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CEPHALOGULLMIA CAUDATA GEN. NOV., SP. NOV. (RHIZARIA, FORAMINIFERA), A MONOTHALAMOUS FORAMINIFERA FROM THE SEA OF JAPAN

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We describe a new species and genus of soft-walled monothalamous foraminifera from the Sea of Japan. The material was sampled off the Primorsky shelf during the 64th cruise of the RV "Akademik Oparin" (17 June to 08 July, 2021). Bottom sediments were sampled at 17 stations in a depth range of 0.3–86 m. The species described here was found at depths of 13 and 86 m. An elongated organic-walled test of *Cephalogullmia caudata* sp. nov. has an inflated anterior (apertural) part which gradually narrows towards the adapertural end. The length varies 600 to 1,180 μm; the width at the widest part (the 'head') is 50 to 135 μm, and at the narrowest part, it is 10 to 20 μm. A single apertural structure (10–28 μm in diameter) is located at the widest end of the test. The apertural structure is slightly elevated; in some specimens, it resembles a nipple. The nucleus is visible only in some specimens; its size is from 16 × 12 μm to 30 × 15 μm. The comparative analysis shows that the new genus *Cephalogullmia* differs from *Micrometula* Nyholm, 1952 in the shape of the test: it has more rounded and inflated apertural end, compared to that of the slender conical test of *Micrometula*. The new genus differs from *Cylindrogullmia* Nyholm, 1974 in the shape of the test as well: in the latter one, it is cylindrical. It also differs from another organic-walled monothalamid with the elongated test, *Bowseria* Sinniger et al., 2008, in having a darker protoplasm and a narrowed (tail-shaped) adapertural end.

Keywords: soft-walled foraminifera, Sea of Japan, *Cephalogullmia caudata* gen. nov., sp. nov., monothalamids

Soft-walled monothalamous foraminifera are an important component of meiofauna in many coastal and deepwater habitats [Gooday, 2002; Majewski et al., 2007; Sergeeva, Anikeeva, 2018, 2023], as well as in freshwater ones [Holzmann et al., 2021]. In recent years, scientific interest in this group has increased significantly [Anikeeva et al., 2013; Sergeeva et al., 2010]. Although molecular analysis is now available for many monothalamous foraminifera [Gooday et al., 2011, 2022; Lejzerowicz et al., 2015; Siemensma et al., 2021; Voltski, Pawłowski, 2015], some recent taxonomic descriptions still rely on morphological characteristics alone [Anikeeva et al., 2013; Golemansky, 1999; Gooday et al., 2006; Henderson, 2023; Ohkawara et al., 2009; Sergeeva, Anikeeva, 2008, 2020, 2021]. Here, we describe a new monothalamous taxon, an organic-walled 'allogromiid,' based on its morphological features.

Studies of meiobenthos in the Sea of Japan have been mainly focused on multicellular eukaryotes, especially the dominant group, free-living nematodes. Out of unicellular eukaryotes, only hard-shelled foraminifera have been considered as a component of meiobenthic communities [Preobrazhenskaya, Tarasova, 1990]. The results of detailed studies of the species diversity of hard-shelled foraminifera in the Sea of Japan are provided by T. Lukina and T. Tarasova [2013] in their check-list of free-living invertebrates in Far Eastern seas of Russia – a publication covering 217 foraminifera species. A representative of a genus of soft-walled foraminifera, *Allogromia* sp. (the family Allogromiidae), is reported

to be found in the Bering Sea and off the South Kuril Islands and northeastern Sakhalin Peninsula. This appears to be the only record of soft-walled foraminifera in the Northwestern Pacific reflecting the lack of information on these protists, their specific morphological characteristics, and the need to apply special methods to study them.

For the first time, soft-walled foraminifera were investigated in Far Eastern waters of Russia (the Sea of Japan) in summer 2021, during the research cruise of the RV "Akademik Oparin." In total, 49 species and morphotypes of monothalamids representing the families Allogromiidae and Saccamminidae were recorded in this area [Sergeeva, Anikeeva, 2023]. The fauna of monothalamids in the Sea of Japan included the one that we describe here as the type species of a new genus.

