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RESEARCH ARTICLE

New records of deep-water ascidians (Ascidiacea: Stolidobranchia) from the Arctic Ocean, with comments on nomenclature and taxonomy

Новые находки глубоководных асцидий (Ascidiacea: Stolidobranchia) из Северного Ледовитого океана с комментариями по номенклатуре и таксономии

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Abstract. Three species of stolidobranch ascidians, *Asajirus arcticus* (Hartmeyer, 1923), *Eugyrioides pedunculatus* (Traustedt, 1886), **comb. nov.**, and *Kukenthalia borealis* Hartmeyer, 1903 are recorded from the deep waters of the Arctic Ocean for the first time and are briefly described based on new material. The nomenclature of the involved ascidian taxa is discussed. It is shown that *Eugyra* Hancock, 1870 (Ascidiacea) is preoccupied by *Eugyra* Fromentel, 1857 (Anthozoa) and that the valid generic name for ascidians currently assigned to *Eugyra* is *Eugyrioides* Seeliger, 1907. The currently accepted subfamily name Polyzoinae Michaelsen, 1900 is invalid, as it is a junior synonym of Polystyelinae Herdman, 1886.

Резюме. Три вида асцидий отряда Stolidobranchia, *Asajirus arcticus* (Hartmeyer, 1923), *Eugyrioides pedunculatus* (Traustedt, 1886), **comb. nov.** и *Kukenthalia borealis* Hartmeyer, 1903, впервые отмечены на больших глубинах в Арктике. Приведены их краткие описания на основании нового материала. Обсуждается номенклатура связанных с этими видами таксонов. Показано, что родовое название *Eugyra* Hancock, 1870 (Ascidiacea) преокупировано названием *Eugyra* Fromentel, 1857 (Anthozoa). Валидным родовым названием для видов асцидий, относимых в настоящее время к роду *Eugyra*, является *Eugyrioides* Seeliger, 1907. Также показано, что принятое в настоящее время название подсемейства Polyzoinae Michaelsen, 1900 не валидно, так как является младшим синонимом Polystyelinae Herdman, 1886.

Key words: taxonomy, nomenclature, biodiversity, Arctic, abyssal, Ascidiacea, Polystyelidae, Polyzoinae, *Eugyra*, *Eugyrioides*, new combination

Ключевые слова: таксономия, номенклатура, биоразнообразие, Арктика, абиссаль, Ascidiacea, Polystyelidae, Polyzoinae, *Eugyra*, *Eugyrioides*, новая комбинация

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Introduction

Ascidians of the Arctic Ocean are primarily documented in earlier publications. The most significant of these are the monographs by Robert Hartmeyer, published in the early 20th century. The first of these works is a volume on ascidians in "Fauna Arctica" (Hartmeyer, 1903), in which he summarised all previously known information on Arctic ascidians and provided descriptions of each species. His second work, published in two volumes of "The Danish Ingolf—Expedition", included all ascidians known at that time (183 species) from the northern boreal and Arctic waters (Hartmeyer, 1923, 1924). Additional information on Arctic ascidians can be found in several other publications and guides (e.g., Van Name, 1945; Millar, 1966). Although Arctic ascidians are considered relatively well-studied (Trason, 1964), records from the deep-water regions of the Central Arctic Basin are scarce. This area remains one of the least explored parts of the Arctic Ocean due to its inaccessibility, primarily resulting from permanent ice cover. Sampling benthic fauna at depths exceeding 1,000 m beneath drifting ice presents significant technical challenges. These challenges include the need for heavy sampling equipment, dealing with constant ice drift, and enduring low temperatures. As a result, the material collected by Arctic expeditions is often fragmentary; however, each new expedition provides valuable data on the distribution and ecology of various species. In this paper, we report on the ascidians collected by the drifting polar station "North Pole 41", which operated from the ice-resistant, self-propelled platform "North Pole". This platform is a unique research vessel, equipped with the capabilities of a research centre, designed for year-round expeditions in the high latitudes of the Arctic Ocean.

Material and methods

The specimens reported in this study were collected during the drifting expedition "North Pole 41" (hereafter referred to as "NP41") from 2022 to 2024 (Fig. 1). Samples were collected using either a box corer with a sampling area of 50 × 50 cm or a small biological dredge. The entire volume of sediment from both the box corer and the dredge was washed with seawater through a nylon sieve with a mesh size of 0.5 mm. Most of the collected ascidians were fixed in formalin and subsequently transferred to 70% ethanol. Several specimens were initially preserved directly in 96% ethanol for future molecular studies. The specimens are deposited at the Kamchatka Branch of the Pacific Geographical Institute, Far Eastern Branch of the Russian Academy of Sciences, Petropavlovsk-Kamchatsky (KBPGI).

