

A new species of *Kirkegaardia* (Annelida: Polychaeta, Cirratulidae) from the southeast coast of India

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A new polychaete species, *Kirkegaardia serracroochaeta* sp. nov. belonging to family Cirratulidae collected from the Chennai port, southeast coast of India is described here. This species possesses distinctly serrated capillary setae. The unique morphological characters of this species are presence of four serrated chaetae, which are referred as special chaetae 1–4. They possess important species-level characteristics such as serrated capillaries, less-spaced teeth and barbs downwards; in addition chaeta 2 is crooked in the middle. This species is named after the special characteristics it possesses when compared to the already existing species of genus *Kirkegaardia*.

Keywords: *Kirkegaardia serracroochaeta*, port, sediment, serrated capillary setae.

CIRRATULIDAE is a family of marine polychaetes that are deposit feeders which burrow or crawl through the substratum (soft substrate). They are found mostly in organically enriched sediments in estuaries and ports, and often reach high population densities¹. Their population is governed by abiotic factors such as depth and the sediment characteristics². The family Cirratulidae is characterized by a single pair of palps or groups of tentacles attached anteriorly. It can be easily recognized by the numerous slender filiform branchiae present throughout the body. The family consists of 11 accepted genera and 159 species worldwide, organized in three groups, namely the multitentaculate genera (*Cirratulus* Lamarck, 1801; *Timarete* Kinberg, 1866; *Protocirrinis* Czerniavsky, 1881; *Cirriiformia* Hartman, 1936 and *Fauvelicirratulus* Çinar & Petersen, 2011), the bitentaculate soft-substrate genera (*Chaetozone* Malmgren, 1867; *Tharyx* Webster & Benedict, 1887; *Caulleriella* Chamberlin, 1919; *Kirkegaardia* Laubier, 1961 and *Aphelochaeta* Blake, 1991), and the bitentaculate hard-substrate genera (*Dodecaceria* Örsted, 1843)^{3–6}.

Cirratulidae represents one of the most speciose families among the Polychaeta. Yet the species from many coastlines is poorly known⁷. It is reported that Cirratulidae is poorly known and many common species are

often called by different names⁴. Further, it has been reported that their inconsistent diagnostic characters of these species are used to describe their morphology and also that most of the older descriptions are not sufficient to adequately characterize them; thus many eastern Pacific species are being misidentified. It has also been reported that such a situation exists in the western Pacific islands given that most of the descriptions are not adequately detailed and several of them have been listed as undetermined species or named after European species³. Recently, a new name, *Kirkegaardia* is proposed to replace *Monticellina* Laubier, 1961, a bitentaculate cirratulid polychaete genus, that is a junior homonym of the turbellarian *Monticellina* Westbald, 1953 (Platyhelminthes, Rhadocoela)^{8,9}. The genus *Kirkegaardia* comprises 38 species worldwide (Table 1). Around 20 sedentarian families have been reported in the shelf region of the northwest Indian coast. Among them, Cirratulidae contributed maximum (19.7%) to the polychaete density⁷. Several studies have reported organisms belonging to the genera *Cirratulus*, *Tharyx*, *Cirriiformia* and *Chaetozone* from India^{10–20}. However, there are no reports of organisms belonging to the genus *Kirkegaardia* from India. In this study, a previously unidentified Cirratulid species belonging to the genus *Kirkegaardia* collected from Chennai port, southeast coast of India is described as a new species.

Materials and methods

Specimens were collected from in and around the Chennai port during a survey (October 2012 and April 2013) conducted as part of the port biological baseline survey of the Ballast Water Management Programme, India. Specimens belonging to the genus *Kirkegaardia* were observed during these collections. The sediment samples were collected using a 0.04 m² Van Veen grab from an average depth of 12 m. These samples were sieved using a 500 µm mesh sieve, initially preserved in 10% buffered formaldehyde in sea water containing rose bengal stain, and later transferred to 5% formalin. Sediment samples were also collected for the analysis of sediment texture, organic carbon (OC) and chlorophyll. OC and percentage composition of sediment (sand, silt and clay) were

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determined by standard titration methods and pipette analysis respectively^{21,22}. OC was expressed as percentage of sediment dry weight. Estimation of sediment chlorophyll was carried out using spectrophotometric analysis²³. Stained specimens were imaged using a SZX16 stereomicroscope (Olympus, Japan) fitted with DP73 camera, and images were traced using photo editing software (Adobe Photoshop), wherever required. Specimens for scanning electron microscopy (SEM) were fixed in 1% osmium tetroxide in filtered sea water for 15 min, rinsed in distilled water and stored in 70% ethanol, and after critical point drying image (Hitachi S-4300, Japan)²⁴.