The aim of this paper is to provide a description of *Cephalogullmia caudata* gen. nov., sp. nov., an inhabitant of the Sea of Japan (the Northwestern Pacific).

MATERIAL AND METHODS

Material was sampled off the Primorsky shelf, the Sea of Japan, during the 64th cruise of the RV "Akademik Oparin" (17 June to 08 July, 2021). Bottom sediments were sampled at 17 stations in a depth range of 0.3 to 86 m. The species described was found at sta. 1 and 40 (depths of 13 and 86 m). At shallower stations, divers sampled sediment cores (two replicates), 5 cm long, with a cross-sectional area of 10 cm^2. At greater depths, similar cores were taken from sediment obtained with a Van Veen grab sampler. Samples of bottom sediments were fixed onboard the RV with 75% ethanol and later processed and analyzed in IBSS laboratory (Sevastopol, Russian Federation). Samples were washed through two sieves: an upper one with a mesh size of 1 mm and a lower one with a mesh size of 63 μm. For the second series of samples, we used a lower sieve with a mesh size of 32 μm.

Detailed microscopic analysis of soft-walled foraminifera was performed under MSP-2, Olympus CX41, Nikon, and Mikmed-6 microscopes equipped with photo cameras.

RESULTS

Taxonomy. According to traditional morphology-based classification systems [Kaminski, 2004; Loeblich, Tappan, 1988], the new single-chambered (monothalamous) taxa described here belong to the suborder Allogromiina (organic-walled). However, recent molecular phylogenetic studies, which revealed a series of monophyletic clades that cut across morphology-based taxa, have undermined the traditional higher-level classification of monothalamous organic-walled and agglutinated foraminifera [Habura et al., 2008; Pawlowski et al., 2003, 2013]. Therefore, we avoid formal higher taxa and place the new genera in the informal group of 'monothalamids' [Pawlowski et al., 2013].

Rhizaria Cavalier-Smith, 2002

Foraminifera d'Orbigny, 1826

'Monothalamids' Pawlowski et al., 2013

Genus *Cephalogullmia* Sergeeva et Anikeeva, gen. nov.

Type species *Cephalogullmia caudata* Sergeeva et Anikeeva, sp. nov.

Diagnosis of the genus. A monothalamous foraminifera having an elongated organic-walled test with an inflated anterior (apertural) part that gradually narrows towards the adapertural end (Fig. 1). The width at the inflated front part (the 'head') exceeds the width of the body by 5–6 times at the narrowest part. A single slightly elevated apertural structure is located at the widest end of the test. In some specimens, it resembles a nipple. The oval nucleus is localized in the widened part of the body before its tapering and is visible only in some specimens.

Derivation of the genus name. The name of the genus indicates its similarity to the genus *Nemogullmia* in terms of test length and the rounded apertural end resembling a head (in Latin, 'cephalo').

Remarks. Comparative analysis showed that the investigated specimens cannot be related to any of the known foraminifera genera. We made a comparative diagnosis of the new genus with three morphologically most similar genera of soft-walled foraminifera. The key difference between the new genus *Cephalogullmia* and *Micrometula* Nyholm, 1952 is in the shape of the test: there is the test with a more rounded and inflated apertural end than the slender conical test of *Micrometula*. The new genus differs from *Cylindrogullmia* Nyholm, 1974 by the presence of a sharply tapering 'tail' part, while the test of *Cylindrogullmia* specimens has approximately the same diameter throughout the body length. It also differs from another elongated organic-walled monothalamid, *Bowseria* Sinniger et al., 2008, in having a darker protoplasm and a narrowed (tail-shaped) adapertural end.