References to the articles of the International Code of Zoological Nomenclature (ICZN, 1999) are cited in the text as "Article ...".

Results

Class **Ascidiacea**

Order **Stolidobranchia**

Family **Styelidae** Herdman, 1882

Subfamily **Polystyelinae** Herdman, 1886

Validity of the subfamily names Polyzoinae and Polystyelinae. The subfamily name Polyzoinae is considered here invalid, while the valid name for this taxon is Polystyelinae.

The family Polystyelidae (as Polystyelidæ) was established by Herdman (1886: 323) for "a very interesting little group of Ascidians, the position of which is difficult to determine". Herdman (1886) provided a detailed discussion of this family and listed six colonial styelid genera, including *Polystyela* Giard, 1874. The family name was created correctly; it is based on the available generic name *Polystyela*, which Herdman (1886) treated as valid (Article 11.7.1.1).

The family Polyzoidae was established by Michaelsen (1900), contrary to the currently accepted attribution to Hartmeyer (1903) (e.g., see Kott, 1985). Michaelsen (1900, 1907) acknowledged the priority of the family name Polystyelidae Herdman, 1886. However, he argued that the genus *Polystyela*, on which Polystyelidae is based, is not well known. He preferred to create a new family name based on the oldest genus in this group, *Polyzoa* Lesson, 1831. Nevertheless, these arguments do not substantiate the erection of a new family name. The genus *Polystyela* is currently considered a junior synonym of the colonial styelid genus