Results

Type material

Bay of Bengal, Chennai port, India, holotype: 13°09'7"N, 80°29'6"E, 18 m depth, sandy-silt, 18 October 2012;

holotype and six paratypes deposited in divisional repository of NIO (NIO/BBD/1/2017/Kirk); 18 m depth, sandy-silt, 22 April 2013; 11 paratypes.

Etymology

This species is named based on the characteristics of the distinct chaetae it possesses. Particularly, all the chaetae (Sp ch 1, 2, 3 and 4) are serrated ('serra') on one side and the barbs point downwards, and one of the chaeta (Sp ch 2) is crooked ('croo') in the middle. Therefore, this species is named *Kirkegaardia serracroochaeta*.

Type species

Kirkegaardia morae Elias, Rivero and Orensanz, 2016 (*Monticellina* Laubier, 1961, junior homonym of *Monticellina* Westblad, 1953).

Table 1. List of 38 species belonging to genera *Kirkegaardia*, family Cirratulidae

Species and author name, and reporting year	Location
<i>Monticellina dorsobranchialis</i> Kirkegaard, 1959	Western North Atlantic, Northeastern South America, Mediterranean, West Africa
<i>Monticellina tessellata</i> Hartman, 1960	Central and Southern California
<i>Monticellina heterochaeta</i> Laubier, 1961	Mediterranean Sea – NW Atlantic
<i>Monticellina anulosa</i> Hartman, 1965	New England; Northeastern South America
<i>Monticellina serratiseta</i> Banse and Hobson, 1968	Washington
<i>Monticellina secunda</i> Banse and Hobson, 1968	Washington
<i>Monticellina luticastella</i> Jumars, 1975	Southern California
<i>Monticellina aphelocephala</i> Hutchings & Murray, 1984	New South Wales, Australia
<i>Monticellina baptistae</i> Blake, 1991	Western North Atlantic
<i>Monticellina sibilina</i> Blake, 1996	Southern California
<i>Monticellina cryptica</i> Blake, 1996	California
<i>Monticellina setosa</i> Dean and Blake, 2009	Gulf of Nicoya, Costa Rica
<i>Monticellina acunai</i> Dean and Blake, 2009	Gulf of Nicoya, Costa Rica
<i>Monticellina antelaxa</i> Dean and Blake, 2009	Gulf of Nicoya, Costa Rica
<i>Monticellina carrikeri</i> Dean and Blake, 2009	Gulf of Nicoya, Costa Rica
<i>Monticellina elongata</i> Dean and Blake, 2009	Gulf of Nicoya, Costa Rica
<i>Monticellina giribeti</i> Dean and Blake, 2009	Gulf of Nicoya, Costa Rica
<i>Monticellina anterobranchiata</i> Magalhaes and Bailey-Brock, 2013	South Hawaii
<i>Monticellina hanaumaensis</i> Magalhaes and Bailey-Brock, 2013	Hanauma Bay, Hawaii
<i>Monticellina lueldredgei</i> Magalhaes and Bailey-Brock, 2015	Guam, Mariana Islands
<i>Monticellina marypetersenae</i> Lezziet, Çinar and Giangrande, 2016	Mediterranean (Taranto), Italy
<i>Monticellina morae</i> Elias, Rivero and Orensanz, 2016	Bahia Blanca, Argentine
<i>Kirkegaardia antonbruunae</i> Blake, 2016	Off Peru
<i>Kirkegaardia araiotrachela</i> Blake, 2016	Off Peru
<i>Kirkegaardia brigittae</i> Blake, 2016	Antarctic seas
<i>Kirkegaardia carolina</i> Blake, 2016	North California
<i>Kirkegaardia carinata</i> Blake, 2016	Off northern California
<i>Kirkegaardia chilensis</i> Blake, 2016	Off Chile
<i>Kirkegaardia cristata</i> Blake, 2016	Northeast Pacific Ocean
<i>Kirkegaardia dutchae</i> Blake, 2016	Northeast Pacific Ocean
<i>Kirkegaardia fragilis</i> Blake, 2016	Abyssal Pacific
<i>Kirkegaardia franciscana</i> Blake, 2016	Off northern California
<i>Kirkegaardia hampsoni</i> Blake, 2016	US Atlantic shelf
<i>Kirkegaardia heroae</i> Blake, 2016	Off Tiera del Fuego, Staten Island
<i>Kirkegaardia jumarsi</i> Blake, 2016	Peru-Chile Trench
<i>Kirkegaardia kladara</i> Blake, 2016	North Carolina
<i>Kirkegaardia neotessellata</i> Blake, 2016	New England
<i>Kirkegaardia olgahartmanae</i> Blake, 2016	Off Antarctic Peninsula