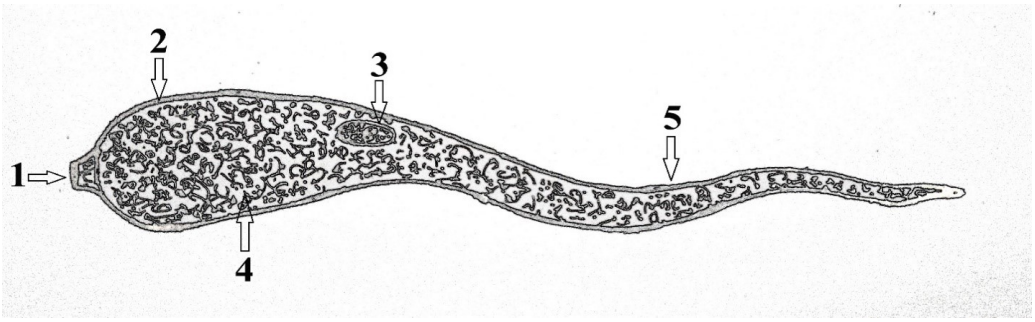

Fig. 1. Schematic image of *Cephalogullmia caudata*: 1, aperture; 2, organic test wall; 3, nucleus; 4, cytoplasm; 5, 'tail' part

Рис. 1. Схематическое изображение *Cephalogullmia caudata*: 1 — апертура; 2 — органическая стенка раковины; 3 — ядро; 4 — цитоплазма; 5 — «хвостовая» часть

Cephalogullmia caudata Sergeeva et Anikeeva, sp. nov. (Fig. 2).

Syn. Allogromiid sp. 9J [Sergeeva, Anikeeva, 2023, pp. 446–447, Fig. 9e, f].

Diagnosis of species. The elongated organic-walled test has an inflated anterior (apertural) part which gradually narrows towards the adapertural end. The body length varies from 600 to 1,180 μm; the width at the widest part (the 'head') is 50 to 135 μm, and at the narrowest part, it is 10 to 20 μm. A single apertural structure (10–28 μm in diameter) is located at the widest end of the test. The apertural structure is slightly elevated; in some specimens, it resembles a nipple. The nucleus is visible only in some specimens, and its size is from 16 × 12 μm to 30 × 15 μm. Coefficient C (length-to-width ratio) ranges 8.7 to 16.5 (based on the maximum width of the body).

Derivation of specific name. Latin 'caudata' = 'tail' refers to the shape of the main part of the body.

Type material. The type specimen (registration number Meib.93.Al.t) and two paratype specimens (registration numbers Meib.94.Al.p.1 and Meib.95.Al.p.2) are mounted in water–glycerol preparations and stored at IBSS. Previous experience has shown that similar organic-walled specimens are too delicate to be mounted in either Canada balsam or a gelatin–glycerol mixture.

Type locality. The type specimen and the paratype specimens (Figs 2–4) are from the Sea of Japan (43°42.7′N, 135°25.6′E; depth of 86 m). They were picked from samples taken during the research cruise of the RV "Akademik Oparin," 17 June to 08 July, 2021.

Other material. Three more specimens from the type locality (Fig. 5) were examined.

Description. The type specimen has an elongated shape (Fig. 2A). The test is organic, thin, and transparent. It gradually narrows from the apertural end to the adapertural one. The cytoplasm is homogeneous and fine-grained. The single aperture is located at the widest end of the test and is 16 μm in diameter (Fig. 2B). The test length is 1,070 μm, and the maximum width is 90 μm. The nucleus is ellipsoidal, oblong (Fig. 2C); it is located in the middle part of the cell, and it is 30 × 15 μm. Coefficient C is about 11.8 (based on the maximum width of the body).