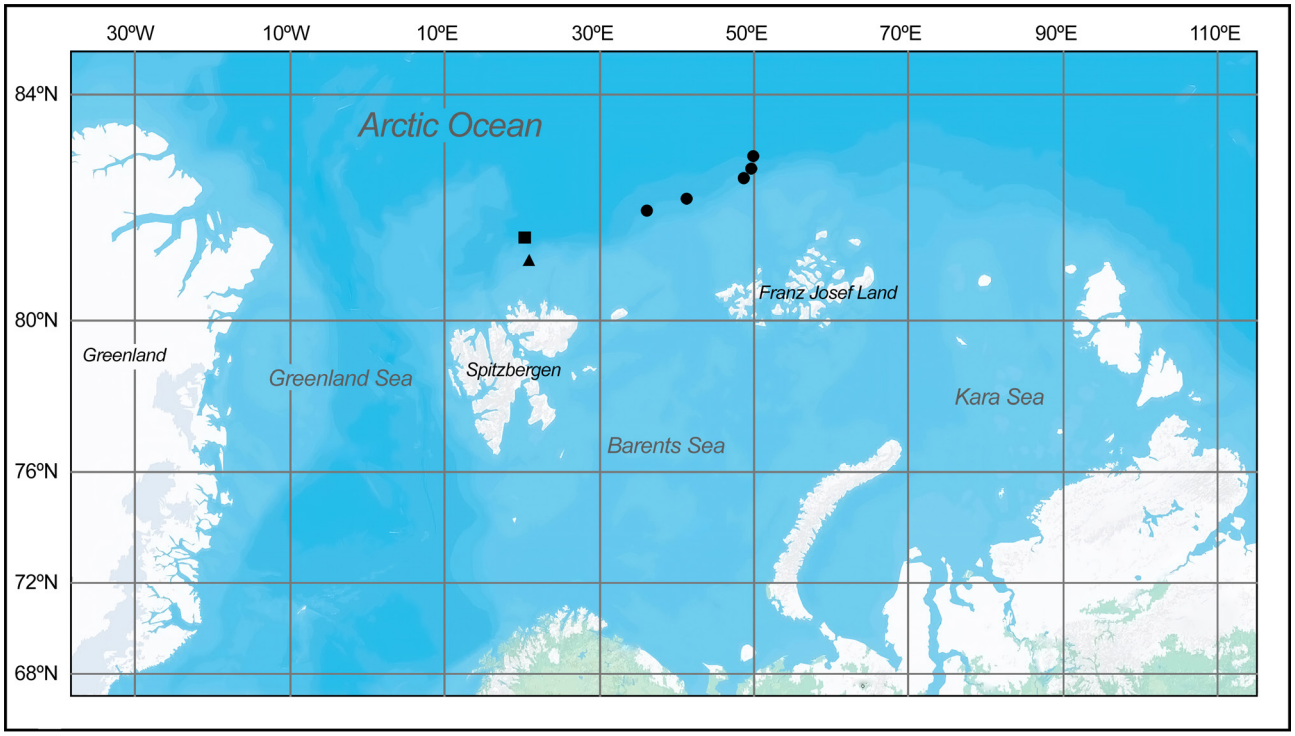

Fig. 1. Approximate locations of collected samples. Localities where *Eugyrioides pedunculatus* (Traustedt, 1886), **comb. nov.** were collected are designated by circles, *Asajirus arcticus* (Hartmeyer, 1923) by squares, and *Kukenthalia borealis* Hartmeyer, 1903 by triangle.

Distomus Gaertner, 1774 (see Harant & Vernières, 1933) and is classified within the same subfamily as *Polyzoa*. Therefore, Polystyelidae is a senior subjective synonym of Polyzoidae. Polyzoidae was downgraded in rank to the subfamily Polyzoinae by Hartmeyer (1903) and is currently recognised as a subfamily within the family Styelidae.

The name Polyzoinae cannot be preserved under Article 23.9.1 because Polystyelidae was used as valid since 1899 (e.g., by Van Name, 1902 and Oka, 1915) (Article 23.9.1.1). The only way to continue using Polyzoinae would be to refer the matter to the Commission (under Article 23.9.3) for a ruling under its plenary power. However, Polyzoinae has not been frequently used in recent literature, as most authors have not mentioned the subfamily name in their works. We believe that replacing it with its older synonym, Polystyelinae, will not threaten the stability of nomenclature. Furthermore, "stability by itself is not a scientific aim" (see section "Comments on the concept of 'stability'" in Dubois et al., 2021), and we contend that, in this case, an application to the Commission is unnecessary.

Genus ***Kukenthalia*** Hartmeyer, 1903

Kukenthalia borealis (Gottschaldt, 1894)
(Fig. 2A)

Goodsiria borealis Gottschaldt, 1894: 361.
Kukenthalia borealis: Hartmeyer, 1903: 335; Ärnbäck, 1921: 187; Van Name, 1945: 234; Lützen, 1959: 31; Millar, 1970: 120; Sanamyan, 2000: 75.
Diandrocarpa okai Redikorzev, 1916b: 31.
Symplegma okai: Redikorzev, 1941: 195.

Material examined. **Arctic Ocean**, north off Spitzbergen, station NP41-225B, 81°12.392′N, 20°54.373′E, 196 m, 2 Apr. 2024, 14 colonies.

Description (based on new material). Colonies 5–11 mm in greatest diameter and less than 6 mm in thickness. Some of them dome-shaped, with flattened base and convex upper portion, others with less regular shape. Test very soft, translucent, its surface smooth, without any attached matter except some sand particles in basal portion of one colony. Terminal ampullae of test vessels numerous in basal test, especially around area of attachment, but sparse in upper portion between zooids. Zooids in contracted state reaching