Diagnosis

Prostomium (Pr) long or short, sometimes pointed; peristomium (Per) elongated to short, with asetigerous annulations (an); dorsal tentacles (dt) usually arising anterior to chaetiger 1; middle body segments sometimes bead-like; posterior segments usually expanded or enlarged. Chaetae include serrated capillaries with less-spaced teeth and barbs downwards.

Description

A moderate-sized species, holotype, complete, 8.8 mm long, 0.3 mm wide for 103 chaetigers, thoracic region 26 chaetigers and paratype body parts same as holotype, differs only in size. Body long, rounded, narrow, posterior bead-like, thoracic segments much longer than wide, middle as wide as long and posterior segments wider than long (Figure 1 *a*). The noto- and neuropodia in each body segment are generally close together throughout the body, each segment with low podial lobes from which chaetae emerge (Figure 1 *b*), forming narrow, with dorsum body unflattened, raised middorsal ridge, ventral surface of thorax rounded without groove. Chaetigers of middle and posterior segments are rounded (Figure 1 *c*). Pygidium conical, anus dorsal (Figure 1 *d*).

Prostomium narrow, triangular with slit-like nuchal organs (no) present at prostomium border and eyes

absent. Peristomium elongate, as long as wide with three asetigerous annulations (Figure 2 *b*) and the everted proboscis-like structure resembling a sucker (Figure 2 *a* and *b*). Dorsal tentacles (Figure 2 *c*, marked with visible scars) arise from the posterior margin of the last annulation together with the first pair of branchiae (br) that arises laterally to the first notopodial lobe and emerge posterior to dorsal tentacle; subsequent branchiae emerging from dorsal border of notopodial lobe (Figure 2 *c*).

Prostomium, peristomium (Figure 3 *a*) and setae between notopodia (Noto) and neuropodia (Neuro), is a small gap (Figure 3 *c*). All setae are capillary-type, with five distinct setae (among them special chaetae 1–4), thoracic region 26 chaetigers with 5–6 serrated capillaries (Figure 3 *b*). Abdominal region from chaetiger 27, modified short and longer capillaries with basally expanded blades and sawtooth edge from anterior abdominal neuropodia (Figures 3 *c* and 4 *a*). Anterior abdominal notopodia with 5–6 modified serrated capillaries reducing to 4–5 posteriorly; anterior abdominal neuropodia with six modified capillaries (Figures 3 *d* and 4 *a, b*) reducing to three posteriorly. Notopodial and neuropodial serrated capillaries similar in shape, but the latter are four modified capillaries, one slightly shorter and other three longer. Pygidium chaetae number further decreased to 3–4 posteriorly.

Habitat

The sediment was dominated by sand followed by silt and clay in the habitat of these organisms. During October 2012 and April 2013, the contribution of sand was 76% and 85% and silt was 17% and 15% respectively. OC was more (2.8%) during April 2013 when compared to pre-monsoon season and it was less than 1% during October 2012. The sediment chlorophyll *a* ranged from 2.9 to 17.8 mg m⁻².