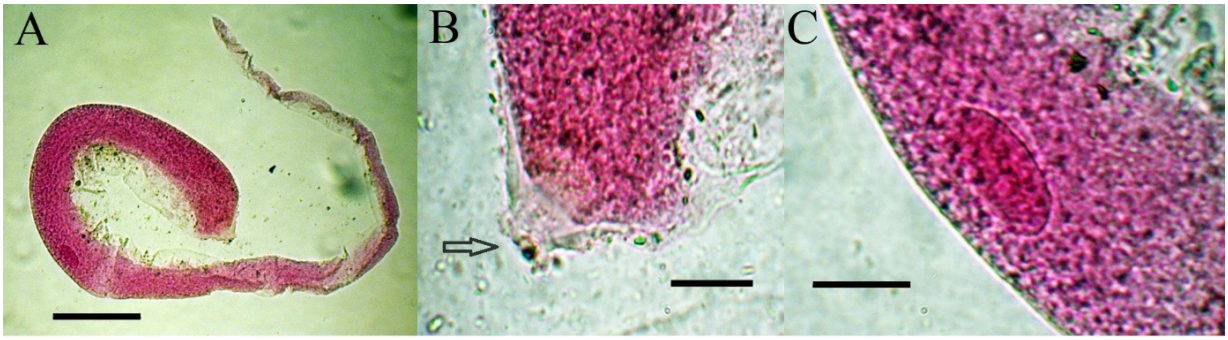

Fig. 2. The type specimen: A, general view; B, aperture; C, nucleus. Scale bars are 100 μm (A) and 20 μm (B, C)

Рис. 2. Типовой экземпляр: A — общий вид; B — апертура; C — ядро. Масштабные линейки: 100 мкм (A) и 20 мкм (B, C)

The paratype specimen 1 (Fig. 3A) is 1,150 μm in length and tapers from 110 μm in width at the widest point to 20 μm at the narrow adapertural end (Fig. 3B). The aperture has a diameter of 28 μm. Coefficient C is 10.4.

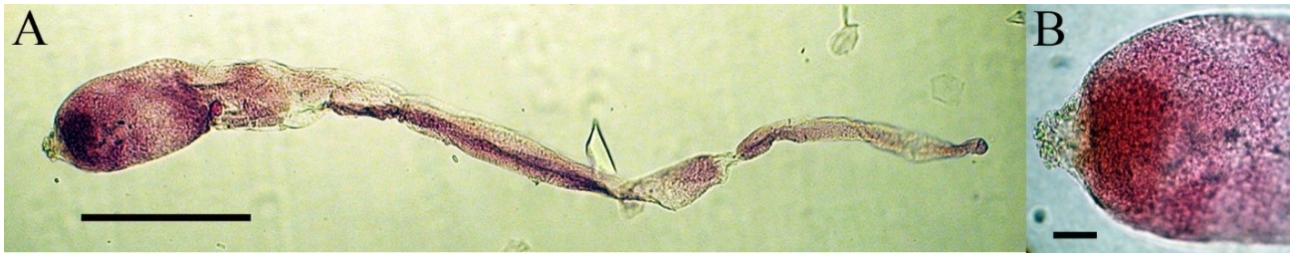

Fig. 3. The paratype specimen 1: A, general view; B, aperture. Scale bars are 200 μm (A) and 20 μm (B)

Рис. 3. Паратип 1: A — общий вид; B — апертура. Масштабные линейки: 200 мкм (A) и 20 мкм (B)

The paratype specimen 2 (Fig. 4A) is 1,180 μm in length and tapers from 135 μm in width at the widest point to 25 μm at the narrow adapertural end. The aperture (Fig. 4B) is located at the wider end of the body; however, its size cannot be measured, as it is not clearly visible. Coefficient C is 8.7. The nucleus is not clearly visible in either of the paratypes.

