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SHORT NOTE

A new species of *Armodoris* (Mollusca, Gastropoda, Nudibranchia, Akiodorididae) from McMurdo Sound, Antarctica

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Abstract Recently collected specimens of *Armodoris* from McMurdo Sound, Antarctica, were morphologically examined and sequenced. Comparison between this new material and literature sources revealed that it belongs to an undescribed species, *Armodoris anudeorum*. Although this new species is externally very similar to *Armodoris antarctica* (the only previously known species of *Armodoris*), these two species differ in several details of their external morphology, and particularly in their reproductive anatomy and radular morphology. This is the second known species of *Armodoris*; thus, this paper doubles the known diversity of this exclusively Antarctic group.

Keywords Systematics · Taxonomy · Biodiversity · Ross Sea

Introduction

The genus *Armodoris* was introduced by Minichev (1972) for *Armodoris antarctica* Minichev 1972, based on a specimen collected from Tokarev Island in the Davis Sea, Antarctica. The original description, in Russian, includes the details of the reproductive anatomy and radula.

More recently, Millen and Martynov (2005) re-examined the holotype of *Armodoris antarctica* as well as additional specimens from around Antarctica. They also conducted a phylogenetic analysis that confirmed that *Armodoris* is basal to the closely related *Doridunculus* G.O. Sars, 1878, *Echinocorambe* Valdés and Bouchet, 1998, and *Prodoridunculus* Thiele, 1912. Millen and Martynov (2005) erected the new family name Akiodorididae to include all these groups plus the most basal *Akiodoris* Bergh, 1879. In separate paper, Martynov and Roginskaya (2005) provided details on the anatomy and biology of *Doridunculus*.

During two expeditions to McMurdo Station, Antarctica, in the 2006–2007 and 2007–2008 summer seasons, several specimens of *Armodoris* were collected by divers on SCUBA and photographed alive. The present paper deals with the description of these animals and a comparison with specimens of *Armodoris antarctica* described in the literature. This description doubles the diversity of this genus, which appears to be endemic to the Antarctic, and contributes substantially to our understanding of the overall diversity of Antarctic nudibranchs.

Materials and methods

Specimens were collected by SCUBA divers at two locations in McMurdo Sound: Explorer's Cove, New Harbor (NH) (77°34′17.84″S, 163°30′40.93″ E) and the Cape Evans Wall dive hut located near Cape Evans, Ross Island (CEW) (77° 23′4.78″ S, 66° 18′67.20″ E). The CEW site is approximately 25 km from McMurdo Station, and NH is on

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the continent approximately 84 km from McMurdo Station. At CEW, animals were found crawling on rock surfaces in a boulder field starting at approximately 25 m depth and continuing to at least 40 m. At NH, animals were found between 24 and 27 m crawling on rocks or shells on a flat muddy bottom. Specimens were collected by hand, brought back to McMurdo Station alive, and kept at -1°C until photographed. Live animals were photographed with a Nikon D-70S with 105-mm macro lens in a flow-through saltwater tank, measured, and preserved immediately in 99% EtOH.

The two paratypes were dissected by dorsal incision. The internal features were examined and drawn using a Nikon SMZ-100 dissecting microscope with the aid of a *camera lucida* attachment. Special attention was paid to the morphology of the reproductive and digestive systems. The penis of one specimen was dissected, dried, mounted, and sputter-coated for examination with a scanning electron microscope (SEM) Hitachi S-3000 N at the Natural History Museum of Los Angeles County. The buccal mass was removed and dissolved in 10% sodium hydroxide until the radula was isolated from the surrounding tissue. The radula was then rinsed in water, dried, mounted, and sputter-coated for examination with the SEM.

The material examined was deposited at the Malacology Section of the Natural History Museum of Los Angeles County (abbreviated LACM) and the Museo Nazionale dell'Antartide (Section of Genoa), Italy (abbreviated MNA).

Results

Armodoris anudeorum new species (Figs. 1, 2, and 3).

Material examined

Holotype

Cape Evans Wall site, McMurdo Sound, Ross Sea, Antarctica (77° 38′24.78″ S, 166° 31′7.20″ E), 27–37 m depth, November 11, 2007, 1 specimen 19 mm in length (LACM 3117).