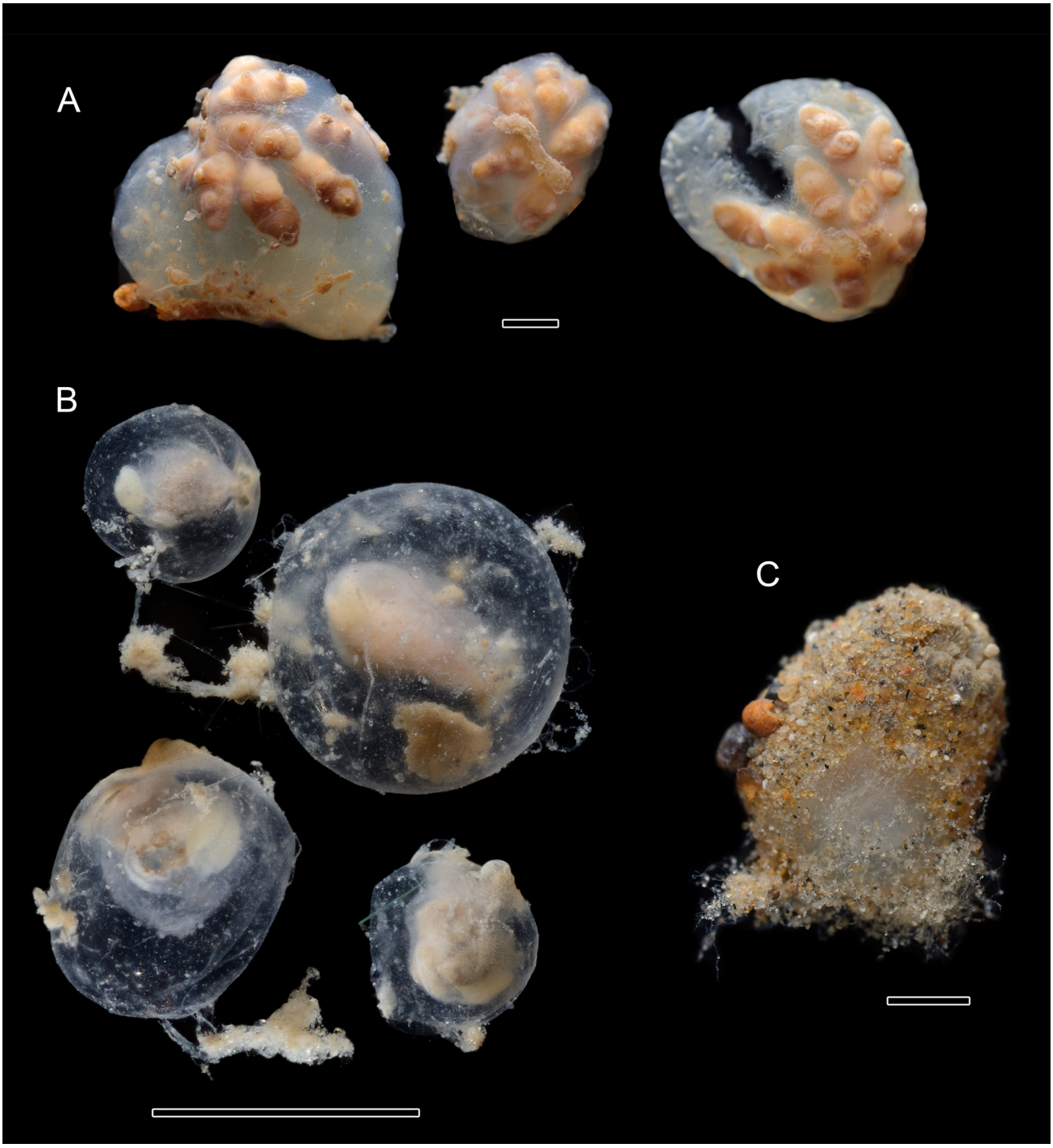

Fig. 2. General appearance of ascidians. **A**, *Kukenthalia borealis* Hartmeyer, 1903; **B**, *Eugyrioides pedunculatus* (Traustedt, 1886), **comb. nov.**; **C**, *Asajirus arcticus* (Hartmeyer, 1923). Scale bars: 2 mm.

up to 4 mm in greatest diameter, although many smaller. Zooids mostly located in upper portion of colony, in superficial layer of test, where they located without any apparent order. Branchial sac with four very high longitudinal vessels on each side. Numerous straight stigmata forming nine transverse rows crossed by parastigmatic vessels. Dorsal lamina smooth. Gut loop forming short, closed primary loop and deep open secondary loop. Stomach short, with nine or ten very prominent longitudinal folds. Gonads not developed in examined zooids.

Remarks. Although the examined specimens lack gonads (the key feature used for the taxonomic differentiation of Polystyelinae), all other characteristics—including the shape of the small gelatinous colonies, the number of internal longitudinal vessels in the branchial sac, and the shape of the gut loop—enable easy identification. *Kukenthalia borealis* is the only species of Polystyelinae known from Arctic waters. Originally described from Spitzbergen at depths of 20, 50, and 65 fathoms (36, 91, and 118 m) (Gottschaldt, 1894), it has since been recorded from numerous Arctic locations, including East Greenland, Iceland, the Faroe Islands, the northern coasts of Norway, and the Sea of Okhotsk. Most records are from depths between 100 and 500 m (Lützen, 1959), although it has occasionally been found at much greater depths, reaching up to 2,078 m (Millar, 1970), a record from the Labrador Sea.

