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2024년 2월
석사학위 논문

**Taxonomic Study on the
Multitentaculate Cirratulids
(Polychaeta: Terebellida) from
Korean Waters**

조선대학교 대학원

글로벌바이오융합학과

정 유 석

Taxonomic Study on the Multitentaculate Cirratulids (Polychaeta: Terebellida) from Korean Waters

한국 해역에 서식하는 신타래갯지렁이과 다모류
(다모강: 유령갯지렁이목)의 분류학적 연구

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이 논문을 이학석사학위 신청 논문으로 제출함

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국문초록

한국 해역에 서식하는 신타래갯지렁이과 다모류

(다모강: 유령갯지렁이목)의 형태학적 연구

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신타래갯지렁이류는 해양 저서무척추동물 군집에서 발견되는 가장 크고 흔한 여과섭식 다모류의 한 무리이다. 신타래갯지렁이류는 총 12 개 속에 속하는 종들을 포함하며, 촉수다발을 가지거나 쌍을 이루는 등쪽 촉수를 가지는 2 개의 군으로 구분된다. 그 가운데 촉수다발을 가지는 다중촉수 신타래갯지렁이류는 마디별 촉수와 아가미다발의 상대적 위치, 마디당 아가미의 수, 존재하는 강모의 종류에 따라 5 개 속으로 분류된다. 우리나라 해역에서는 다중촉수 신타래갯지렁이류로서 4 속 5 종이 보고된 바 있다. 그러나 기존의 분류학적 연구는 대강의 형태에만 초점을 맞추었으므로, 이 종들에 대한 정확한 정보와 그들의 계통발생학적 관계를 검토할 필요가 있는 상태이다. 따라서 본 연구에서는 현대적인 관점의 분류체계에 따라 국내에 분포하는 다중촉수 신타래갯지렁이류를 조사, 검토하고자 하였다. 2021 년 5 월부터 2023 년 8 월까지 국내 12 개 지역의 조간대에서 채집된 다중촉수 신타래갯지렁이류 표본들에 대한 분류학적 연구를 수행한 결과, 4 개 속에 속하는 신종후보 4 종, 즉 *Protocirrinieris* n. sp., *Cirratulus* n. sp., *Timarete* n. sp.

및 *Cirriformia* n. sp. 를 확인하였다. 그 가운데, *Protocirrinervis* n. sp. 의 경우 capillary 강모만이 존재하고, acicular spine 강모가 없으며, 여러 전방 마디에 걸쳐 세로줄로 배열된 촉수다발이 다른 속의 종들과 구별되는 특징을 가졌으며, 특히 전방 배면 마디에서 나타나는 특징적인 메틸그린염색패턴(methyl green staining pattern, MGSP)에 의해 최근에 기술된 같은 속의 종들과 구별된다. 또한, *Cirratulus* n. sp. 의 경우 촉수다발이 첫번째 강모마디에서 발생하며, 아가미가 촉수다발과 같은 마디에서 발생하고, 입앞마디에 가로로 늘어선 안점이 존재하는 것이 다른 속의 종들과 구별되는 특징이며, 안점의 개수, 각 마디에서 발생하는 아가미의 위치, 등쪽 및 배쪽 측각에서의 spine 발생 지점 등에 의해 같은 속의 종들과 구별된다. *Timarete* n. sp. 의 경우 아가미가 앞마디에서 등쪽 측각과 가깝고, 뒷마디에서는 중간 등쪽으로 이동하는 점이 다른 속의 종들과 구별되는 특징이며, 촉수다발의 배열 및 개수의 차이, 각 마디에서 발생하는 아가미의 위치와 이동 지점, 그리고 등쪽 및 배쪽 측각의 spine 발생 지점에 의해 같은 속의 종들과 구별된다. 한편, *Cirriformia* n. sp. 의 경우 아가미가 등쪽 측각 전체에 걸쳐 발생하는 점이 다른 속의 종들과 구별되는 특징이며, *Protocirrinervis* n. sp. 와 마찬가지로 독특한 MGSP 을 보이는 점, 촉수다발의 개수 차이, 등쪽 측각의 spine 발생 지점 등에 의해 근연종들과 구별된다. 본 논문에서는 4 종의 신종후보에 대하여 자세한 기재와 도판을 작성하였으며, 각각의 근연종들에 대한 형태학적 특징을 비교·검토하였다.

주요어: 분류학, 다모강, 신타래갯지렁이과, 다중촉수, *Protocirrinervis*,

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I. INTRODUCTION

1. Phylogeny and taxonomy of the multitentaculate cirratulid worms

The family Cirratulidae Ryckholt 1851 comprises 12 genera divided into two groups with either tentacular filaments or paired dorsal tentacles, the multitentaculate genera and bitentaculate genera. Multitentaculate cirratulids are categorized into five genera based on the relative segmental position of tentacles and branchial filaments, number of branchiae per segment, and the types of chaetae (Blake and Magalhães, 2017). Within the multitentaculate cirratulid genera, *Protocirrineris* Czerniavsky 1881 is characterized by the presence of capillaries only, absence of modified chaetae, and presence of tentacular filaments arranged in longitudinal rows across several anterior segments (Magalhaes and Bailey–Brock, 2013). Among the four genera that possess modified chaetae, *Cirratulus* Lamarck, 1801, and *Fauvelicirratulus* Çinar and Petersen, 2011 differ from *Cirriformia* Hartman, 1936, and *Timarete* Kinberg, 1866 in that their tentacular filaments arise from chaetiger 1 and branchiae beginning on the same segment with tentacular filaments. *Fauvelicirratulus* differs by having multiple pairs of branchiae per segment and long, straight, tapering spines, while *Cirratulus* has a pair of branchiae per segment and short, stout, sigmoid–shape spines (Çinar and Petersen, 2011). *Timarete* and *Cirriformia* are much similar each other in that their tentacular filaments arise from two or more segments posterior to chaetiger 1 and branchiae are originating from an earlier segment than tentacular filaments. In *Timarete*, however, the branchiae are arising close to notopodial base in anterior chaetigers and shifted toward mid–dorsum on posterior segments, while the branchiae are inserted near all the notopodial bases in *Cirriformia* (Magalhães *et al.*, 2014).

2. Previous researches in Korea

Currently, a total of five genus, 96 valid species are acknowledged as members of the multitentaculate cirratulids, but the majority of them were recorded under an old concept of cirratulid taxonomy (WoRMS, 2023). Within Korean waters, only five species belonging four genus have been documented (Paik, 1989; Choi *et al.*, 2018). However, apart from *Timarete posteria* Choi, Kim and Yoon, 2018, particular attention should be given to this records because other four species are known as so-called "cosmopolitan" species. Due to have studied and recorded with deficient species descriptions and illustrations for numerous polychaetes in many countries, previous studies have resulted some taxonomic difficulties including misidentifications of the species and application of European species names to taxa worldwide (Hutchings and Kupriyanova, 2018). Therefore, it is especially necessary to reevaluate previous records of Korean fauna (Paik, 1989) under the European species names since it is highly unlikely for a Mediterranean species to naturally occur in Korean waters.

3. Purpose of the present study

During the investigation of polychaetes inhabiting Korean waters, the author discovered several unknown species belonging to the multitentaculate cirratulids. To properly classify this species, the author carefully examined these species in accordance with a modern multitentaculate cirratulid taxonomy. Analysis involved a meticulous assessment of various aspects, including the using methyl green staining pattern (MGSP) and several ontogenetic characteristics such as the morphological attributes of the prostomium and peristomium, the segmental origins of the branchiae, and the arrangement of tentacular filaments. In this study, detailed descriptions and illustrations of four Korean multitentaculate cirratulid species, new to science, is provided with discussions for their related species.

II. MATERIALS AND METHODS

1. Sampling and morphological observation

The material examined in this study were collected at 12 localities in South Korea during the period from May, 2021 to August, 2023 (Fig. 1). Samples were collected from intertidal sand–mud habitats in Korean waters. The Specimens were extracted using a sieves with a 0.5 mm mesh. After extraction, they were initially fainted with a freshwater and then transferred to 95% ethanol. Using dissection forceps, surgical knives, and needles, we observed the dissected appendages from the petri dish under a stereoscopic microscope (Discovery V8; Carl Zeiss, Germany). The dissected samples were mounted on hole slide–glass using glycerol and examined them under an optical microscope (BX50F4; Olympus, Japan). Drawing was made with a stereoscopic microscope (SZH–ILLD; Olympus, Japan) and an optical microscope with aids of drawing tubes. Methyl green staining was carried out following the methods described by Winsnes (1985). To determine the methyl green staining pattern (MGSP), the sample was immersed in an 80% ethanol–saturated solution of methyl green for at least 60 seconds. Afterwards, the excess stain was rinsed off using 80% ethanol. The research materials are deposited at Chosun University and the National Institute of Biological Resources (NIBR) in Korea.

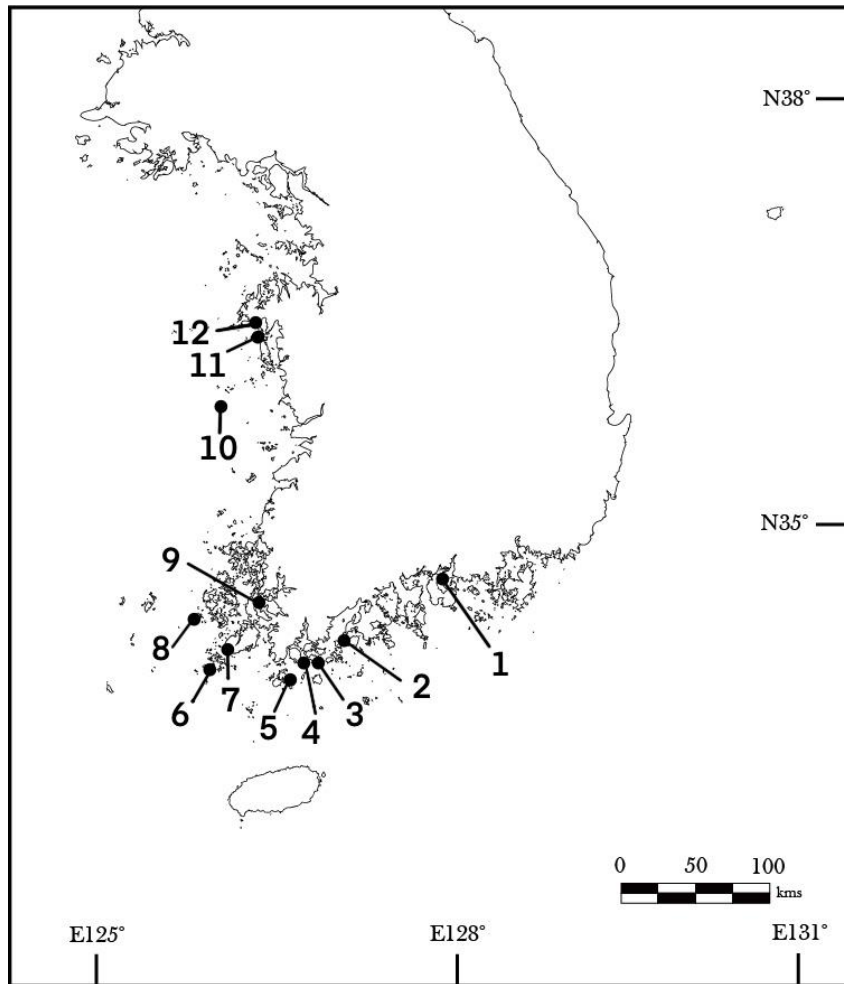


Fig. 1. Localities where the specimens were collected in this study: 1, Munhang-ri, Seolcheon-myeon, Namhae-gun, Gyeongsangnam-do; 2, Sinjeon-ri, Geumsan-myeon, Goheung-gun, Jeollanam-do; 3, Deugam-ri, Yaksan-myeon, Wando-gun, Jeollanam-do; 4, Daegok-ri, Sinji-myeon, Wando-gun, Jeollanam-do; 5, Iwol-ri, Soan-myeon, Wando-gun, Jeollanam-do; 6, Chang-yu-ri, Jodo-myeon, Jindo-gun, Jeollanam-do; 7, Namdong-ri, Imhoe-myeon, Jindo-gun, Jeollanam-do; 8, U-ido-ri, Docho-myeon, Sinan-gun, Jeollanam-do; 9, Geumho-ri, Sani-myeon, Haenam-gun, Jeollanam-do; 10, Eocheongdo-ri, Okdo-myeon, Gunsan-si, Jeollabuk-do; 11, Uihang-ri, Sowon-myeon, Taeon-gun, Chungcheongnam-do; 12, Banggal-ri, Wonbuk-myeon, Taeon-gun, Chungcheongnam-do.

2. External morphology of cirratulids

1. Body (Fig. 2A)

: Elongated, cylindrical in cross section, tapering both anteriorly and posteriorly, and typically forming distinct grooves, usually on ventral side.

2. Prostomium (Fig. 2C)

: Broad, wedge-shaped, conical lobe sometimes bearing small eyespot and pair of ciliated nuchal organs visible on dorso-lateral margins.

3. Peristomium (Fig. 2C)

: Achaetous, dorsally smooth or with apparent segmental lines exhibiting annulations; three subequal annulations existed in most species.

4. Tentacular filaments (Fig. 2C)

: Arise from anterior thoracic segments instead of peristomium, always grooved.

5. Branchiae (Fig. 2E)

: Typically occurred along body, always cylindrical, usually positioned just above notochaetae; shifted towards groove along dorsal midline in certain related species.

6. Parapodium (Fig. 2E)

: Biramous, appeared in numerous segments; lobes rudimentary but contain distinct noto- and neuropodium.

7. Chaetae (Figs. 2E, 2F)

: Emerged from small tori and comprising capillaries and acicular spines; noto- and neuropodial acicular spines existed in all multitentaculate genera except *Protocirrinieris*.