Paratypes

Cape Evans Wall site, McMurdo Sound, Ross Sea, Antarctica (77° 38′24.78″ S, 166° 31′7.20″ E), 27–37 m depth, November 11, 2007, 1 specimen 16 mm in length, dissected (LACM 3118). New Harbor, McMurdo Sound, Ross Sea, Antarctica (77°34′17.84″ S, 163°30′40.93″ E), 24–27 m depth, November 12 2007, 1 specimen 19 mm in length, dissected (LACM 3119).

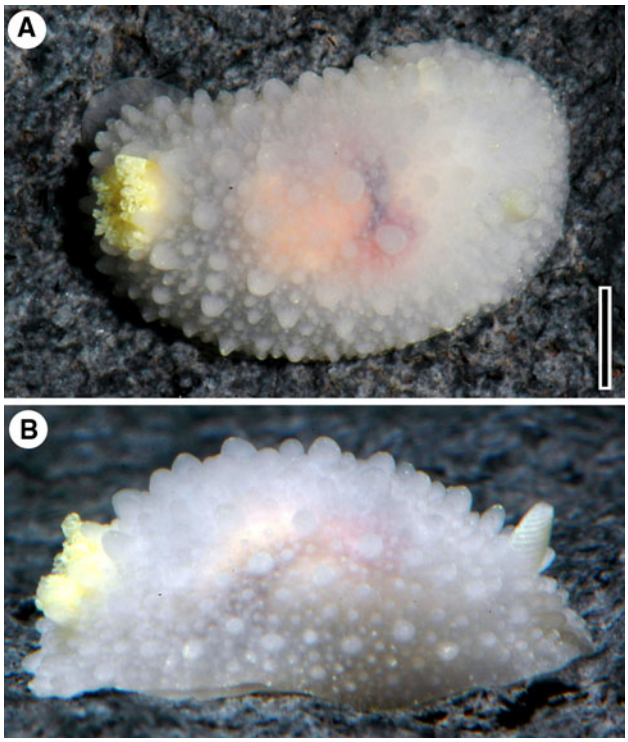

Fig. 1 Living holotype (LACM 3117). **a** *Dorsal view*, *scale bar* = 4 mm. **b** *Lateral view*. Photos by C. Shields

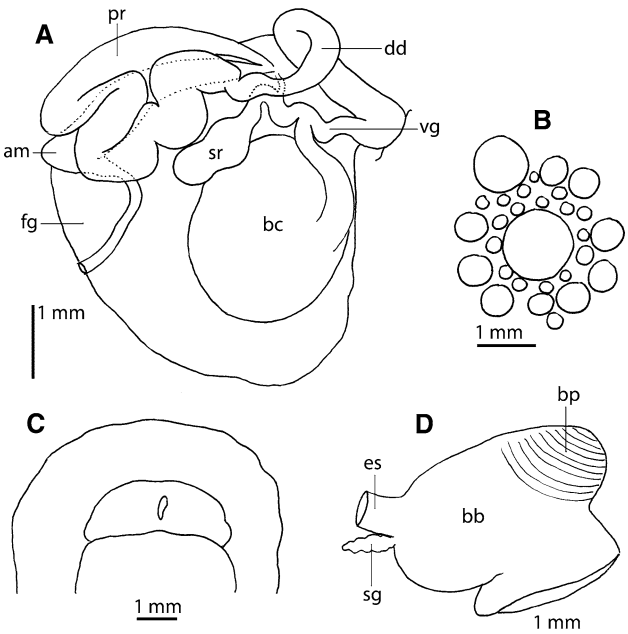

Fig. 2 Drawings of the external morphology and anatomy of a paratype (LACM 3119). **a** Reproductive system. **b** Dorsal tubercles. **c** *Dorsal view* of the mouth area. **d** *Lateral view* of the buccal mass. Abbreviations: *am*, ampulla; *bb*, buccal bulb; *bc*, bursa copulatrix; *bp*, buccal pump; *dd*, deferent duct; *es*, esophagus; *fg*, female glands; *pr*, prostate; *sg*, salivary gland; *sr*, seminal receptacle; *vg*, vagina