Family **Molgulidae** Lacaze-Duthiers, 1879

Genus ***Eugyrioides*** Seeliger, 1907

Validity of the generic names *Eugyra* Hancock, 1870 and *Eugyrioides* Seeliger, 1907. *Eugyra* Hancock, 1870 is a preoccupied and invalid name; the valid name for this taxon is *Eugyrioides* Seeliger, 1907.

In the original description of *Eugyra*, Hancock (1870) indicated the authorship of *Eugyra* as "Alder & Hancock, MS". According to Article 50.1, the authorship of this genus should be attributed to Hancock (1870) rather than to "Alder & Hancock" as is currently accepted (e.g., see Kott, 1998).

The generic name *Eugyra* Hancock, 1870 (Ascidiacea) is preoccupied by *Eugyra* Fromentel, 1857 (Anthozoa). The latter name was established by Fromentel (1857) for two species of fossil corals. *Eugyra* Fromentel, 1857 does not qualify for the reversal of precedence under Article 23.9.1, as it is currently in use as a valid name for a genus containing at least two species of fossil corals (Baron-Szabo et al., 2003). Consequently, there is no way to retain the ascidian generic name *Eugyra*. The Principle of Priority requires that *Eugyra* Hancock, 1870 be replaced by the next oldest available name among its synonyms (Article 23.3.5). *Eugyra* Hancock, 1870 has two subjective synonyms: *Gamaster* Pizon, 1896 and *Eugyrioides* Seeliger, 1907. *Gamaster* takes precedence over *Eugyrioides*, and if we accept the synonymisation of *Eugyra*, *Gamaster*, and *Eugyrioides*, the valid name for the genus would be *Gamaster*. However, the synonymy of these genera is not universally accepted.

The type species of *Eugyra*, *Molgula arenosa* Alder et Hancock, 1848, has a single gonad on the left side of the body only. Species with two gonads (one on each side) were previously assigned to the genus *Eugyrioides* Seeliger, 1907 (with the type species *Cynthia glutinans* Moeller, 1842), while species with one gonad on the right side, characterised by a rosette of testis follicles at the proximal end of the ovary, were assigned to the genus *Gamaster* Pizon, 1896. Michaelsen (1915) argued that differences in the number of gonads are insufficient to justify the establishment of separate genera, leading him to synonymise *Eugyrioides* and *Gamaster* with *Eugyra*. The opinions of modern authors regarding the validity of *Eugyrioides* and *Gamaster* vary. Some researchers consider these generic names to be valid (e.g., C. Monniot, 1997; C. Monniot & F. Monniot, 1994; C. Monniot et al., 2001), while others regard them as synonyms of *Eugyra* (e.g., Nishikawa, 1991; Kott, 1998; F. Monniot, 2016).

In our view, *Eugyrioides* and *Eugyra* are synonyms. However, *Gamaster* should be retained as a separate genus, characterised not by the number of gonads but by their shape: *Gamaster* includes species with one or two gonads, featuring long male follicles arranged in a single rosette around the proximal end of the ovary (this definition was proposed by Tokioka, 1965). If *Gamaster* is removed from the synonymy of *Eugyra*, the next available synonym, *Eugyrioides*, becomes the valid name for the preoccupied *Eugyra*.

Eugyrioides pedunculatus (Traustedt, 1886), **comb. nov.**
(Fig. 2B)

Eugyra pedunculata Traustedt, 1886: 427; Hartmeyer, 1903: 129, 1923: 40; Redikorzev, 1907: 128, 1908: 9, 1916a: 16; Millar, 1966: 16.

Material examined. **Arctic Ocean**, stations: NP41-190B, 82°49.314′N, 49°38.860′E, 2028 m, 25 Nov. 2023, 2 specimens; NP41-178B, 82°46.772′N, 48°38.417′E,

1790 m, 29 Nov. 2023, 5 specimens; NP41-82D, 82°44.871′N, 48°40.865′E, 1635 m, 30 Nov. 2023, 8 specimens; NP41-83D, 82°43.018′N, 48°48.436′E, 1465 m, 3 Dec. 2023, 2 specimens; NP41-84D, 82°44.122′N, 48°50.090′E, 1557 m, 7 Dec. 2023, 2 specimens; NP41-85D, 82°49.704′N, 49°15.303′E, 2047 m, 8 Dec. 2023, 2 specimens; NP41-89D, 83°02.740′N, 49°50.946′E, 2959 m, 21 Dec. 2023, 1 specimen; NP41-93D, 82°19.528′N, 41°23.978′E, 1703 m, 12 Jan. 2024, 5 specimens; NP41-96D, 82°10.810′N, 36°13.600′E, 1968 m, 24 Jan. 2024, 2 specimens.