Remarks

Table 2 presents a comparative account of species-level characteristics of *Kirkegaardia serracroochaeta* sp. nov. with closely related species belonging to genus *Kirkegaardia*. *K. serracroochaeta* sp. nov. is closely related to *K. morae* and *K. siblina* having similar shape of the anterior region, posterior region is swollen and expanded, and pygidium is like a papilla. The peristomium is short and divided with three annuli in *K. siblina* (Blake, 1996), *K. morae* (Elias, Rivero and Orensanz, 2016), *K. serratiseta* (Banse and Hobson 1968), *K. secunda* (Banse and Hobson, 1968) and *K. tessellata* (Hartman, 1960). First special chaeta (Sp ch 1) has little similarities to one in *K. morae* (type species) as in *K. serracroochaeta* sp. nov. (Figure 2 *d* and 4 *a*). In *K. morae*, capillaries are serrate from the first chaetigers (even in juveniles) and they are an important

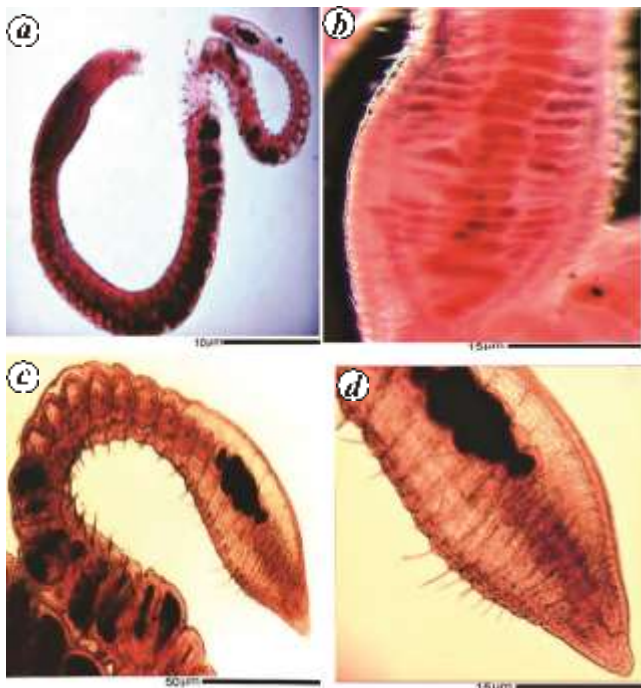


Figure 1. *Kirkegaardia serracroochaeta* sp. nov. *a*, Entire body structure and anterior end; *b*, Dorso-lateral view; *c*, Posterior end segments with pygidium; *d*, Pygidium, dorsal view.