8. Pygidium (Fig. 2B)

: Terminating in simple rounded or pointed lobe.

9. Methyl green staining patterns (MGSP)

: Staining patterns often different from each other among cirratulid species, allowing for distinction of several similar species.

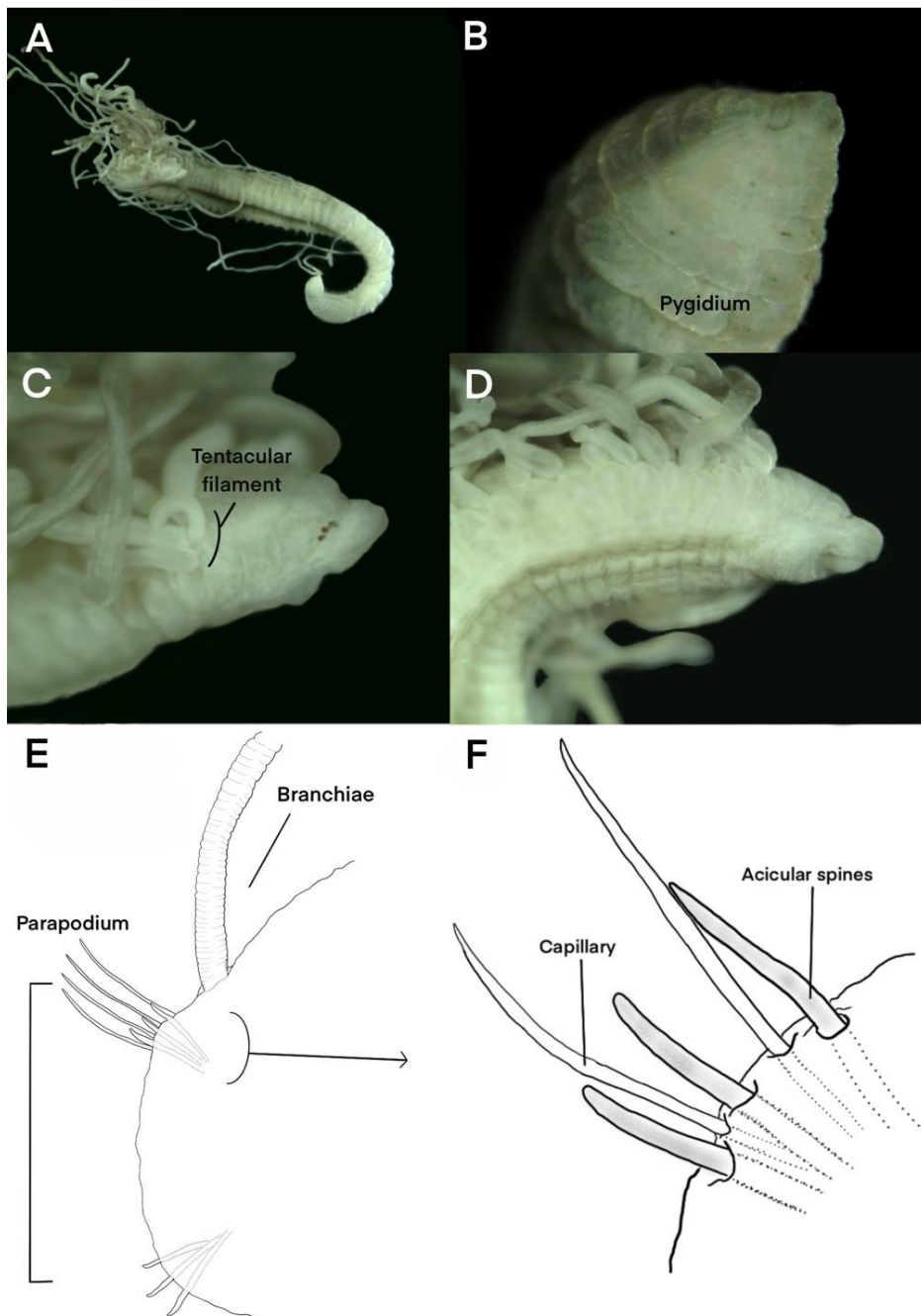


Fig. 2. Taxonomic characters of cirratulids (A–D, *Cirratulus n. sp.*; E, F, *Timarete n. sp.*). A, whole body; B, pygidium, dorsal view; C, anterior end, lateral view; D, anterior end, ventral view; E, parapodium cross section; F, capillary chaeta and acicular spines.

III. SYSTEMATIC ACCOUNTS

Phylum Annelida Lamarck, 1809 환형동물문

Class Polychaeta Grube, 1850 다모강

Subclass Sedentaria Lamarck, 1818

Infraclass Canalipalpata, Rouse & Fauchald, 1997

Order Terebellida Rouse & Fauchald, 1997 유령갯지렁이목

Suborder Cirratuliformia Fauchald, 1997

Family Cirratulidae Ryckholt, 1851 실타래갯지렁이과

Genus *Protocirrineris* Czerniavsky, 1881

1. *Protocirrineris* n. sp.

Genus *Cirratulus* Lamarck, 1818 가는실타래갯지렁이속

2. *Cirratulus* n. sp.

Genus *Timarete* Kinberg, 1866 모듬실타래갯지렁이속

3. *Timarete* n. sp.

Genus *Cirriformia* Hartman, 1936 명주실타래갯지렁이속

4. *Cirriformia* n. sp.

Key to genera of multitentaculate cirratulids from Korean waters (Blake, 2018)

1. Chaetae all capillaries; tentacular filaments on each side arranged in longitudinal rows over multiple segmentsGenus *Protocirrinieris*
 - Chaetae include both capillaries and acicular spines; tentacular filaments on each side typically forming transverse series.....2
2. Tentacular filaments arising from two or more segments posterior to chaetiger 1; first branchiae arising from segments anterior to tentacular filaments3
 - Tentacular filaments arising from chaetiger 1; first branchiae on same chaetiger as tentacular filaments.....Genus *Cirratulus*
3. Branchiae arising close to notopodium in anterior chaetigers, shifting toward mid–dorsum of body in middle chaetigers; some species may have multiple branchiae on individual parapodia.....Genus *Timarete*
 - Branchiae arising just dorsal to notopodium throughout, not shifting dorsally along body; all branchiae singular on individual parapodia.....Genus *Cirriformia*

Genus *Protocirrinervis* Czerniavsky, 1881

Type Species: *Protocirrinervis tenuisetis* (Grube, 1860), designated by Hartman (1959)

Diagnosis. Prostomium bluntly conical to wedge-shaped, with or without nuchal organs. Body approximately round in cross section and displays well-defined segments. Tentacular filaments Grooved typically limited in number and arranged singly or in paired groups on several longitudinal rows. Branchiae occurring singly, usually originating from segments with tentacular filaments, occasionally from more anterior chaetigers. All chaetae form of capillaries. Pygidium simple lobe (Blake, 1996; Elías *et al.*, 2019).

1. *Protocirrinervis* n. sp.

(Figs. 3, 4, 5)

Material examined. Type locality: South Korea, Deugam-ri, Yaksan-myeon, Wando-gun, Jeollanam-do (34°21'29"N, 126°54'26"E), 06 April 2023, intertidal sandy-mud bottom.

Holotype: complete ind. **Paratypes:** 1 ind. (complete); 1 ind. (complete); 1 ind. (complete).

Non-type materials: South Korea: 1 ind. (incomplete), Daegok-ri, Sinji-myeon, Wando-gun, Jeollanam-do (34°19'26"N 126°49'56.2"E), 21 August 2021, intertidal sandy-mud bottom; 1 ind. (incomplete), Namdong-ri, Imhoe-myeon, Jindo-gun, Jeollanam-do (34°21'59"N 126°09'02"E), 13 August 2022, intertidal sandy-mud bottom; 1 ind. (incomplete), Chang-yu-ri, Jodo-myeon, Jindo-gun, Jeollanam-do (34°17'53"N 126°01'07"E), 13 August 2022, intertidal rocky-mud bottom; 1 ind. (incomplete), Uihang-ri, Sowon-myeon, Taeon-gun, Chungcheongnam-do (36°49'50"N 126°09'19"E), 20 May 2023, intertidal rocky bottom.

Description. Holotype complete, 50 mm length, 2 mm width in anterior and middle segments, with wide gradually decreasing in posterior segments, for about 350 chaetigers; additional specimens, including paratypes, were 20–70 mm length, 1–3 mm width for 200–650 chaetigers.

Body rounded dorsally, flattened ventrally, appearance of a ventral groove along body (Figs. 3C, 5B); dorsal dome narrowest at thoracic region due to height of anterior lateral shoulder then increases in height; pygidium not inflated, conical, simple, anus dorsally (Fig. 3D). Body colour in ethanol tan; tentacular filaments and branchiae appearing paler than body; some branchiae exhibit long dark brown vertical vessels; in one paratype material specimen, parapodia in middle region begin to darken starting at chaetiger 105 while those in posterior area become paler.

Prostomium short bluntly conical, lacking eyespot, with a small pair of postero-lateral nuchal organs (Figs. 3A, 5A). Peristomium approximately same length as three anterior chaetigers, with three same-sized annuli; without distinct dorsal peristomial annuli; dorsum lacking crest; ventral borders of peristomium feature a V-shaped groove (Figs. 3C, 5B). Tentacular filaments emerged from chaetigers 4–7, arranged in longitudinal rows of 2–3 filaments per row (Figs. 3B, 5A); paired groups of 4–5 longitudinal rows present on each side above chaetigers 5–9 in largest paratype specimen; In segment where first tentacular filaments occurred, point of occurrence slightly further from notopodium; tentacular filaments much thicker than branchiae. Branchiae first appeared starting from tentacle-bearing chaetiger 5 (Fig. 5A), arising in postero-dorsal part of parapodial shoulders, continuing on subsequent segments towards posterior of body; with one pair per segment; branchiae more prominent in anterior one-third of body, gradually become sparse as move further back.

Parapodia well developed, forming distinct lateral shoulders, especially in thoracic region, extends up to one-third of body; distance between parapodia at each segments not crowded and remains constant, distance between noto- and neuropodia closer to each other anteriorly and become even closer in middle and posterior segments, appearance of being combined (Fig. 5A); noto- and neuropodia project laterally in anterior chaetigers, becoming more expanded ventrally in posterior chaetigers. Chaetae all simple capillaries, no acicular spines present; notopodial capillaries longer than neuropodial capillaries in whole segments (Figs. 3E, 3F, 5C).

Methyl green staining pattern (MGSP). Entire body stained uniformly light blue, with distinctive

stained pattern apparent on anterior part of ventral chaetigers. Staining pattern appears at both ends just below neuropodia at chaetiger 15, and gradually thickens and continues as transverse band detected on posterior–ventral half of each segment, and ends at chaetiger 75 (Fig. 4).

Habitat. This species was collected from mudflats, sandy–mud and silt–clay sediments in the intertidal zone.

Distribution. South Korea (present study).

Remark. The methyl green staining pattern (MGSP) is regarded as a valuable diagnostic feature in the polychaete taxonomy including cirratulids (Blake and Magalhães, 2017). The MGSP has been reported from nine species in the genus *Protocirrineris*: *P. angelicollatio* Elías and Rivero, 2009; *P. baiana* Elías, Saracho–Bottero and Magalhaes, 2019; *P. camamuensis* Elías, Saracho–Bottero and Magalhaes, 2019; *P. magalhaesi* Elías, Saracho–Bottero and Simon, 2019; *P. mascaratus* Magalhães and Bailey–Brock, 2013; *P. nuchalis* (Ehlers, 1907); *P. purgamentorum* Lezzi, Çinar and Giangrande, 2016; *P. socialis* Blake, 1996; *P. strandloperarum* Elías, Saracho–Bottero and Simon, 2019 (Blake, 1996; Elías and Rivero, 2009; Magalhães and Bailey–Brock, 2013; Lezzi *et al.*, 2016; Elías *et al.*, 2019; Elías *et al.*, 2019). *Protocirrineris* n. sp. is distinguished from these nine species in its highly distinctive MGSP on the anterior ventral segments by combination of the following features; the staining pattern appears at both ends just below the neuropodia in chaetiger 15, gradually thickens and continues as a transverse band detected on the posterior–ventral half of each segment, and ends at chaetiger 75 (Blake, 1996; Elías and Rivero, 2009; Magalhães and Bailey–Brock, 2013; Lezzi *et al.*, 2016; Elías *et al.*, 2019; Elías *et al.*, 2019). The new species has a very long average body length in relation to previously recorded *Protocirrineris* species. The ventral border of peristomium showing a V–shaped groove of *Protocirrineris* n. sp. is closely similar to that of recently described *P. purgamentorum* Lezzi, Çinar and Giangrande, 2016, but the former differs from the latter in having the branchiae first

appeared from chaetiger 5 (*vs.* from the anteriormost tentacle-bearing chaetiger 3–8 in *P. purgamentorum*), tentacular filaments arranged in 2–5 longitudinal rows (*vs.* single longitudinal rows in *P. purgamentorum*), notopodial capillaries longer than neuropodial (*vs.* no difference in length between notopodial and neuropodial capillaries in *P. purgamentorum*), and longer body length (20–70 mm *vs.* 5–14 mm in *P. purgamentorum*) (Lezzi *et al.*, 2016). In Table 1, comparison of the morphological characteristics for known *Protocirrinieris* species is provided.

Genus *Cirratulus* Lamarck, 1881

Type Species: *Lumbricus cirratus* Müller, 1776, accepted as *Cirratulus cirratus* (O. F. Müller, 1776)

Diagnosis. Prostomium elongate, blunt, or wedge-shaped; usually featuring with transverse rows of eyespot. Pair of small nuchal organs can be observed at postero-lateral edge. Peristomium displays two or three annulations. Two or more grooved tentacular filaments arranged between peristomium and first chaetiger or from a single anterior segment. First pair of branchiae located in same chaetiger as tentacular filaments; appear singly and extend over most of body toward posterior end, either above notopodium or becoming more dorsal in middle segments of body. Parapodial rami well separated. Chaetae include capillaries with either serrated or smooth edges and curved acicular spines. Pygidium with or without lobes surrounding anus (after Blake, 1996; Saracho-Bottero *et al.*, 2019).