Description (based on new material). All collected specimens juvenile, very small, with most measuring approximately 1–2 mm in diameter. Only one specimen (NP41-84D) measuring 4 mm at its greatest dimension. Body spherical, with thin peduncle (Fig. 2B), test thin, transparent, almost without attached foreign matter. Body wall not well preserved, collapsed into small mass being either not attached to tunic or attached only by small area around siphons. Morphological details in smaller specimens unclear. In largest (4 mm) specimen, branchial sac with six longitudinal vessels and spiral stigmata in seven transverse rows. Dorsal lamina smooth-edged. Gut forming compact, wide, closed loop. Stomach spherical, bearing longitudinal folds with indeterminable number. Incipient immature gonad in gut loop of largest specimen only; gonads absent in remaining smaller specimens.

Remarks. The records of *Eugyrioides pedunculatus* are limited and primarily derived from older sources. However, its distribution appears to be extensive: originally described from the Kara Sea, it has since been recorded along the eastern coasts of Greenland, Spitzbergen, the Barents Sea, and the White Sea, as well as from several locations along the Siberian coasts of Russia (see references in the synonymy). Previous records were from depths of 10 to 300 m, while the examined specimens were collected from significantly greater depths, specifically between 1,635 and 2,959 m.

The examined specimens superficially resemble minute species from the deep-sea genera *Minipera* C. Monniot et F. Monniot, 1974 or *Protomolgula* F. Monniot, 1971. However, the structure of the branchial sac, characterised by spiral stigmata, confirms that they belong to *Eugyrioides*. Only one species of this genus, *E. pedunculatus*, is known from high Arctic latitudes. It has six longitudinal vessels on each side of the branchial sac and a single gonad located within the gut loop. These features align with those observed in the larger specimen of the present material.

Family **Hexacrobylidae** Seeliger, 1906

Notes on the family position of the genera *Asajirus* Kott, 1989 and *Oligotrema* Bourne, 1903. Two genera of deep-water carnivorous ascidians, previously classified under Hexacrobylidae, *Asajirus* Kott, 1989 and *Oligotrema* Bourne, 1903, were transferred to Molgulidae by Tatián et al. (2011). The close relationship between Hexacrobylidae and Molgulidae was earlier suggested by Kott (1969, 1985, 1989), who even proposed that members of Hexacrobylidae could be included within Molgulidae, although she ultimately chose to maintain them as separate families (Kott, 1998). According to Kott (1998: 166), the family Hexacrobylidae "has close affinities with Molgulidae—closer than between Molgulidae and other taxa of the Ascidiacea. It appears to have evolved, probably from a molgulid ancestor, by profound changes in the pharynx and other parts of the gut". Molecular analysis based on partial sequences of 18S rRNA, conducted by Tatián et al. (2011), supports this conclusion. However, in this analysis, *Oligotrema* was resolved in a rather unusual position, forming a clade with the tropical shallow-water species *Molgula occidentalis* Traustedt, 1883. This clade was distinct from other *Molgula* species, which were separated by members of different molgulid genera. From a morphological perspective, it is evident that *Oligotrema* is unlikely to have a closer affinity with *M. occidentalis* than *M. occidentalis* has with other *Molgula* species. We believe that in cases of contradiction between morphological and molecular data, priority should not automatically be given to molecular data. We do not think that Hexacrobylidae should be united with Molgulidae based solely on these molecular findings, at least until new molecular data are obtained and analysed. Currently, the "profound changes in the pharynx and other parts of the gut" (see above) seem to provide sufficient justification for retaining *Asajirus* and *Oligotrema* in a separate family that is closely related to Molgulidae.

Genus ***Asajirus*** Kott, 1989

Asajirus arcticus (Hartmeyer, 1923)
(Figs 2C, 3)

Hexacrobylus arcticus Hartmeyer, 1923: 133.
Hexadactylus arcticus: C. Monniot & F. Monniot, 1990: 261.

Material examined. **Arctic Ocean**, north off Spitzbergen, station NP41-220B, 81°39.594′N, 20°14.553′E, 2303 m, 28 March 2024, one specimen.