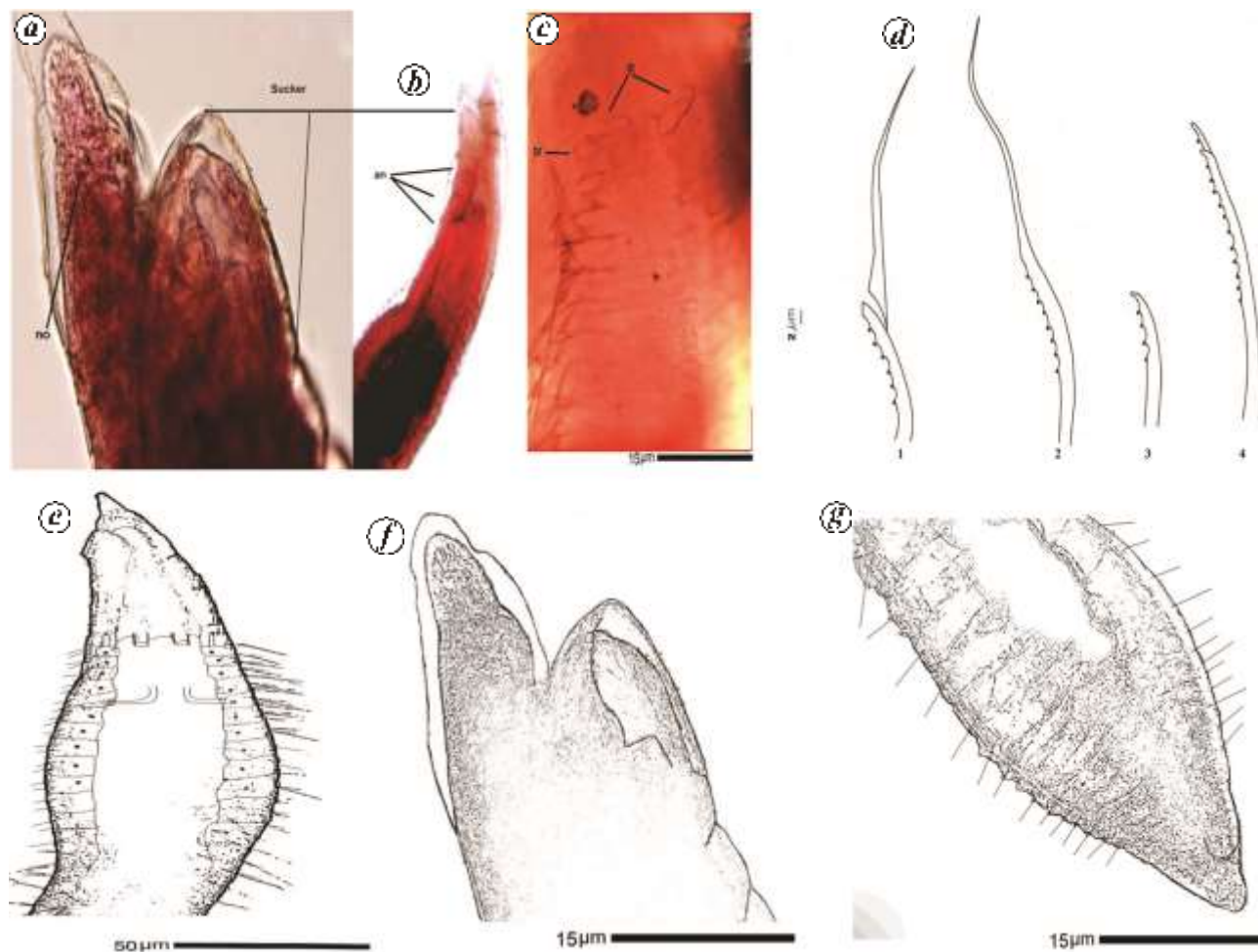


Figure 2. *K. serracroochaeta* sp. nov. **a**, Everted proboscis (sucker part) and nuchal organ; **b**, triangular prostomium and annulations; **c**, Antero-lateral view; **d**, Four special chaetae (1–4); **e**, Thorax; **f**, Prostomium with everted proboscis; **g**, Pygidium.

species-level character. Although one of the chaeta and annulations (3 nos) are common, other morphological characters (long, wide, other chaetigers, sucker and serrated capillaries begins from chaetiger 27th onwards) are unique to *K. serracroochaeta* sp. nov. In addition, *K. serracroochaeta* sp. nov. has short and long narrow serrated noto- and neurochaetae, which are unique to this species (Figures 2 *d* and 4 *a*, *b*). However, among five chaetae, one serrated chaeta seems to be very similar to those in *K. lueddredgei*, *K. elongata* and *K. acunai*. Another unique character is the presence of everted proboscis (sucker)-like organ (Figure 2 *a*, marked with visible everted proboscis) placed on the peristomium, which was not reported in other *Kirkegaardia* species and was observed in both holotype and paratype of *K. serracroochaeta* sp. nov. The conical pygidium has unique small line at the tip (Figure 1 *c* and *d*). The denticulation pattern of noto- and neurochaetae with less-spaced teeth and barbs downwards is an important species-level character (Figure 2 *d*). Special chaeta 1 (Sp ch 1) begins with serrated edge on one side, branched from the middle portion and

ends with pseudo-articulated tip. The second longer chaeta, special chaeta 2 (Sp ch 2), one half is serrated at the edge and other half crooked till ends with a sharp pointed tip without pseudo-articulated tip. Special chaeta 3 (Sp ch 3) is shorter than other special chaetae, serrated edge on one side and does not end with pointed tip (Figures 3 *d* and 4 *a* and *b*). In case of posterior special chaeta 4 (Sp ch 4), 3/4th is serrated edge and remaining portion with barbed space and ends with small pseudo-articulated tip (Figure 4 *c* and *d*).

Systematics

Phylum: Annelida
 Class: Polychaeta
 Subclass: Sedentaria
 Order: Terebellida
 Family: Cirratulidae Carus, 1863
 Genus: *Kirkegaardia* Blake, 2016
 Species: *serracroochaeta* sp. nov. Atchuthan & Desai, 2017.