2. *Cirratulus* n. sp.

(Figs. 6, 7, 8)

Material examined. Type locality: South Korea, Banggal-ri, Wonbuk-myeon, Taean-gun, Chungcheongnam-do (36°54'13"N, 126°12'22"E), 19 May 2023, intertidal muddy-rock bottom.

Holotype: complete ind. **Paratypes:** 13 ind. (complete); 1 ind. (incomplete). **Non-type**

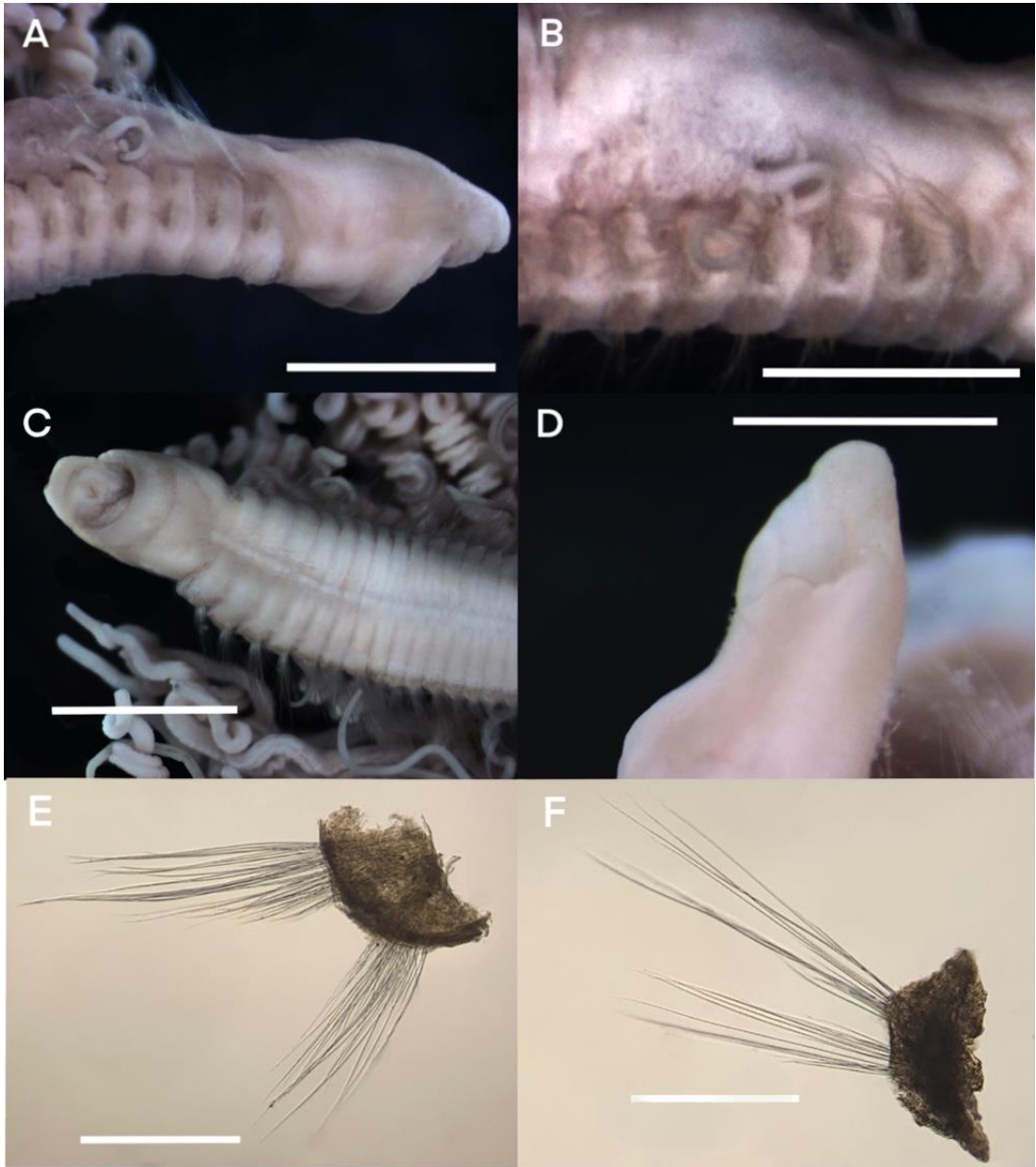


Fig. 3. Photographs of *Protocirrinieris* n. sp. A, anterior end, lateral view; B, insertion of tentacular filaments from chaetiger 4–7; C, anterior end, ventral view, V-shaped groove on peristomium; D, posterior end with pygidium; E, anterior, noto- and neuropodium; F, posterior, noto- and neuropodium. Scale bars: A, C = 2 mm; B, D = 1 mm; E, F = 0.5 mm.

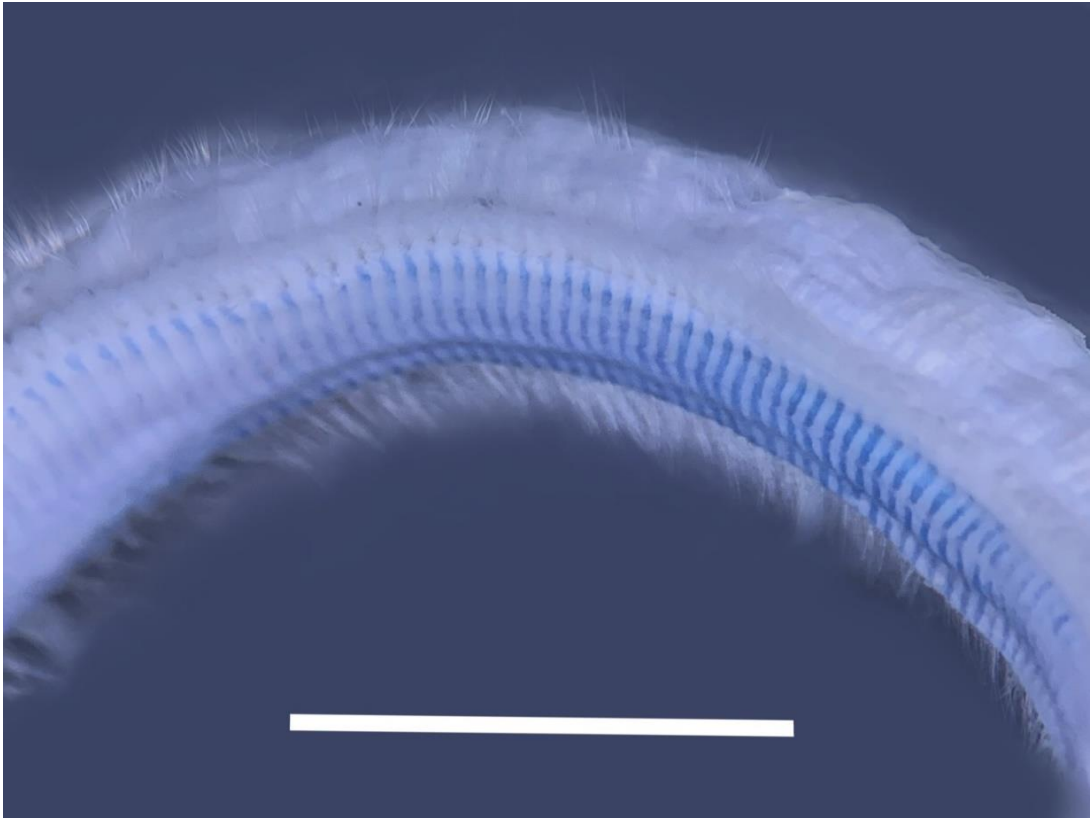


Fig. 4. MGSP of *Protocirrineris* n. sp. showing stained pattern, anterior–ventral view. Scale bar = 5 mm.

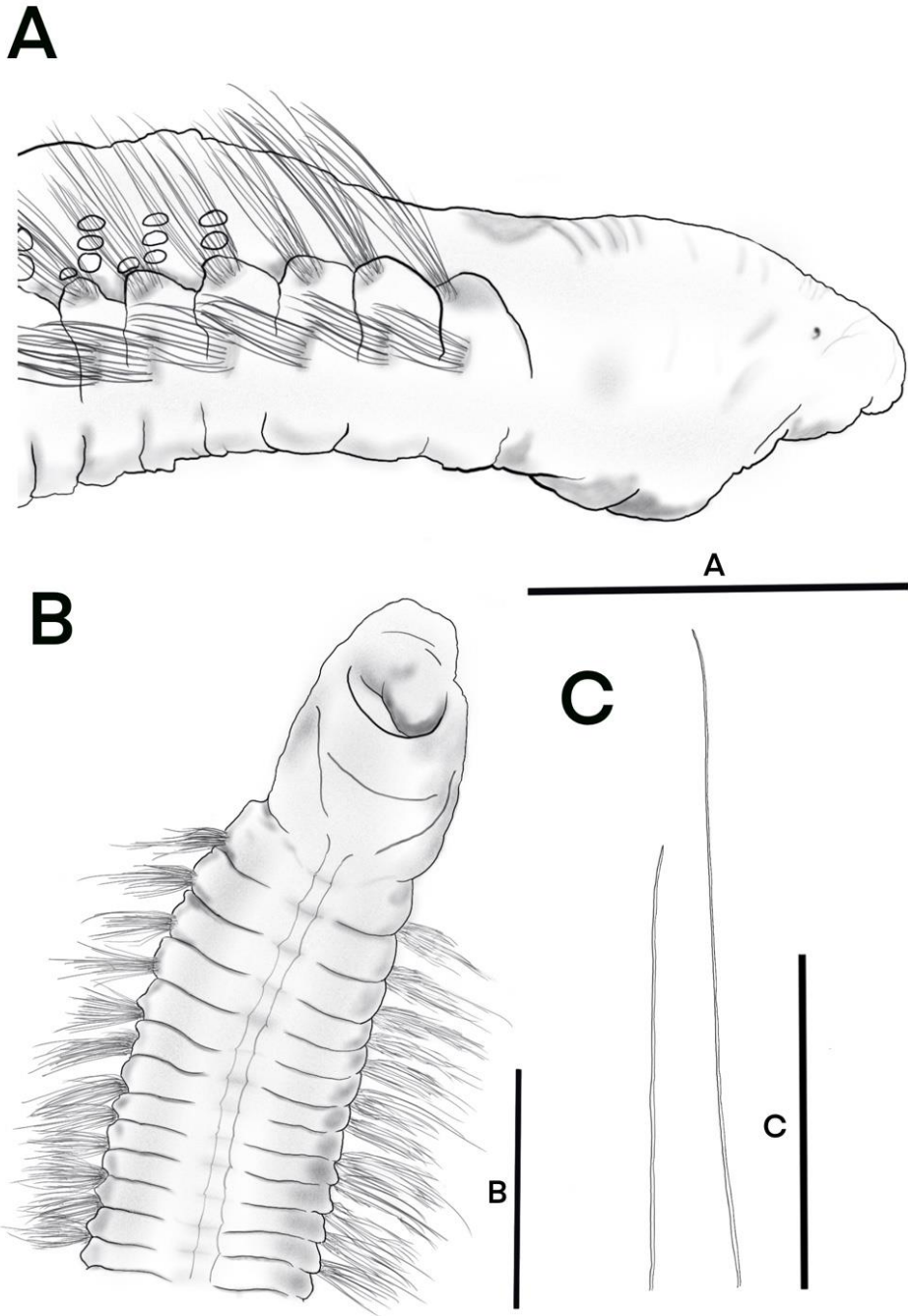


Fig. 5. *Protocirrinervis* n. sp. A, anterior end, lateral view; B, anterior end, ventral view; C, neuro- and notopodium capillary chaeta. Scale bars: A, B = 2 mm; C = 500 μ m.

Table 1. Comparison of the morphological characteristics in *Protocirrineris* species.

Species	Type locality	Body length, width (mm)	Prostomium	Peristomium	Origin of branchiae	Arrangement of tentacular filaments	MGSP	Reference
						Number of tentacular filaments		
<i>P. angelicollatio</i> Elias & Rivero, 2009	Argentina	18.0, 0.46–1.08	Rounded, short, with nuchal, without eyes	2–3 annuli, 3–5 subannuli, dorsal crest	Chaetiger 6–8	Chaetiger 3–8 2–3	No distinctive staining pattern	Elías and Rivero, 2009; Magalhães <i>et al.</i> , 2013
<i>P. baiana</i> Elias, Saracho–Bottero & Magalhaes, 2019	Brazil	19.0–23.0, 0.1–0.25	Very short, conical, without nuchal, without eyespot	3 annuli, 3–4 subannuli,	Chaetiger 1	Chaetiger 3–4 5–6	Branchiae, tentacular filaments, ventrum stained intense blue; prostomium, peristomium stained pale blue	Elías <i>et al.</i> , 2019
<i>P. camamuensis</i> Elias, Saracho–Bottero & Magalhaes, 2019	Brazil	20.0, unknown	Short and wide, without nuchal, without eyespot	3 annuli, sub–equal, short	Chaetiger 1	Chaetiger 3–4 5–6	Entire body stained with uncolored patches	Elías <i>et al.</i> , 2019
<i>P. chrysotherma</i> (Claparède, 1868)	Italy	20.0–70.0, 0.5–3.0	Triangular, without eyes	Unknown	Chaetiger 4 (presence of subdistal pads on tips)	Chaetiger 4 2–3	Unknown	Fauvel, 1953; Imajima and Hartman, 1964; Lezzi <i>et al.</i> , 2016
<i>P. magalhaesi</i> Elias, Saracho–Bottero & Simon, 2019	South Africa	12.0–14.0, 0.5–0.7	Very short, with nuchal	Single annuli	Chaetiger 2–3	Chaetiger 4–9 2–3	No distinctive staining pattern	Elías <i>et al.</i> , 2019
<i>P. mascaratus</i> Magalhães & Bailey–Brock, 2013	Hawaii, USA	4.0–24.0, 0.4–1.0	Short, conical, with nuchal	3 annuli, sub–equal, dorsal crest	Chaetiger 3–4	Chaetiger 1–3 2	Distinctive staining pattern apparent on prostomium, peristomium and anterior end of the first chaetiger	Magalhães and Bailey–Brock, 2013

Table 1 (Continued).