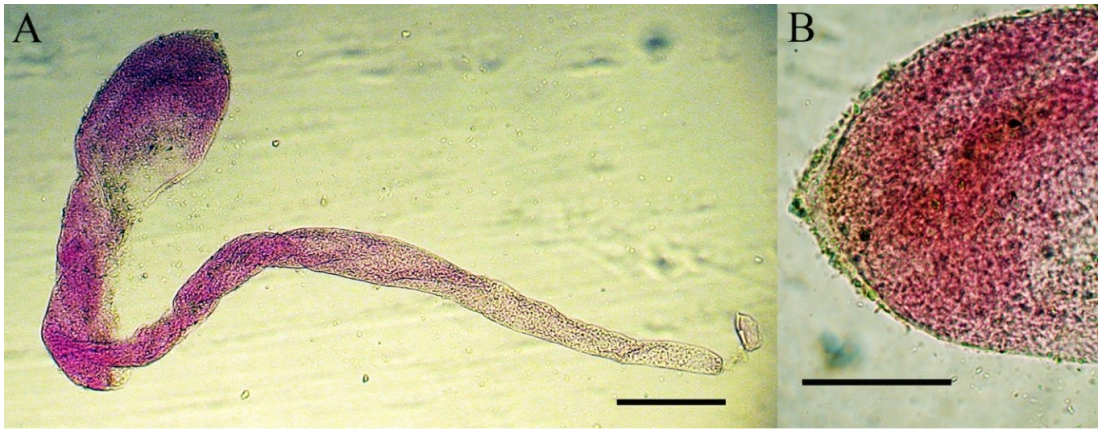

Fig. 4. The paratype specimen 2: A, general view; B, aperture. Scale bars are 100 μm (A) and 50 μm (B)

Рис. 4. Паратип 2: A — общий вид; B — апертура. Масштабные линейки: 100 мкм (A) и 50 мкм (B)