Table 2. Species-level characteristics of *Kirkegaardia*

Species	Prostomium	Annulations	Everted proboscis (sucker)	First appearance of denticulate chaetae	Nature of denticulate chaetae	Special chaeta 1	Special chaetae 2-4	Posterior end	Reference
<i>Kirkegaardia serracrochaetae</i> (this study)	Swollen and rounded	Three	Present	Anterior abdominal noto- and 27th chaetiger onwards neuropodia	Serrate	One half denticulate sawtooth, other half stretched from middle, sharp edge at the tip	Present	Conical	This study
<i>Kirkegaardia siblina</i>	Elongate	Three	Absent	Posterior notosetae 20-25 neurosetae	Broad and denticulate	Absent	Absent	Terminal papilla	Blake (1996)
<i>Kirkegaardia elongata</i>	Conical	Six	Absent	24-25 notosetae 22-24 neurosetae	Proximal serrated region and elongate smooth distal region	Absent	Absent	Lacking	Dean and Blake (2009)
<i>Kirkegaardia acunai</i>	Wide triangular	Four	Absent	22 (23-34) notosetae 22 (21-33) neurosetae	Fimbriated, serrated	Absent	Absent	Ciriform ventral extension (conical in paratypes)	Dean & Blake (2009)
<i>Kirkegaardia lueddagei</i>	Short, conical	Two	Absent	Anterior an dominal noto- and neuropodia	Basally expanded bearing sawtooth edge	Absent	Absent	Pointed	Magalhães and Bailey-Brock (2015)
<i>Kirkegaardia morae</i>	Short, acute (rounded in paratypes)	Three	Absent	All noto and neurosetae, 1st chaetiger onwards	Serrate	Present Serrate	Absent	Simple (conical)	Elias <i>et al.</i> (2016)
<i>Kirkegaardia serraiseta</i>	Triangular to conical, pointed on anterior margin	Three	Absent	Middle and posterior segments neurosetae	Serrated or denticulate; denticulate with numerous denticles along edges	Absent	Absent	Terminal lobe dorsal	Banse and Hobson (1968); Blake (1996)
<i>Kirkegaardia secunda</i>	Short conical	Three	Absent	Middle body segments in neurosetae	Small, fine denticles along one edge	Absent	Absent	Not described	Banse and Hobson (1968); Blake (1996)
<i>Kirkegaardia tessellata</i>	Conical, pointed apically	Three	Absent	Middle and posterior neurosetae	Thicker with sawtooth edges; broadly expanded blade with distinct dentition	Absent	Absent	Narrow to pointed	Hartman (1960); Blake (1996)

Prostomium Annulations, Number of peristomial annulations; Nature of denticulate chaetae; Nature or type of denticulation in chaetae; Posterior end, form of posterior end and pygidium.