Species	Type locality	Body length, width (mm)	Prostomium	Peristomium	Origin of branchiae	Arrangement of tentacular filaments	MGSP	Reference
						Number of tentacular filaments		
<i>P. nuchalis</i> (Ehlers, 1907)	New Zealand	40.0–42.0, 1.5–3.0	Conical, with nuchal	3 annuli, 3 subannuli, dorsal crest	Chaetiger 10	Chaetiger 6–18 2–4	No distinctive staining pattern	Magalhães and Bailey–Brock, 2013
<i>P. purgamentorum</i> Lezzi, Çinar & Giangrande, 2016	Italy	5.0–14.0, 0.3–1.0	Rounded, short, with nuchal	2 annuli, ventral borders feature a V-shaped groove	First present from anteriormost tentacle-bearing chaetiger	Chaetiger 3–8 2	No distinctive staining pattern	Lezzi <i>et al.</i> , 2016
<i>P. socialis</i> Blake, 1996	California, USA	8.0–40.0, 0.5–2.0	Broadly rounded anteriorly, without eyes	2 annuli, enlarge	Chaetiger 1–3	Chaetiger 5–9 3–4	No staining reaction	Blake, 1996
<i>P. strandloperarum</i> Elias, Saracho–Bottero & Simon, 2019	South Africa	7.0–55.0, 0.5–1.45	Short, conical, with nuchal	3 annuli, sub–equal	Chaetiger 7	Chaetiger 5–12 2–3	No distinctive staining pattern	Elias <i>et al.</i> , 2019
<i>P. tenuisetis</i> (Grube, 1860)	Croatia	40.0, 12.7	Blunt, cone, without eyes	Single annuli, bare	Unknown	Chaetiger 4–10 2–3	Unknown	Grube, 1860
<i>Protocirrineris</i> n. sp.	South Korea	20.0–70.0, 1.0–3.0	Short, bluntly conical, with nuchal, without eyes	Three same–sized annuli, ventral borders feature a V–shaped groove	Chaetiger 5	Chaetiger 4–9 2–5	Distinctive staining pattern apparent on anterior part of ventral chaetigers	Present study

materials: South Korea: 5 ind. (complete), U-ido-ri, Docho-myeon, Sinan-gun, Jeollanam-do (34°36'38.7"N 125°49'31.6"E), 31 May 2022, intertidal sandy-mud rock bottom.

Description. Holotype complete, 18 mm length, 1.2 mm width for about 75 chaetigers. Remaining paratypes 12 complete, one incomplete, 6–16 mm length, 0.5–1.0 mm width for about 40–65 chaetigers. Thoracic region not expanded, not composed crowded chaetigers (Fig. 6A). Body rounded dorsally and ventrally flattened grooves in cross section. Pygidium not tapered, terminal anus (Fig. 6B). After preservation in ethanol, body, tentacular filaments and branchiae exhibit same pale yellow color.

Prostomium short, anterior end rounded; three pairs of dark brown eyespot situated dorsolaterally to mouth; nuchal organs absent (Figs. 6C, 8A). Peristomium two anterior chaetigers in length, with two faint annulations visible both laterally and ventrally; smooth dorsally (Figs. 6C, 8A). Two groups of about 2–4 tentacular filaments arise between posterior end of peristomium and chaetiger 1 (Figs. 6C, 8A). First pair of branchiae emerges just posterior to peristomium on chaetiger 1; branchiae one pair per segment throughout body; branchiae abundant and thick in anterior region, gradually decreasing and thickness towards posterior; branchiae initially appear close to notopodial base and subsequently shift to middle dorsum from chaetigers 11–2 (Figs. 6C, 6D, 8A).

Notopodium and neuropodium separated, arise close together on anterior lateral body, shifting ventrally in posterior segments. Abdominal segments less crowded, not moniliform. Anterior segments only capillaries present (Fig. 7C); middle segments alternated with acicular spines and capillaries; posterior segments only neuropodium has acicular spines (Fig. 7D). 5–6 capillaries per fascicle arranged in two rows in anterior region; decreasing in posterior region to 2–4 capillaries in single row. Notochaetae capillaries much longer, neurochaetae capillaries thicker with serrations in proximal region, serrations visible under light microscope (400x) (Figs. 7C, 7D, 7E). Noto- and neuropodial acicular spines number 2–3 spines per fascicle throughout. Notopodial spines present from chaetigers 30–34 (Fig. 7B); neuropodial spines present from chaetigers 11–14 (Fig. 7A). Noto- and neuropodial spines similar in shape and size, slightly

curved distally.

Methyl green staining pattern (MGSP). No distinctive staining pattern. Complete specimens stained light blue.

Habitat. This species was collected from muddy–rock bottom in the intertidal zone.

Distribution. South Korea (present study).

Remark. Among the *Cirratulus* species recorded since 1996, *C. knipovichana* Saracho–Bottero and Elías in Saracho–Bottero, Jaubet, Garaffo and Elías, 2019 is most similar to *Cirratulus* n. sp. in the general body morphology including the arrangement and number of tentacular filaments, position of the first pair of branchiae, and pygidium morphology (Blake, 1996; Taboada *et al.*, 2012; Saracho–Bottero *et al.*, 2017; Saracho–Bottero *et al.*, 2019). However, *C. knipovichana*, originally described from Argentina, differs from the new species in the number of eyespot (one pairs or none on each side *vs.* three in *Cirratulus* n. sp.), position of branchiae in the body (dorsally displaced from chaetigers 5–6 *vs.* from chaetigers 11–12 in *Cirratulus* n. sp.), and arrangement of the noto– and neuropodial spines (notopodial spines from chaetigers 1–7 and neuropodial spines from chaetiger 1 *vs.* notopodial spines from chaetigers 30–34 and neuropodial spines from chaetigers 11–14 in *Cirratulus* n. sp.) (Saracho–Bottero *et al.*, 2019). In Table 2, comparison of the morphological characteristics for known *Cirratulus* species is provided.

Genus *Timarete* Kinberg, 1866

Type Species: *Timarete fecunda* Kinberg, 1866 accepted as *Timarete anchylochaeta* (Schmarda, 1861)

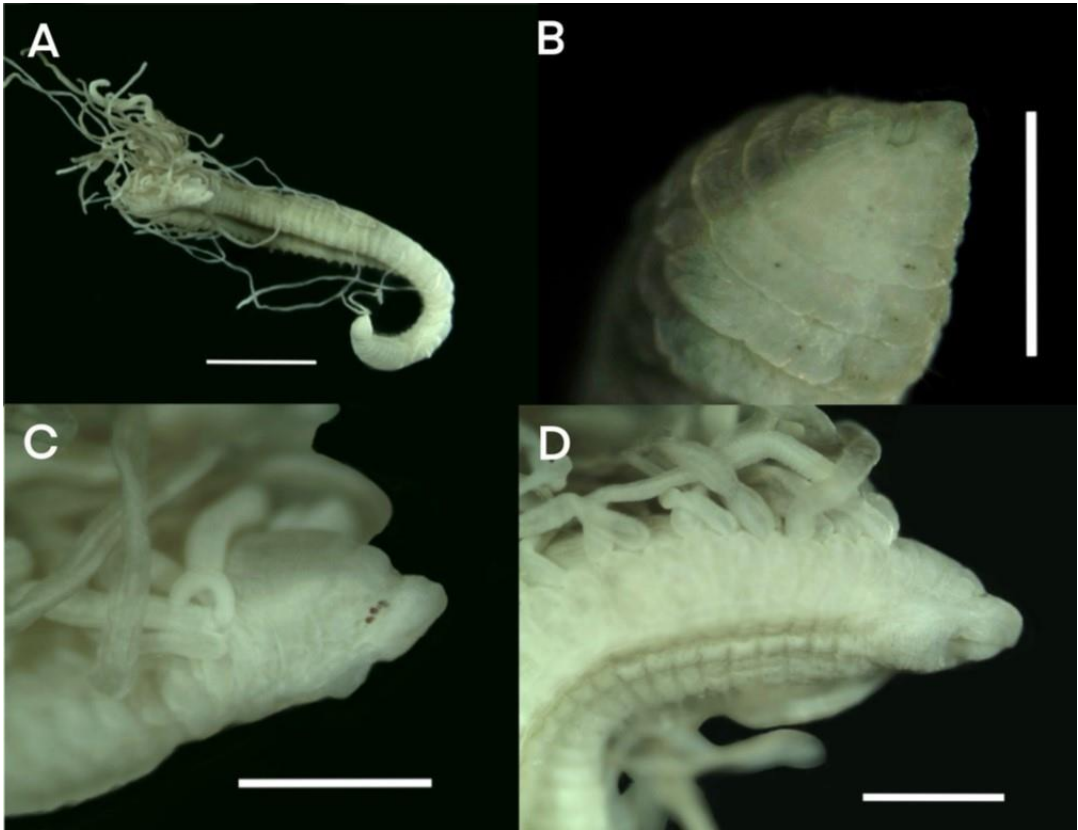


Fig. 6. Photographs of *Cirratulus* n. sp. A, Holotype, complete specimen; B, posterior end with pygidium; C, eyespot on the prostomium; D, anterior end, ventral view. Scale bars: A = 5mm, B–D = 1 mm.

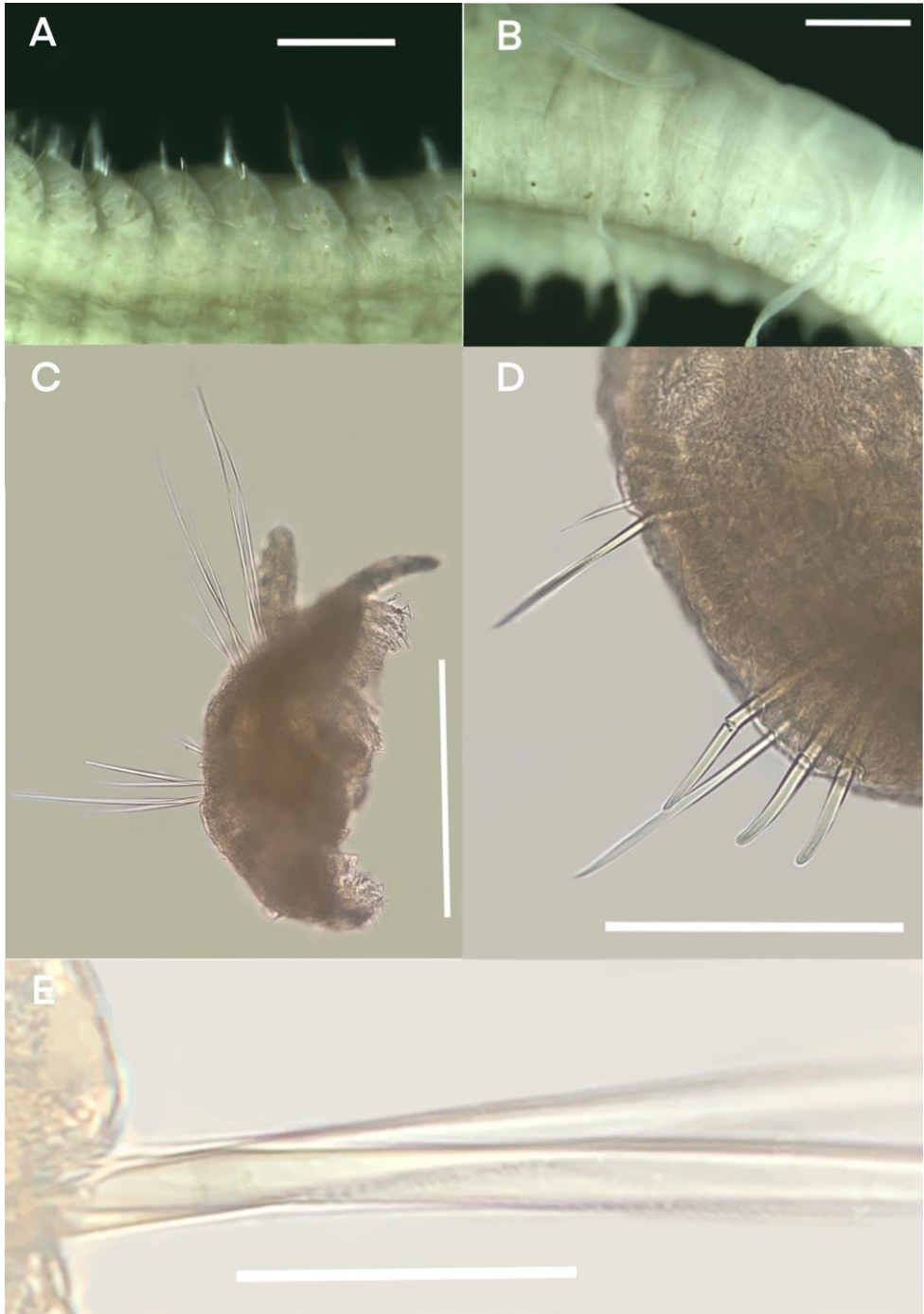


Fig. 7. Photographs of *Cirratulus* n. sp. A, neuropodial spines; B, notopodial spines; C, anterior noto- and neuropodium; D, posterior noto- and neuropodium; E, neurochaetae capillaries serrations in the proximal region. Scale bars: A, B = 0.5 mm; C = 250 μ m; D, E = 20 μ m.