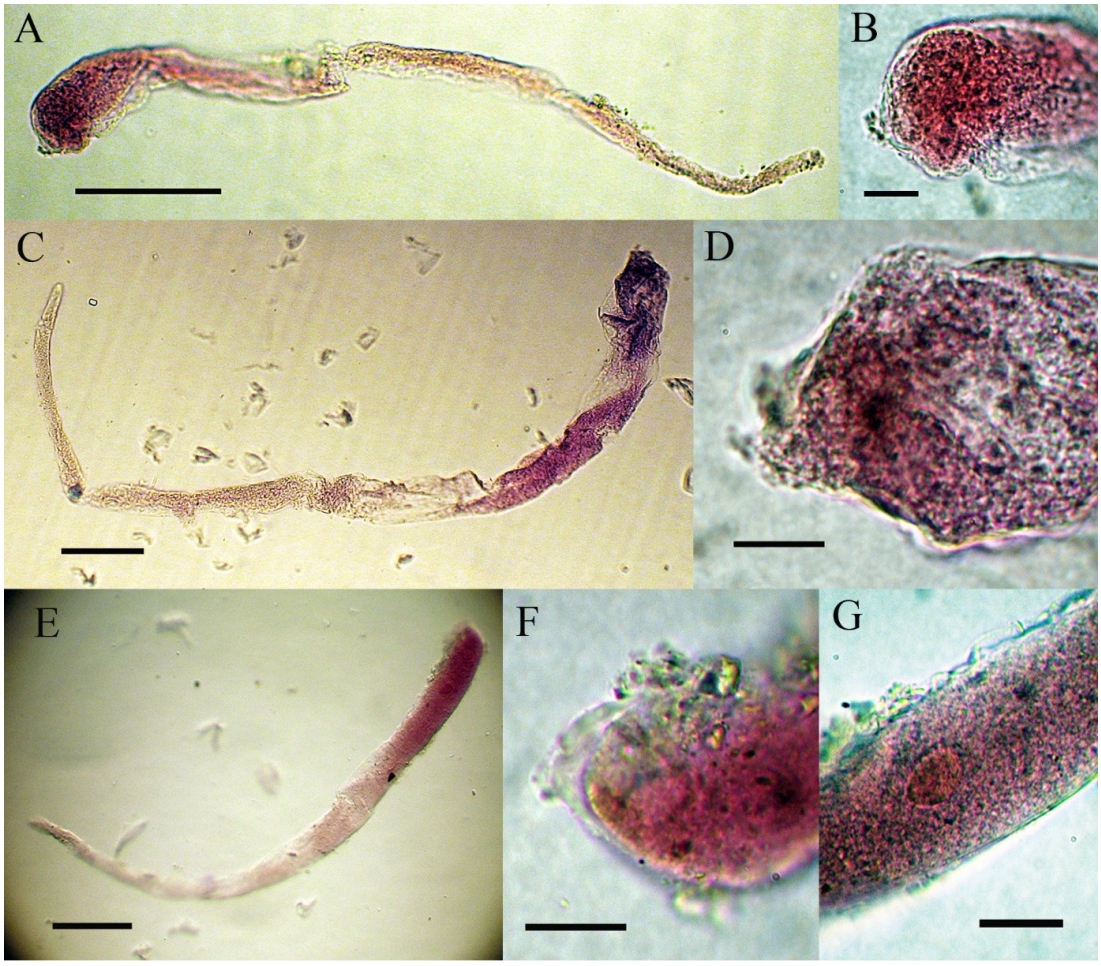

Fig. 5. Specimen 1J ('J' indicates the initial letter in the name of the Sea of Japan): A, general view; B, aperture. Specimen 2J: C, general view; D, aperture. Specimen 3J: E, general view; F, aperture; G, nucleus. Scale bars are 100 μm (A, C, E) and 20 μm (B, D, F, G). Specimens 1J and 2J are partially deformed

Рис. 5. Образец 1J (J обозначает начальную букву в названии Японского моря в английском переводе): A — общий вид; B — апертура. Образец 2J: C — общий вид; D — апертура. Образец 3J: E — общий вид; F — апертура; G — ядро. Масштабные линейки: 100 мкм (A, C, E) и 20 мкм (B, D, F, G). Образцы 1J и 2J частично деформированы

We examined in detail only 6 individuals (Table 1), because very delicate and fragile tests of other specimens were significantly deformed or damaged during the samples washing.

Table 1. Morphological parameters (in μm) of the type specimen, the two paratype specimens, and other examined specimens of *Cephalogullmia caudata* (–, not visible)

Таблица 1. Морфологические параметры (в мкм) типового экземпляра, двух паратипов и других исследованных образцов *Cephalogullmia caudata* (– — не визуализируется)

Specimen	Test length	Test width (maximum)	Diameter of aperture	Nucleus	Coefficient C
Type specimen	1,070	90	16	30 × 15	11.8
Paratype specimen 1	1,150	110	28	–	10.4
Paratype specimen 2	1,180	135	–	–	8.7
Specimen 1J	600	50	13	–	12
Specimen 2J	1,160	70	26	–	16.5
Specimen 3J	640	50	10	16 × 12	12.8

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CEPHALOGULLMIA CAUDATA GEN. NOV., SP. NOV. (RHIZARIA, FORAMINIFERA) — МОНОТАЛАМУСНАЯ ФОРАМИНИФЕРА ИЗ ЯПОНСКОГО МОРЯ

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Мы приводим описание нового вида и рода мягкораковинных моноталамусных фораминифер из Японского моря. Материал собран в районе приморского шельфа во время 64-го рейса НИС «Академик Опарин» (17 июня — 08 июля 2021 г.). Пробы донных осадков отобраны на 17 станциях в диапазоне глубин от 0,3 до 86 м. Описываемый здесь вид был найден на глубинах 13 и 86 м. Удлинённая органическая стенка раковины *Cephalogullmia caudata* sp. nov. имеет раздутую переднюю (апертурную) часть, которая постепенно сужается к дистальному концу. Длина тела варьирует от 600 до 1180 мкм; ширина в самой широкой части («голове») — от 50 до 135 мкм, в самой узкой части — от 10 до 20 мкм. Единственная апертурная структура (диаметр 10–28 мкм) расположена на самом широком конце раковины. Апертура слегка приподнята, у некоторых экземпляров напоминает сосок. Ядро видно только у некоторых экземпляров; его размеры составляют от 16 × 12 мкм до 30 × 15 мкм. Сравнительный анализ показал, что новый род *Cephalogullmia* отличается от *Micrometula* Nyholm, 1952 по форме раковины: она более округлая и раздутая в апертурной части, чем узкая раковина конической формы у *Micrometula*. От *Cylindrogullmia* Nyholm, 1974 новый род также отличается по форме раковины: у *Cylindrogullmia* она больше напоминает цилиндр. Описываемый нами род отличается и от другой моноталамиды с удлинённой раковиной и органическими стенками — *Bowseria* Sinniger et al., 2008 — более тёмной протоплазмой и суженным (хвостообразным) дистальным концом.

Ключевые слова: мягкораковинные фораминиферы, Японское море, *Cephalogullmia caudata* gen. nov., sp. nov., моноталамиды