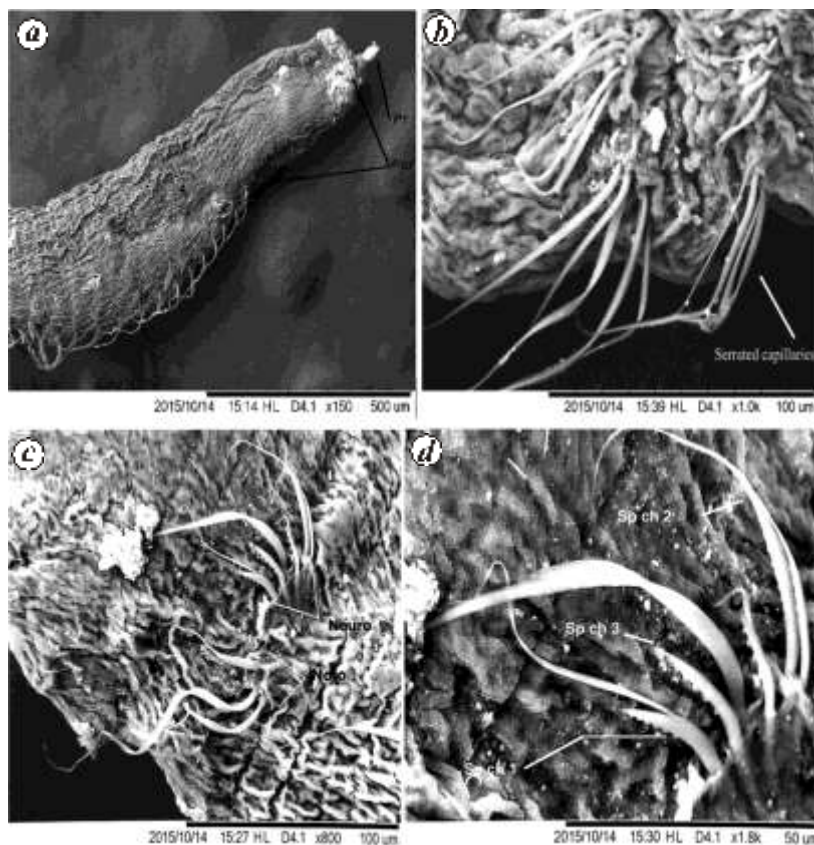


Figure 3. *K. serracrochaeta* sp. nov. *a*, SEM image of thoracic capillary setae. *b*, Serrated capillaries. *c*, *d*, Abdominal serrated capillaries with first, second and third special chaetae. (Pr, Prostomium; Per, Peristomium; Noto, Notopodium; Neuro, Neuropodium; Sp ch 1, Special chaeta 1; Sp ch 2, Special chaeta 2, Sp ch 3, Special chaeta 3).

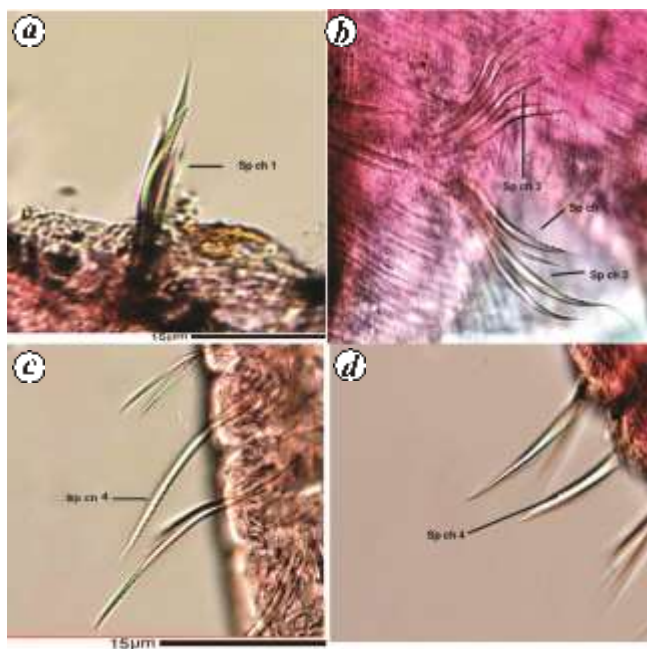


Figure 4. *K. serracrochaeta* sp. nov. *a*, *b*, Abdominal serrated capillaries with special chaetae 1–3. *c*, *d*, Posterior serrated capillaries with fourth special setae showing the spaced barbs. Abbreviations as in Figure 3.

Discussion

The unifying characteristics of the newly described species of genus *Kirkegaardia* in the present study is the presence of distinctly serrated capillary setae. When compared to the previously described species, there is considerable variability in the species-level characteristics between *K. serracrochaeta* sp. nov. and the previously described species (Table 1), especially in the arrangement of special chaetae in the former.

Since this species is reported for the first time in India and its habitat is limited to the port environment, further studies are required to trace back the history or the evolutionary linkages with the closely resembling species of the genus *Kirkegaardia*. A possibility of bio-invasion of this species through ship ballast water cannot be ruled out, as earlier studies carried out in the Chennai port region have not reported organisms belonging to this genus. Historical data on benthic communities are often lacking and this hampers the interpretation of impact assessment data. With the occurrence of new species in the port area, it can be noted that extensive port activities can bring in short-term changes in sediment characteristics and benthic community structure. The seasonal benthic surveys

in Chennai port, with or without port activity due to dredging or dumping waste, may be a reliable source of baseline information for assessing the short- or long-term effects of disturbances on benthic ecosystems in general and on specific species in particular, which are reported only in the port area. It is observed that the occurrence of *K. serracrochaeta* sp. nov. coincides with moderate chlorophyll-*a* and sandy-silt habitats with lower percentage of clay and also with higher OC. An earlier study observed similar influence and indicated that *Kirkegaardia* sp. were distributed throughout the sedimentary granule, very fine or fine sand band indicated for this genus, but distributed according to sedimentary components (sand, or silt and clay)². This may indicate that occurrence and abundance of *Kirkegaardia* sp. is influenced by the sediment characteristics. A comparative account of the influence of different physico-chemical and biological parameters on the distribution and abundance of this species in the port habitat is required to understand the ecology of this new species. Also sampling outside the port area is required regarding the occurrence of this species in the coastal areas. Further studies should also include the phylogenetic reconstruction of this species using molecular data to investigate its relationship within the annelids.

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