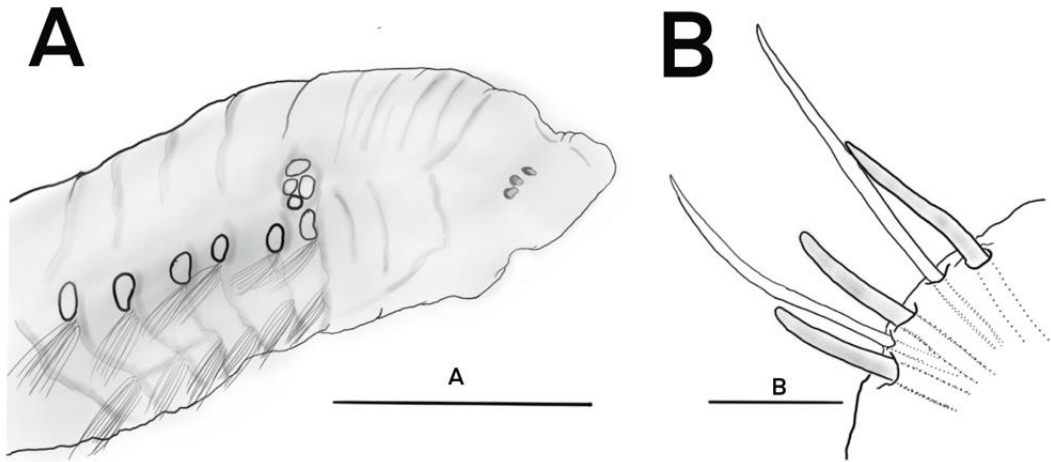


Fig. 8. *Cirratulus* n. sp. A, anterior end, lateral view; B, middle segments alternated with acicular spines and capillaries. Scale bars: A = 1 mm; B = 20 μ m.

Table 2. Comparison of the morphological characteristics in *Cirratulus* species.

Species	Type locality	Eye spot	Arrangement of tentacular filaments	Origin of branchiae	Capillaries remarks	Arrangement of notopodial spines	Pygidium	MGSP	Reference
			Number of tentacular filaments	Reposition of branchiae in body		Arrangement of neuropodial spines			
<i>C. alfonsinae</i> Saracho–Bottero & Elías in Saracho–Bottero, Jaubet, Garaffo & Elías, 2019	Argentina	Absent	Chaetiger 1	Peristomium and chaetiger 1	One edge with blade distinctly striated at base, and serrate edge	Chaetiger 12–16	Simple lobe with anus terminal	No distinctive staining pattern	Saracho–Bottero <i>et al.</i> , 2019
			2–3	Arising close to notopodium always		Chaetiger 7			
<i>C. balaenophilus</i> Taboada, Doner, Blake & Avila, 2012	Antarctica	Absent	Chaetiger 1	Chaetiger 1	Each podial lobe bearing long simple capillaries lacking serrations	Absent	Ventral, simple rounded lobe above terminal anus	Conspicuous ventral staining of chaetigers 10–20; remaining chaetigers of first half of body with thin band on posterior half of segment	Taboada <i>et al.</i> , 2012
			4	Close to notochaeta throughout.		Absent			
<i>C. cingulatus</i> Johnson, 1901	Washington, USA	5–6 pairs (faded)	Chaetiger 1 with wide dorsal gap	Chaetiger 1	Anterior chaetae capillaries; over following chaetigers, capillaries shorter and thicker	Chaetiger 40–42	Unknown	Unknown	Blake, 1996
			11–12	Shifting dorsally from chaetiger 20, one-quarter distance between notopodium and dorsal midline		Chaetiger 25			
<i>C. cirratus</i> (O. F. Müller, 1776)	Greenland	4–8 pairs	Chaetiger 1	Chaetiger 1	Dorsal longer than ventral	Chaetiger 20–23	Unknown	Unknown	Taboada <i>et al.</i> , 2012; Saracho–Bottero <i>et al.</i> , 2019
			2–24	Unknown		Chaetiger 10–12			

Table 2 (Continued).

Species	Type locality	Eye spot	Arrangement of tentacular filaments	Origin of branchiae	Capillaries remarks	Arrangement of notopodial spines	Pygidium	MGSP	Reference
			Number of tentacular filaments	Reposition of branchiae in body		Arrangement of neuropodial spines			
<i>C. concinnus</i> Ehlers, 1908	South Africa	Absent	Peristo- chaetiger 1 1–3	Chaetiger 1 Unknown	Long throughout	Absent Chaetiger 32	Unknown	Unknown	Taboada <i>et al.</i> , 2012; Saracho–Bottero <i>et al.</i> , 2019
<i>C. dillonensis</i> Blake, 1996	California, USA	5–6 pairs (clear)	Chaetiger 1 15–16	Chaetiger 1 Shifting dorsally by about chaetiger 9	Anterior neurochaetae basally thickend capillaries; notochaetae capillaries longer than neurochaetae; reduced in middle and posterior chaetigers	Chaetiger 12–13 Chaetiger 7–8	Anus terminal with ventral pygidial lobe	Transverse bands all along body; segments, tentacular filaments, branchiae, prostomium and peristomium covered with numerous speckles	Blake, 1996
<i>C. gilchristi</i> Day, 1961	South Africa	4 pairs	Chaetiger 1 3–5	Chaetiger 1 Middle of body branchiae arises as far above notochaetae as distance between noto- and neurochaetae	Unknown	Chaetiger 3–6 Chaetiger 3–6	Unknown	Unknown	Taboada <i>et al.</i> , 2012; Saracho–Bottero <i>et al.</i> , 2019
<i>C. jucundus</i> (Kinberg, 1866)	Chile	8 pairs	Chaetiger 1 8–10	Chaetiger 1 Arising close to notopodial base and quickly becoming more dorsal, but not reaching mid–dorsum	Serrate	Chaetiger 6–9 Chaetiger 1	Terminal anus	No distinctive staining pattern	Saracho–Bottero <i>et al.</i> , 2017; Saracho–Bottero <i>et al.</i> , 2019

Table 2 (Continued).

Species	Type locality	Eye spot	Arrangement of tentacular filaments	Origin of branchiae	Capillaries remarks	Arrangement of notopodial spines	Pygidium	MGSP	Reference
			Number of tentacular filaments	Reposition of branchiae in body		Arrangement of neuropodial spines			
<i>C. knipovichana</i> Saracho–Bottero & Elias in Saracho–Bottero, Jaubet, Garaffo & Elías, 2019	Argentina	1 pairs	Peristo–chaetiger 1	Posterior end of peristomium	One serrated edge	Chaetiger 1–7	Simple lobe with anus terminal	No distinctive staining pattern	Saracho–Bottero <i>et al.</i> , 2019
			2–4	Dorsally displaced from 5–6 chaetigers		Chaetiger 1			
<i>C. mianzanii</i> Saracho Bottero, Elias & Magalhães, 2017	Argentina	5–8 pairs	Peristo–chaetiger 1	Chaetiger 1	Basal blade distinctly striated, and a coarse serration	Chaetiger 21–24	Ventral lobe and anus subterminal	No distinctive staining pattern	Saracho–Bottero <i>et al.</i> , 2017; Saracho–Bottero <i>et al.</i> , 2019
			4–5	Dorsally displaced from 5–6 chaetigers		Chaetiger 9–10			
<i>C. multioculatus</i> (Hartman, 1961)	California, USA	2 pairs	Chaetiger 1	Chaetiger 1	Anterior noto– and neuropodia capillaries both basally thickened, tapering to fine tip, with fine fringe of fibrils along one edge	Chaetiger 15–17	Unknown	Prostomium and peristomium staining intensely (except posterior to mouth); stain laterally between each peristomial annulations; irregular band encircles each chaetiger	Blake, 1996
			2–3	Shifting more dorsally in middle body chaetigers, then closer to notopodia again in posterior chaetigers		Chaetiger 10–11			

Table 2 (Continued).

Species	Type locality	Eye spot	Arrangement of tentacular filaments	Origin of branchiae	Capillaries remarks	Arrangement of notopodial spines	Pygidium	MGSP	Reference
			Number of tentacular filaments	Reposition of branchiae in body		Arrangement of neuropodial spines			
<i>C. orensanzii</i> Saracho–Bottero & Elías in Saracho–Bottero, Jaubet, Garaffo & Elías, 2019	Argentina	5–8 pairs	Chaetiger 1 4–6	Chaetiger 1 Slightly more dorsal to on middle region of body	One edge with blade distinctly striated at base, and serrated edge	Chaetiger 10–13 Chaetiger 1	Simple lobe with anus terminal	No distinctive staining pattern	Saracho–Bottero <i>et al.</i> , 2019
<i>C. parafiliformis</i> Hartmann–Schröder & Rosenfeldt, 1989	Antarctica	Unknown	Peristo–chaetiger 1 5–6	Unknown	Unknown	Unknown	Unknown	Unknown	Taboada <i>et al.</i> , 2012
<i>C. patagonicus</i> (Kinberg, 1866)	Chile	6 pairs	Chaetiger 1 15–20	Chaetiger 1 Shifting to middorsum from chaetigers 2–4	Nothing remarkable	Chaetiger 10–12 Chaetiger 1	Terminal anus, lacking lobe	No distinctive staining pattern	Taboada <i>et al.</i> , 2012; Saracho–Bottero <i>et al.</i> , 2017; Saracho–Bottero <i>et al.</i> , 2019

Table 2 (Continued).

Species	Type locality	Eye spot	Arrangement of tentacular filaments	Origin of branchiae	Capillaries remarks	Arrangement of notopodial spines	Pygidium	MGSP	Reference
			Number of tentacular filaments	Reposition of branchiae in body		Arrangement of neuropodial spines			
<i>C. robustus</i> Johnson, 1901	California, USA	5–6 pairs	Chaetiger 1	Chaetiger 1 Shifting more dorsally from chaetiger 25, one–third distance between notopodium and dorsal midline	Anterior chaetae capillaries; over following chaetigers, capillaries shorter and thicker	Chaetiger 29–30	Ventral conical lobe	Body segments with light flecks dorsally, encircling segments with dark concentrations on postchaetal side of each parapodium, and with distinct band ventrally	Blake, 1996
			4–5			Chaetiger 16–17			
<i>C. serratus</i> Hartmann– Schröder, 1974	Namibia	3 pairs	Chaetiger 1	Unknown	Unknown	Chaetiger 1	Unknown	Unknown	Saracho– Bottero <i>et al.</i> , 2019
			5–6	Unknown		Unknown			
<i>C. spectabilis</i> (Kinberg, 1866)	Canada	3 pairs	Chaetiger 1	Chaetiger 1	Anterior neurochaetae capillaries of different lengths and widths, all with fine serrations along one edge; some capillaries shorter, broader, with serrations	Chaetiger 12–13	Terminating in bluntly rounded; divided into 2 large ventral and 3–4 smaller dorsal lobes encircling anal	Prostomium, peristomium and body segments with numerous large glands that stain	Blake, 1996
			5–6	Unknown		Chaetiger 7–10			
<i>Cirratulus</i> n. sp.	South Korea	3 pairs	Peristo– chaetiger 1	Peristo– chaetiger 1	Notochaetae capillaries longer than neurochaetae; neurochaetae capillaries thicker than notochaetae; neurochaetae capillaries with serrations in proximal region.	Chaetiger 30–34	Pygidium not tapered, terminal anus	No distinctive staining pattern	Present study
			2–4	Shifting dorsally by about chaetiger 11–12		Chaetiger 11–14			

Diagnosis. Prostomium wedge-shaped, rounded on anterior margin, with or without eyespot. Body nearly rounded in cross section, with distinct segments. Tentacular filaments grooved arranged in two groups from dorsum of two or more anterior chaetigers, posterior to chaetiger 1. Branchiae occurring singly or with several filaments per parapodium. Individual branchial filaments robust and originate more dorsally in middle body segments, with each sometimes forming dorsolateral bulge over notopodium. Chaetae include capillaries and acicular spines (after Blake, 1996; Blake and Dean, 2019).

3. *Timarete* n. sp.

(Figs. 9, 10, 11)

Material examined. Type locality: South Korea, Sinjeon-ri, Geumsan-myeon, Goheung-gun, Jeollanam-do (34°26'51"N, 127°6'40"E), 06 Sep 2021, intertidal sandy-mud bottom. **Holotype:** complete ind. **Paratypes:** 27 ind. (incomplete). **Non-type materials:** South Korea: 3 ind. (1 complete, 2 incomplete), Iwol-ri, Soan-myeon, Wando-gun, Jeollanam-do (34°11'47"N 126°38'45"E), 05 May 2021, intertidal sandy-mud bottom; 9 ind. (5 complete, 4 incomplete), Geumho-ri, Sani-myeon, Haenam-gun, Jeollanam-do (34°41'37"N 126°21'28"E), 06 Jul 2023, intertidal sandy-mud bottom.

Description. Holotype complete specimens, 10 cm length (6.5–12 cm paratypes) and 10 mm width (6–11 mm paratypes) for about 385 chaetigers. Body elongated, rounded dorsally, flattened ventrally, with crowded segments throughout; dorsal surface exhibits deep groove; ventral also groove, tapering towards posterior end. Pygidium has dorso-terminal anus opening (Fig. 9C). Body color in ethanol, ranges from pale tan to dark tan, with branchiae and tentacular filaments lighter than body.

Prostomium short, bluntly rounded; small nuchal organs located on posterior-lateral region; eyespot absent (Figs. 9A, 11A, 11B). Peristomium as long as 6–7 anterior chaetigers;

triannulations, including dorsal sub-annulations (Figs. 9A, 11A, 11B). Two oblique groups of about 30–32 tentacular filaments arise on chaetigers 6–8 or 8–10 (Figs. 9B, 11A, 11B). Branchiae first appeared from chaetiger 1, with one pair per segment, initially located just above notopodium, gradually shifted dorsally, starting around chaetiger 65–70, and moved towards about one-sixth distance from notopodium to dorsal midline (Figs. 11A, 11B).