Description (based on new material). Egg-shaped specimen 8 mm in height and 6 mm in greatest width. Entire body densely covered with sand grains, except for small bare area near base on right side. Test hair present only at basal part (Fig. 2C). Oral siphon with two large branched dorsal lobes and four much smaller lobes lying opposite to them (two ventral and two lateral). Lateral and ventral lobes more or less triangular, not divided in two, with few short indentations. Lengths of oral and atrial siphons (measured from neural ganglion to aperture edge) almost equal (Fig. 3A). Thick longitudinal muscles on ventral side of body originating on ventral and lateral lobes of branchial siphon as separate ribbons but soon (still on ventral side of branchial siphon) merging together and ending abruptly in one line at level of pole of gut loop (Fig. 3A). Neural ganglion with four anterior nerves. Large elongated pyloric vesicle connected with inner side of pole of gut loop by thick duct. Its other side connected to middle of rectum by two branched ducts. Intestine with constriction in its middle part (Fig. 3A). Male gonads short, composed of several joined follicles forming triangular or fan-shaped structure. Short sperm duct opening slightly anterior to proximal end of ovary, far from female openings. Tubular ovaries curved at almost right angle and opening in close proximity at both sides of anus (Fig. 3B). Ovaries filled with eggs of varying sizes, ranging from 0.05 to 0.35 mm in diameter. Renal sac very large, occupying almost whole space between branchial siphon and gut loop.

Remarks. This species was originally described by Hartmeyer (1923) from several specimens collected during the Danish Ingolf Expedition at two stations in the northern part of the Norwegian Sea (67°40′N, 15°40′W, 905 m and 63°36′N, 7°30′W, 1280 m). Hartmeyer (1923) recognised the close similarity between his species and *A. indicus* (Oka, 1913); however, as follows from his text, he chose to establish a new species primarily due to the significant geographical distance separating them: *A. indicus* was described from the Indian Ocean, south of Sri Lanka. Subsequently, several authors have treated these two species names as synonyms (Millar, 1959; C. Monniot & F. Monniot, 1968; C. Monniot, 1969; Kott, 1989). Later, C. Monniot & F. Monniot (1990) published a revision of the family, recognising twelve species of *Asajirus* (previously described under the generic name *Hexadactylus*, which is a junior objective synonym of *Asajirus*), including seven new species. They reexamined the type material (syntypes) of *A. arcticus* and provided a very detailed description accompanied by precise figures based on the specimens collected during the Norbi cruise at two stations in the Norwegian Sea (64°24′N, 01°43′E, 2615 m and 64°20′N, 01°40′E, 2538 m) and one station in the Greenland Sea (73°31′N, 13°40′W, 2500 m). Kott (1992) again synonymised *A. arcticus* and five other species recognised by C. Monniot & F. Monniot (1990) with *A. indicus*, while also questioning the distinctness of several others. Sanamyan & Sanamyan (2006) supported this viewpoint and provided arguments showing that the distinguishing characters used by C. Monniot & F. Monniot (1990) have limited utility for species differentiation.

C. Monniot & F. Monniot (1990) used several features to distinguish *A. arcticus* from *A. indicus*. The first feature is the relative length of the branchial and atrial siphons, measured from the ganglion to the edge of the aperture. In *A. arcticus*, the atrial siphon is reported to be shorter than the branchial siphon, whereas in *A. indicus*, the atrial siphon is either longer than or equal in length to the branchial siphon. In our Arctic specimen, the atrial siphon is slightly longer than depicted by C. Monniot & F. Monniot (1990: fig. 11) and is nearly of the same length as the branchial siphon. The second reported difference pertains to the shape of the ventral body muscles. They are described as regularly spaced in *A. arcticus* and as arranged in separate bands in *A. indicus*. It is difficult to determine whether the ventral body muscles in the examined specimen should be characterised as "regularly spaced" or "grouped in bundles". These muscles originate from the lobes of the oral siphon

