with 2 hookless chaetigers; body papillae small | <i>S. hernandezii</i> Salazar-Vallejo <i>et al.</i> , 2019 |
| 21. Median antenna slightly longer than laterals; body without a constriction on chaetiger 4; dorsal hooks from chaetigers 30–39 (15–24 mm long); posterior chaetigers without capillary notochaetae | <i>S. olivai</i> Salazar-Vallejo <i>et al.</i> , 2019 |
| – Median antenna twice as long as laterals; body with a constriction on chaetiger 4; dorsal hooks from chaetiger 30–40 (16–24 mm long); posterior chaetigers with a single capillary notochaetae | <i>S. constricta</i> (Southern, 1921) |
| 22. Pharynx with 8 marginal papillae | 23 |
| – Pharynx with 14–16 marginal papillae | 25 |

23. Median antenna slightly longer than lateral ones 24
– Median antenna twice as long as lateral ones; dorsal hooks from chaetigers 26–28.....
.....*S. ligneroi* Salazar-Vallejo *et al.*, 2019
24. Dorsal hooks from chaetiger 4 (0.7 mm wide), tentacular segment as long as wide
.....*S. healyae* Gagaev, 2008
– Dorsal hooks from chaetigers 23–30 (45–70 mm long); tentacular segment 4–5 times as wide as
long *S. wassi* Pettibone, 1966
25. Dorsal hooks from chaetiger 7, with accessory capillaries; dorsal cirri progressively longer from
chaetiger 2.....*Sigambra* sp. Imajima, 2001
– Dorsal hooks from chaetigers 43–70, without capillary chaetae; dorsal cirri of chaetiger 2 smaller
than those in following chaetigers *S. robusta* (Ehlers, 1908)
26. Dorsal hooks from chaetiger 6 (1.5 mm long)..... *S. ocellata* (Hartmann-Schröder, 1959)
– Dorsal hooks from chaetiger 3 (3.7 mm long)..... *S. magnuncus* (Paterson & Glover, 2000)

* As per Salazar-Vallejo *et al.* (2019), this is not completely identified and based upon some specimens which have not been described yet, but are distinct and deserve to be described.

Discussion

In general, there are two patterns regarding positional variation of notopodial hooks in *Sigambra*. It either starts from a specific chaetiger (1–3 chaetiger variation) or shows variation. The position of the notopodial hook in *S. sundarbanensis* sp. nov. follows the first pattern, whereas most of its congeners show variations. The general variability in the first appearance of the hooks and the number of hookless chaetigers in pre-pygidial segments can limit its taxonomic position (Licher & Westheide 1997).

Based on literature, *Sigambra sundarbanensis* sp. nov. is the first reported species of this genus with parapodial glandular structures. According to the methyl green stained images, these glands resemble the chromophile glands found in the neuropodial pinnae among the members of Tomopteridae (Grube, 1850) (e.g., *Tomopteris helgolandica* Greeff, 1879) which are pelagic in nature and involved in light production (Gouveneaux *et al.* 2017). For the taxonomic classification of tomopterids, Fauvel (1923) mentioned these glands and their affinity towards nuclear dyes like haematoxylin. Later on, a detailed histochemical examination on these light-producing parapodial glands by Gouveneaux (2016) confirmed their similar staining property. However, no such parapodial structures have so far been reported for any species of *Sigambra* in particular or pilargids in general. Even though the histochemistry of this gland is unknown, methyl green staining images (Fig. 4B–F) depict a visual resemblance with the image in Gouveneaux *et al.* (2017: fig. 2f). Moreover, the first appearance of these glands from the anterior parapodia along with their gradual enlargement can be similar to what is shown in specimens of *Enapteris euchaeta* Chun, 1888 or *Tomopteris elegans* Chun, 1888. Their chromophile glands are very conspicuous and situated inferiorly from segment 4, although in *Tomopteris apsteini* Rosa, 1908 they are visible from the third pair of parapodia, progressively larger, becoming enormous globes hanging under ventral rami (Støp-Bowitz 1948; Böggemann 2009). However, without having a detailed knowledge on its histochemistry and function, the observed structure in our study should not be further named; rather, it would be more appropriate referring them as parapodial glands.

Sigambra sundarbanensis sp. nov. is described from a mangrove dominated estuary of the Indian Sundarbans. The species has been described with morphological features along with the environmental factors in different seasons from the rivers Matla and Thakuran, Sundarbans. This report contributes to the polychaete checklist of Indian waters. It also includes the first documentation of some parapodial

glands in *Sigambra*. Moreover, it also delivers a global map of the type localities of all the accepted species of *Sigambra*.

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Compliance with ethical standards

Conflict of interest

The authors declare that they have no conflict of interest.

Ethical approval

No animal testing was performed during this study.

Sampling and field studies

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Data availability statement

All data generated or analyzed during this study are included in this published article.

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