Noto- and neuropodium widely separated throughout. Chaetae include capillaries with serrated edges, observed under light microscopy (400x), and acicular spines (Figs. 10A, 10B, 10C, 10D, 11C, 11D). Anterior chaetigers have two rows of 9–12 capillaries per fascicle, gradually decrease and absent posteriorly; neuropodial capillaries thicker than notopodial capillaries. Notopodial acicular spines present from chaetiger 90–95, with 5–6 spines per segment throughout (Fig. 10A). Neuropodial acicular spines present from chaetiger 60–65, with 3–4 spines per segment throughout (Fig. 10B). Shape of noto- and neuropodial acicular spines similar; weakly curved distally (Figs. 11C, 11D).

Methyl green staining pattern (MGSP). No distinctive staining pattern. Complete specimens stained light blue.

Habitat. This species was collected from sandy-mud in the intertidal zone.

Distribution. South Korea (present study).

Remark. Compared to related *Timarete* species, *Timarete* n. sp. exhibits the most similarity to *T. luxuriosa* (Moore, 1904) regarding general morphology including the shapes of prostomium and peristomium, origin of the branchiae, shape of the acicular spines, and pygidium morphology (Monro, 1930; Blake, 1996; Çinar, 2007; Çinar, 2009; Magalhães and Bailey-Brock, 2010; Díaz-Díaz *et al.*, 2014; Magalhães *et al.*, 2014; Choi *et al.*, 2018). However, *T. luxuriosa* differs in the arrangement of tentacular filaments from *Timarete* n. sp. (tentacles appear from chaetigers

5–6, while from chaetigers 6–8 or 8–10 in *Timarete* n. sp.), the number of tentacular filaments (12 or more tentacles each vs. 20–23 tentacles in *Timarete* n. sp.), position of the shifting of branchiae within the body (beginning around chaetiger 35, shifted dorsally toward pygidium, and finally positioned about two–thirds distance from notopodium to dorsal midline, whereas in *Timarete* n. sp. has gradually shift begins around chaetiger 65–70 and moves towards about one–sixth of the distance), and the arrangement of noto– and neuropodial spines (notopodial spines from chaetiger 50 and neuropodial spines from chaetiger 31 vs. notopodial spines from chaetiger 90–95 and neuropodial spines from chaetigers 60–65 in *Timarete* n. sp.) (Blake, 1996; Choi *et al.*, 2018). In Table 3, comparison of the morphological characteristics for known *Timarete* species is provided.

Genus *Cirriformia* Hartman, 1936

Type Species: *Terebella tentaculata* Montagu, 1808 accepted as *Cirriformia tentaculata* (Montagu, 1808)

Diagnosis. Prostomium elongate or blunt, typically lacking eyespot. Peristomium exhibits two to three annulations. Tentacular filaments grooved limited to one to three anterior segments, emerging between chaetigers 2–7. Branchiae occurring singly, usually first appearing from chaetiger 1, arising close to notopodia throughout without becoming dorsal in middle body segments and without forming dorsolateral branchial bulges. Parapodial rami well separated. Chaetae include capillaries and acicular spines (after Blake, 1996; Magalhães *et al.*, 2014).

4. *Cirriformia* n. sp.

(Figs. 12, 13)

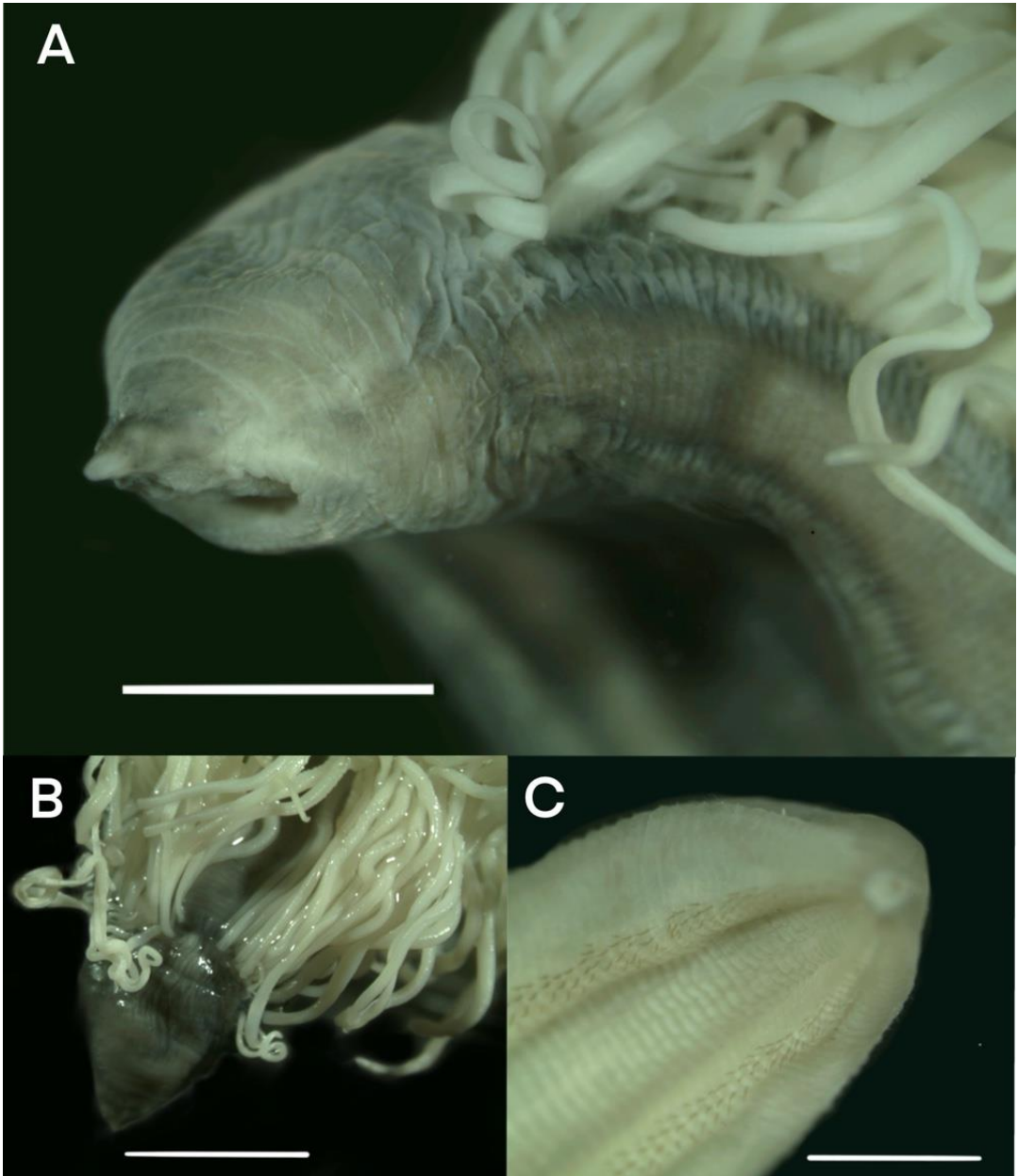


Fig. 9. Photographs of *Timarete* n. sp. A, anterior end, dorsolateral view; B, anterior end in dorsal view showing insertion of tentacular filaments; C, posterior end with pygidium. Scale bars: A–C = 3 mm

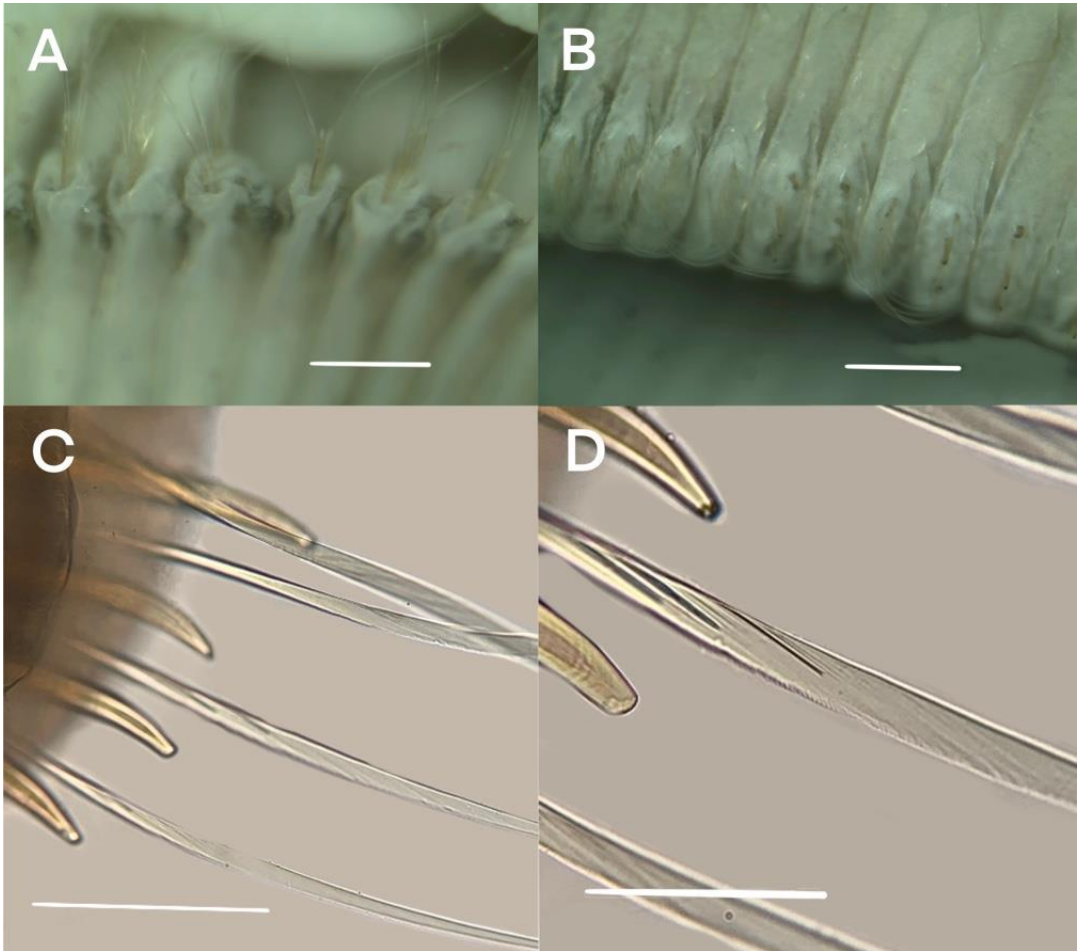


Fig. 10. Photographs of *Timarete* n. sp. A, boundary point at acicular spine begins in notopodium; B, boundary point at acicular spine begins in neuropodium; C, chaetae include capillaries with serrated edges and acicular spines; D, closed to capillaries with serrated edges. Scale bars: A, B = 0.5 mm; C = 20 μ m; D = 40 μ m.

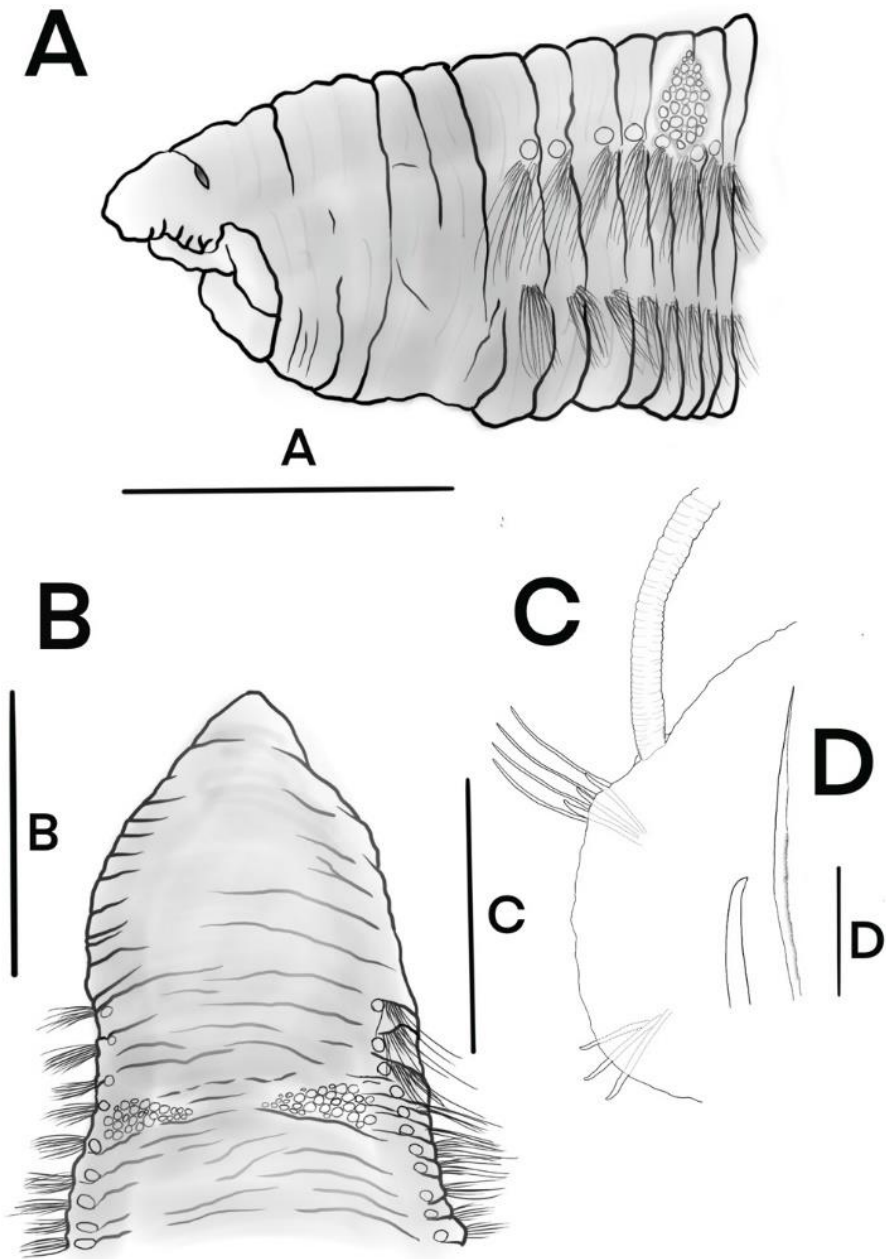


Fig. 11. *Timarete* n. sp. A, anterior end, lateral view; B, anterior end, dorsal view; C, notoneuropodium; D, acicular spines and capillaries with serrated edges. Scale bars: A, B = 3 mm, C = 1.5 mm, D = 20 μ m.