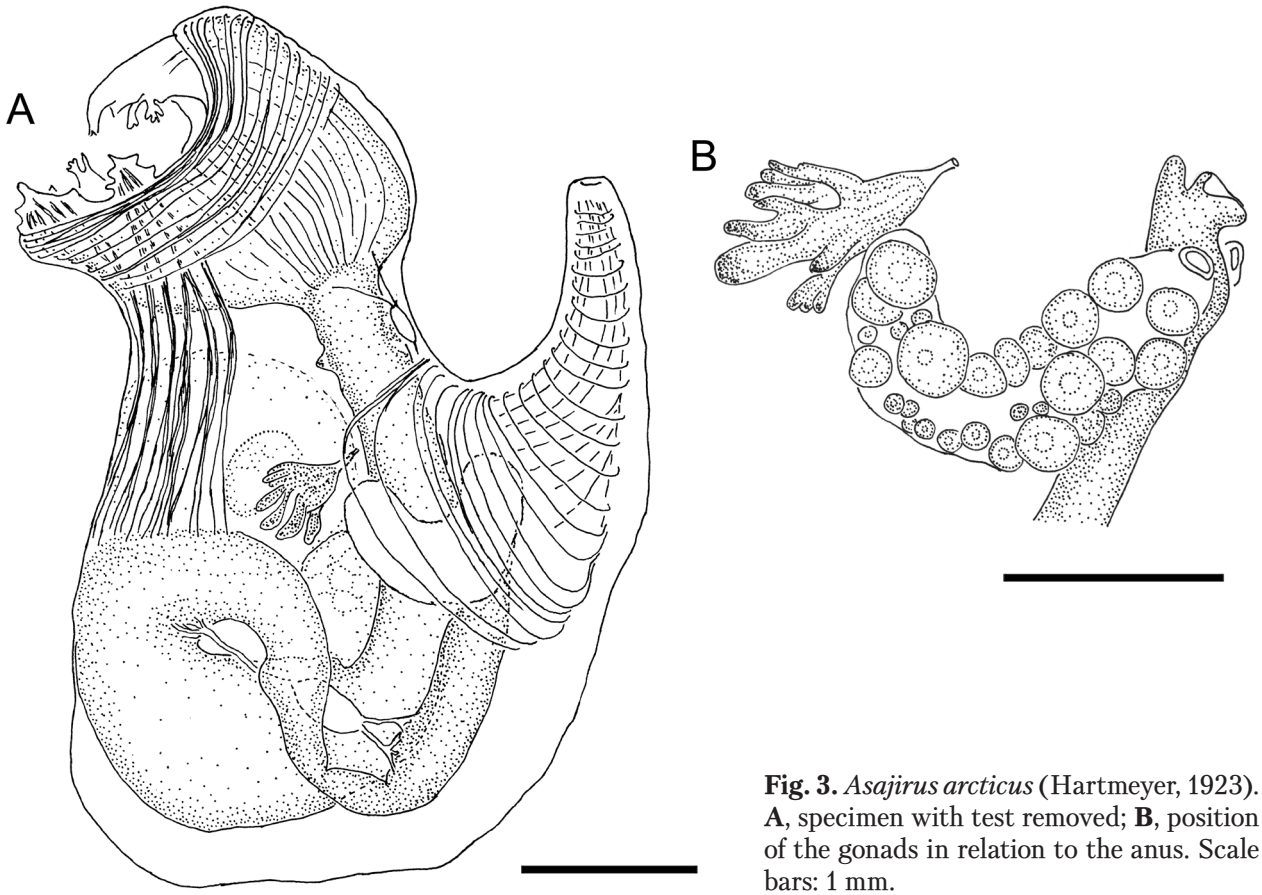

Fig. 3. *Asajirus arcticus* (Hartmeyer, 1923). **A**, specimen with test removed; **B**, position of the gonads in relation to the anus. Scale bars: 1 mm.

in clearly separate bundles but gradually become more widely spaced and evenly distributed across the ventral surface of the body. At least some specimens of *A. indicus* exhibit the same arrangement of the muscles (see C. Monniot & F. Monniot, 1990: fig. 16A). Therefore, this feature appears insufficient for differentiating between the two species.

The next feature is a constriction of the intestine, which is reported to be present in *A. arcticus* but absent in *A. indicus*. In our specimen, the intestine is narrowed at the pole of the secondary loop (Fig. 3A); however, this state is not different from that observed in some specimens of *A. indicus* (see C. Monniot & F. Monniot, 1990: fig. 16A). This feature appears to be variable and may depend on the physiological state of the specimen. In conclusion, we currently do not observe any reliable morphological differences between *A. indicus* and *A. arcticus*, except perhaps a slight variation in the shape of the testis, which requires confirmation from additional specimens. However, this does not necessarily mean that the taxa are conspecific, as they were originally described from two geographically distant regions: the Arctic and Sri Lanka. In this study, we prefer to treat *A. arcticus* as a distinct species, pending future (possibly molecular) data, primarily due to the significant geographical distance of its records from the type locality of *A. indicus*.

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