Table 3. Comparison of the morphological characteristics in *Timarete* species.

Species	Type locality	Nuchal organs	Arrangement of tentacular filaments	Origin of branchiae	Origin on notopodial spines	Shape of acicular spines	Pygidium	MGSP	Reference
			Number of tentacular filaments	Reposition of branchiae in body	Origin on neuropodial spines				
<i>T. antarcticus</i> (Monro, 1930)	South Georgia	Unknown	Chaetiger 3–5 6–8	Chaetiger 3 Unknown	Unknown	Unknown	Conical and anus pointing upwards	Unknown	Monro, 1930
<i>T. caribous</i> (Grube & Ørsted in Grube, 1859)	West Indies	Present	Chaetiger 3–4, 4–5 or 5–7 10–16	Peristomium Abrupt; 10–26; forming lateral bulge over notopodia	Chaetiger 15–44 Chaetiger 8–24	Thick, curved, solitary and darker	Small ventral lobe; dorso-terminal anal aperture	No distinctive staining pattern	Çinar, 2009; Díaz-Díaz <i>et al.</i> , 2014; Magalhães <i>et al.</i> , 2014
<i>T. ceciliae</i> Magalhães, Seixas, Paiva & Elias, 2014	Brazil	Present	Chaetiger 2–3, 2–4 or 4–5 5–6	Peristomium Gradual; 8–14; not forming lateral bulge	Chaetiger 11–23 Chaetiger 5–12	Neuropodial spines slightly longer and thicker than notopodial spines	Anus terminal or dorso-terminal with small ventral lip	Dense green speckles present on individual body segments forming complete rings. Branchial filaments also stained with green speckles.	Magalhães <i>et al.</i> , 2014
<i>T. dasylophius</i> (Marenzeller, 1879)	Sri Lanka	Unknown	Chaetiger 3–4 24	Unknown	Chaetiger 43 Chaetiger 29	Unknown	Unknown	Unknown	Imajima and Hartman, 1964
<i>T. filigera</i> (Delle Chiaje, 1828)	Tunisia	Absent	Chaetiger 2–5 15–20	Peristomium Abrupt; 15–20; forming bulge over notopodia	Chaetiger 27–31 Chaetiger 15–21	Neuropodial spines darker and thicker than notopodial spines; curved	Small ventral lip and dorsal anal aperture	Unknown	Magalhães <i>et al.</i> , 2014
<i>T. gibbosa</i> (Moore, 1903)	Japan	Unknown	Chaetiger 2 4	Chaetiger 1 Unknown	Chaetiger 13–14 Chaetiger 1	Unknown	Unknown	Unknown	Moore, 1903; Imajima and Hartman, 1964

Table 3 (Continue).

Species	Type locality	Nuchal organs	Arrangement of tentacular filaments	Origin of branchiae	Origin on notopodial spines	Shape of acicular spines	Pygidium	MGSP	Reference
			Number of tentacular filaments	Reposition of branchiae in body	Origin on neuropodial spines				
<i>T. hawaiiensis</i> (Hartman, 1956)	Hawaii, USA	Present	Chaetiger 3–4 7–9	Peristomium Abrupt; 10–18; forming a bulge over notopodia	Chaetiger 21–78 Chaetiger 8–19	Neuropodial spines curved and more robust than notopodial spines	Terminal anus	First peristomial annulation stained intensely	Magalhães and Bailey–Brock, 2010; Magalhães <i>et al.</i> , 2014
<i>T. luxuriosa</i> (Moore, 1904)	California, USA	Unknown	Chaetiger 5–6 12 or more	Chaetiger 1 Gradual; about chaetiger 35	Chaetiger 50 Chaetiger 31	Dark brown, neuropodial ones thicker than notopodial ones	Anal opening terminal	Unknown	Blake, 1996; Magalhães <i>et al.</i> , 2014
<i>T. oculata</i> (Treadwell, 1932)	Brazil	Present	Chaetiger 4–5 or 6–7 15–20	Peristomium Gradual; 20–25; not forming bulge over notopodia	Chaetiger 57–58 Chaetiger 38–40	Neuropodial spines darker and thicker than notopodial spines and slightly curved	Terminal anus	Prostomium and peristomium, parapodial regions staining with dark green except for notopodial and neuropodial ridges	Magalhães <i>et al.</i> , 2014
<i>T. perbranchiata</i> (Chamberlin, 1918)	California, USA	Unknown	Chaetiger 5–7 40	Chaetiger 1 Gradual; 11–12; not forming a bulge over notopodia	Chaetiger 31–35 Chaetiger 17–20	large, heavy, curved black spines	Flattened lobe below terminal anus	Unknown	Blake, 1996; Magalhães <i>et al.</i> , 2014
<i>T. posteria</i> Choi, Kim & Yoon, 2018	South Korea	Present	Chaetiger 5–6, 6–7 or 7–8 18–21	Chaetiger 1 shifting gradually to mid–dorsum forming lateral bulge over notopodia from chaetiger 43 to near posterior end	Chaetiger 40 Chaetiger 30	Curved distally, neuropodial spine slightly thicker than notopodial spine	Terminal anus	Body stained with transverse bands on posterior half of each segment forming complete rings. Prostomium, peristomium, and dorsum of first 3–4 chaetigers intensely stained with dark green	Choi <i>et al.</i> , 2018

Table 3 (Continue).

Species	Type locality	Nuchal organs	Arrangement of tentacular filaments	Origin of branchiae	Origin on notopodial spines	Shape of acicular spines	Pygidium	MGSP	Reference
			Number of tentacular filaments	Reposition of branchiae in body	Origin on neuropodial spines				
<i>T. punctata</i> (Grube, 1859)	West Indies	Present	Chaetiger 3–4 or 4–5	Peristomium or chaetiger 1	Chaetiger 8 or 9–25	Short, slightly curved distally	Ventral lip and dorsal anal aperture	No distinctive staining pattern	Çinar, 2007; Magalhães <i>et al.</i> , 2014
			10–14	Gradual; 7–18 or 10–26; forming or not a bulge over notopodia	Chaetiger 6 or 6–17				
<i>Timarete</i> n. sp.	South Korea	Present		Chaetiger 1		Weakly curved distally, neuropodial spine and notopodial spine same shape	Dorso–terminal anus opening	No distinctive staining pattern	Present study
			Chaetiger 6–8 or 8–10	Gradually shift dorsally, starting around chaetiger 65–70, and move towards about one–sixth of distance from notopodium to dorsal midline	Chaetiger 90–95				
			30–32		Chaetiger 60–65				

Material examined. Type locality: South Korea, Munhang-ri, Seolcheon-myeon, Namhae-gun, Gyeongsangnam-do (34°54'37"N, 127°55'31"E), 04 Aug 2023, intertidal sandy-mud bottom.

Holotype: complete ind. **Paratypes:** 10 ind. (complete); 1 ind. (incomplete). **Non-type materials:** South Korea: 28 ind. (19 complete, 9 incomplete), Eocheongdo-ri, Okdo-myeon, Gunsan-si, Jeollabuk-do (36°07'12"N 125°58'55"E), 25 Jul 2021, intertidal sandy-mud.

Description. Holotype Complete specimens 50mm length, 3.5 mm width for about 250 chaetigers. Remaining paratypes 25–75 mm length, 2–6 mm width for about 200–340 chaetigers. Body elongated, ventral surface exhibits deep groove; anterior crowded segments with parapodia form lateral shoulders from thoracic region to middle segments; rounded dorsally and flattened ventrally in cross section. Pygidium tapers posteriorly; anus placed dorso-terminally (Fig. 12B). Color in ethanol, body pale yellow to tan, tentacular filaments and branchiae appear more pale.

Prostomium bluntly pointed, features faint postero-lateral nuchal organs; eyespot absent (Figs. 12A, 13A, 13B). Peristomium as long as two anterior chaetigers and exhibits three similar-sized annulations (Figs. 12A, 13A, 13B). Tentacular filaments formed by two groups dorsally located on each side of chaetigers 6–7, each with 10–12 tentacles in most specimens (Fig. 2B). Branchiae first appear between posterior end of notopodial chaetiger 1, with one pair per segment, most present in first one-third of body, and few present in posterior chaetigers. (Figs. 13A, 13B).

Notopodium and neuropodium well separated. In a segment with lateral shoulders, notopodia positioned dorsally and towards lateral side from end of lateral shoulder; neuropodia ventrally located throughout. Anterior chaetigers have two rows of capillary chaetae per fascicle gradually decrease and absent posteriorly (Fig. 13D). 3–5 curved notopodial acicular spines from chaetigers 100 throughout; 5–6 curved neuropodial acicular spines from chaetigers 40 throughout; spines slightly curved, neuropodial spines larger and thicker than notopodial spines.

Methyl green staining pattern (MGSP). Clear methyl green staining pattern observed on peristomium, with intense pigmentation and speckles along dorsal and lateral regions, extending

to anterior segments before dorsal tentacles (Fig. 12C). Subsequently, staining continues towards posterior end on each parapodium. In mid–body regions, stain forms transversal bands ventrally around individual parapodium segments, conspicuous up to mid–segment, but becoming fainter thereafter (Fig. 13D). Prostomium, inter–segmental areas, tentacular filaments, and branchiae show no staining pattern.

Habitat. This species was collected from sandy–mud in the intertidal zone.

Distribution. South Korea (present study).

Remark. *Cirriformia* n. sp. exhibits a distinctive methyl green staining pattern (MGSP) that distinguishes it from six species recently described on staining patterns. Among these species, *Cirriformia* n. sp. is most similar to *C. capixabensis* Magalhães, Seixas, Paiva and Elias, 2014 in the origin of the tentacular filaments with branchiae, segmental origin on the neuropodial spines, and pygidium morphology (Fauvel, 1953; Blake, 1996; Magalhães and Bailey–Brock, 2010; Magalhães *et al.*, 2014). However, *C. capixabensis* differs from the new species in the number of tentacular filaments (20–25 tentacles each *vs.* 10–12 in *Cirriformia* n. sp.), and arrangement of notopodial spines (from chaetigers 45–55 *vs.* from chaetiger 100 in *Cirriformia* n. sp.). Both species have the common MGSP of the intense staining on peristomium dorsally and laterally and staining forming transversal bands around individual segments on the ventral region of mid–body segments. But they differ from each other in that *C. capixabensis* has a distinct staining reaction on the prostomium (Magalhães *et al.*, 2014). In Table 4, comparison of the morphological characteristics for known *Cirriformia* species is provided.

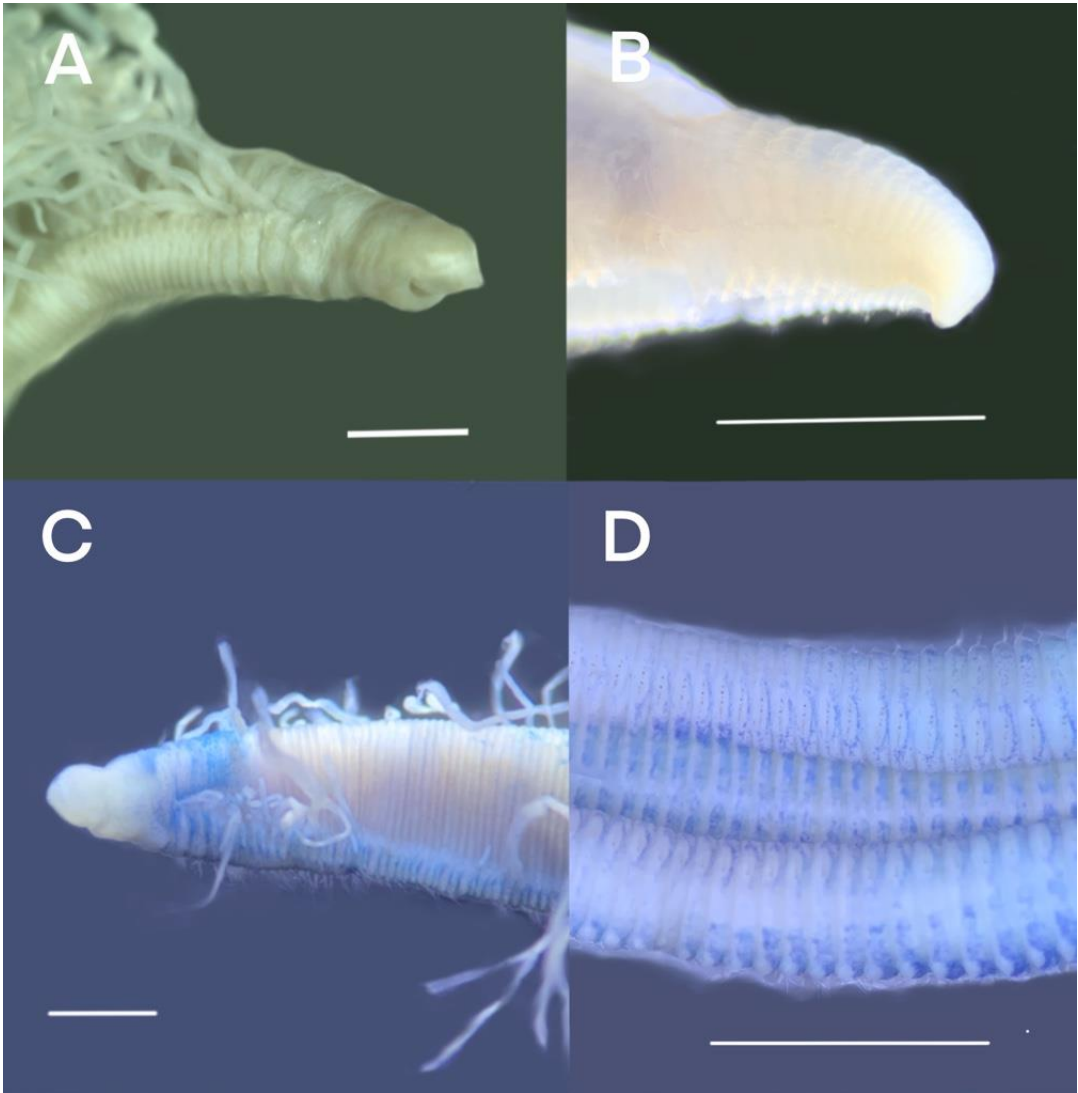


Fig. 12. Photographs of *Cirriformia* n. sp. A, anterior end, lateral view; B, posterior end with pygidium; C, methyl green staining pattern observed on the peristomium; D, stain forms transversal bands around individual parapodial segments. Scale bars: A–C = 1 mm; D = 3 mm.

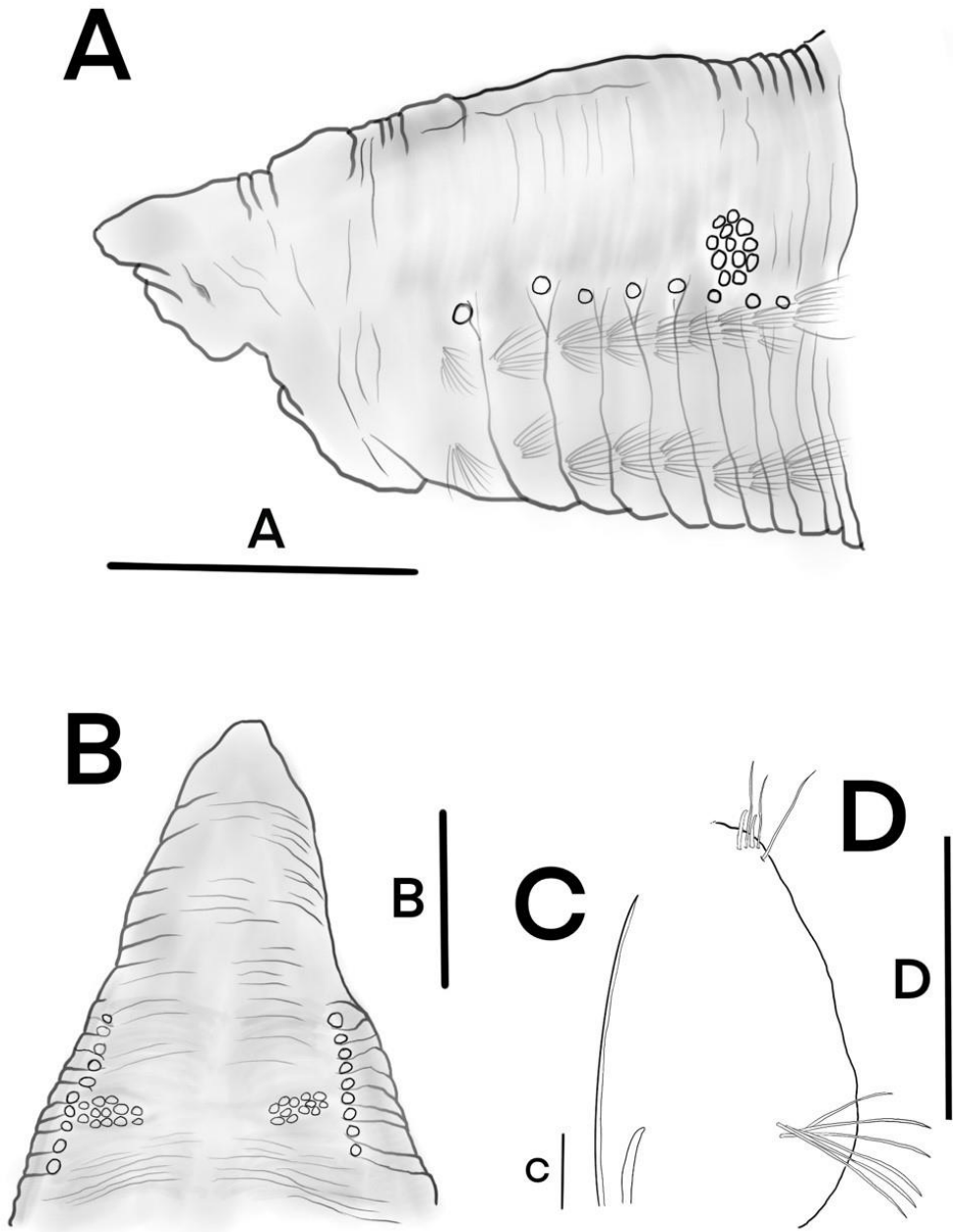


Fig. 13. *Cirriformia* n. sp. A, anterior end, lateral view; B, anterior end, dorsal view; C, capillary and acicular spines; D, noto- and neuropodium. Scale bars: A, B = 1 mm, C = 20 μ m, D = 0.75 mm.

Table 4. Comparison of the morphological characteristics in *Cirriformia* species.

Species	Type locality	Arrangement of tentacular filaments	Origin of branchiae	Origin on notopodial spines	Shape of acicular spines	Pygidium	MGSP	Reference
		Number of tentacular filaments		Origin on neuropodial spines				
<i>C. afer</i> (Ehlers, 1908)	Angola	Chaetiger 2 8–10	Chaetiger 1	Chaetiger 10–12 Chaetiger 10–12	Short, slender	Ventral lobe; dorsal anal, aperture	Homogeneous staining; branchiae and tentacular with darker stain	Magalhães <i>et al.</i> , 2014
<i>C. capixabensis</i> Magalhães, Seixas, Paiva & Elias, 2014	Brazil	Chaetiger 5–6 or 6–7 20–25	Chaetiger 1	Chaetiger 45–55 Chaetiger 34–40	Unknown	Ventral lobe; dorsoterminal anal aperture	Prostomium, peristomium staining dorsally and laterally. Segmental regions stained and forming complete rings	Magalhães <i>et al.</i> , 2014
<i>C. chicoi</i> Magalhães, Seixas, Paiva & Elias, 2014	Brazil	Chaetiger 3–4 or 4–5 18–20	Posterior end of peristomium	Chaetiger 31–42 Chaetiger 19–24	Knobbed-like spines	Small ventral lobe; terminal anal aperture	Mid-body region and posterior end stained with transversal bands on posterior half of segments forming complete rings	Magalhães <i>et al.</i> , 2014
<i>C. crassicollis</i> (Kinberg, 1866)	Hawaii	Chaetiger 4–5 8–12	Chaetiger 1	Chaetiger 8–34 Unknown	Slightly curved on anterior end	Simple ventral lip with terminal anus	Intensely stained; dorsal junction with peristomium, Second peristomial annulation and anterior chaetigers before dorsal tentacles, Mid-segmental areas	Magalhães <i>et al.</i> , 2010
<i>C. filigera</i> (Delle Chiaje, 1828)	Tunisia	Chaetiger 3–4 15–20	Chaetiger Peristomium	Chaetiger 27–31 Chaetiger 15–21	darker and thicker than notospines; curved	Small ventral lip and dorsal anal aperture	Unknown	Magalhães <i>et al.</i> , 2014
<i>C. grandis</i> (Verrill, 1873)	New England, USA	Chaetiger 1 10–12	Posterior end of peristomium	Chaetiger 35 Chaetiger 19	Unknown	Unknown	Unknown	Magalhães <i>et al.</i> , 2014

Table 4 (Continued).

Species	Type locality	Arrangement of tentacular filaments	Origin of branchiae	Origin on notopodial spines	Shape of acicular spines	Pygidium	MGSP	Reference
		Number of tentacular filaments		Origin on neuropodial spines				
<i>C. moorei</i> Blake 1996	California, USA	Chaetiger 6 20–30	Chaetiger 1	Chaetiger 100 Chaetiger 85	Unknown	Unknown	Dorsum anterior to tentacular cirri staining darkly; following segments staining lightly in narrow band across dorsum and around setal fascicles, and to lesser extent ventrally	Blake, 1996
<i>C. nasuta</i> (Ehlers, 1897)	Argentina	Chaetiger 4–5 15–20	Peristomium	Chaetiger 20–30 Chaetiger 14–16	Notopodial spines slender than neuropodial spines	Ventral lip and dorsal anal aperture	Unknown	Magalhães <i>et al.</i> , 2014
<i>C. semicineta</i> (Ehlers, 1905)	Hawaii	Chaetiger 3–4 Unknown	Chaetiger 1	Unknown	Unknown	Unknown	Unknown	Fauvel 1953
<i>C. spirabrancha</i> (Moore, 1904)	California, USA	Chaetiger 5 20–30	Chaetiger 1	Chaetiger 60–70 Chaetiger 40–45	Unknown	Unknown	Dorsum of peristomium, setigers anterior to tentacular cirri with lightly speckled pattern; anterior part of prostomium, ventrum of peristomium staining very darkly ending at border of chaetiger 1. Each Body segments with stained band encircling; Tentacular filaments, branchiae speckled	Blake, 1996
<i>C. tentaculate</i> (Montagu, 1808)	England	Chaetiger 5–6 or 6–7 Unknown	Chaetiger 1	Chaetiger 50 Chaetiger 25	Unknown	Unknown	Unknown	Magalhães <i>et al.</i> , 2014
<i>C. tortugaensis</i> (Augener, 1922)	Florida, USA	Chaetiger 6–8 or 4–5 Unknown	Chaetiger 2	Chaetiger 10 Chaetiger 2	Neuropodial spines thicker and shorter than notopodial spines	Posterior end tapers before pygidium; terminal anal aperture	No staining reaction	Magalhães <i>et al.</i> , 2014

Table 4 (Continued).

Species	Type locality	Arrangement of tentacular filaments	Origin of branchiae	Origin on notopodial spines	Shape of acicular spines	Pygidium	MGSP	Reference
		Number of tentacular filaments		Origin on neuropodial spines				
<i>C. websteri</i> (Verrill, 1900)	Bermuda	Chaetiger 4 3	Unknown	Unknown Chaetiger 8	Neuropodial spines curved and larger than notopodial spines	Unknown	Unknown	Magalhães <i>et al.</i> , 2014
<i>Cirriformia</i> n. sp.	South Korea	Chaetiger 6–7 10–12	Chaetiger 1	Chaetiger 100 Chaetiger 40	Slightly curved; neuropodial spines larger and thicker than notopodial spines	Tapers posteriorly; anus placed dorso-terminally	Distinct staining reaction occurs on peristomium, extended along dorsal and lateral areas, reaching anterior segments before dorsal tentacles. It continues onto parapodium, forming clear transversal bands around mid-body parapodial segments	Present study

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ABSTRACT

Taxonomic Study on the Multitentaculate Cirratulids (Polychaeta: Terebellida) from Korean Waters

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The family Cirratulidae Ryckholt 1851 is one of the largest and most common filter-feeding polychaete families found in marine benthic invertebrate communities. The Cirratulidae comprises 12 genera divided into two groups based on either having tentacular filaments or having paired dorsal tentacles. Multitentaculate cirratulids are categorized into five genera based on the relative segmental position of tentacular filaments and branchial filaments, number of branchiae per segment, and type of the chaetae. In Korean waters, five species of multitentaculate cirratulids belonging to four genera have been reported. But most taxonomic studies recorded these species focused on simple morphology only, so the validation of the species records need to examine more information of the species such as the fine structure of chaetae and phylogenetic relationship to related species. The taxonomic study was conducted on the cirratulid specimens collected at 12 localities of intertidal zone from May 2021 to August 2023 in Korea. As a result of the study, four cirratulid species new to science were identified: *Protocirrineris* n. sp., *Cirratulus* n. sp., *Timarete* n. sp., and *Cirriformia* n. sp. *Protocirrineris* n. sp. is distinctly characterized by the presence of capillaries only, absence of modified chaetae, and presence of tentacular filaments arranged in longitudinal rows across several anterior segments. It also

exhibits a highly distinctive methyl green staining pattern (MGSP) on the anterior ventral segments. These distinguishing characteristics set it apart from other recently recorded *Protocirrinieris* species. *Cirratulus* n. sp. is distinctly characterized by the tentacular filaments arise from chaetiger 1 and branchiae beginning on the same segment with tentacular filaments, presence of transverse rows of eyespot. It differs in the number of eye spots, position of branchiae in the body, and arrangement of noto- and neuropodial spines. These distinctive features set it apart from other recently recorded *Cirratulus* species. *Timarete* n. sp. is characterized by position of the shifting of branchiae within the body. It is distinguished from recently described species based on the arrangement and number of tentacular filaments, position of branchiae within the body, and arrangement of noto- and neuropodial spines. *Cirriformia* n. sp. is characterized by the branchiae inserted near all the notopodial base. It also displays a unique MGSP. It is distinguishes it from recently described species based on the number of tentacular filaments and arrangement of notopodial spines. In this thesis, detailed descriptions and illustrations of four new species are provided, with comparison of the species related.

Keywords: Taxonomy, Polychaeta, Cirratulidae, Multitentaculate, *Protocirrinieris*, *Cirratulus*, *Timarete*, *Cirriformia*, New species, Korea