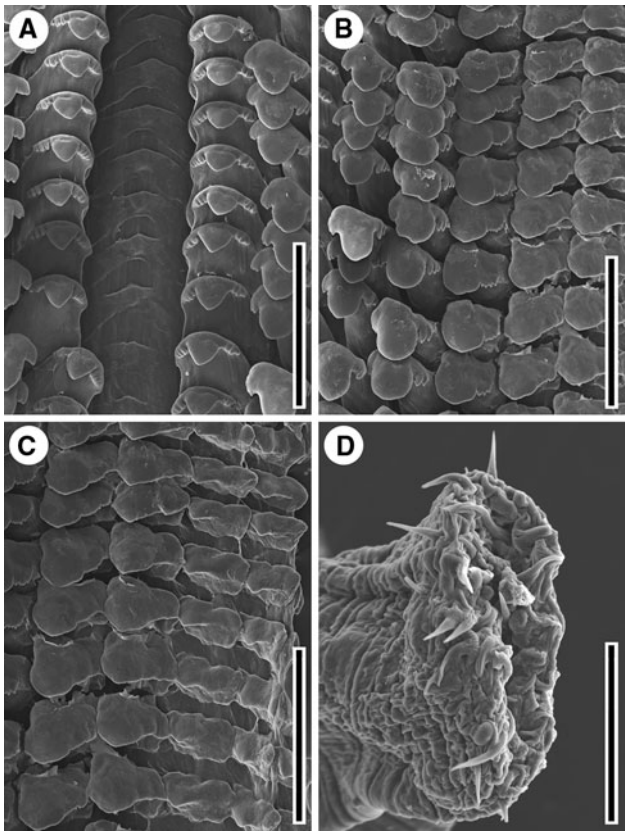

Fig. 3 Scanning electron micrographs of the radula and penis of a paratype (LACM 3119). **a** Innermost radular teeth, *scale bar* = 100 μm. **b** Mid-lateral radular teeth, *scale bar* = 100 μm. **c** Outermost lateral teeth, *scale bar* = 100 μm. **d** Penis, *scale bar* = 30 μm

Additional specimen

Terra Nova Bay, Ross Sea, Antarctica (74°44′98″S, 164°06′44″E), 73–75 m depth, 1 specimen collected by Marino Vacchi (ex pisce, *Trematomus bernacchii*) during the VI PNRA Expedition to Antarctica (1990–1991). Station Cala 80 (MNA 786).

External morphology

Body color translucent white; digestive gland visible through the tegument as an orange to dark brown area (Fig. 1a, b). Rhinophores pale yellow. Branchial leaves bright yellow. Body oval to elongate. Dorsum covered by numerous tubercles of different sizes. Largest tubercles (0.9–1.2 mm in diameter) rounded to conical, separated from one another by relatively wide gaps, larger near the center of the dorsum. Smaller tubercles of two class sizes, smallest tubercles (0.2–0.3 mm in diameter) forming rings around the largest tubercles. Larger small tubercles (0.5–0.6 mm in diameter) irregularly distributed in between the largest tubercles. Rhinophores short, wide, with 11 lamellae. Gill composed of five, short, unipinnate leaves. No tubercles present within the gill circlet.

Ventral side of the body with an enlarged mouth area and a velar projection on each side (Fig. 2b).

Anatomy

Digestive system with an oval buccal bulb having a low, forward oriented buccal pump (Fig. 2c). Radular formula 60 × 3–8.3.1.3.3-8 (LACM 3118) and 57 × 3–8.3.1.3.3–8 (LACM 3119). Rachidian teeth plate-like, lacking cusps or denticles, but slightly thicker in the center (Fig. 3a). Three innermost teeth in each row with a central rounded cusp and 2–4 denticles on each side (Fig. 3b, c). Remaining 3–6 outer teeth with a less pronounced cusp with 6–0 denticles on the outer side only (Fig. 3c). The radular teeth show no signs of abrasion or erosion, and their morphology is consistent between the two specimens here dissected. There is little variation between anterior and posterior rows, although teeth in the posterior rows tend to have slightly longer cusps. Labial cuticle smooth, with no differentiated jaw.

Reproductive system of both paratypes (LACM 3118, LACM 3119) with a long and convoluted ampulla that branches into a tubular prostate and the female glands (Fig. 2b). The prostate narrows and expands again into the distal portion of the deferent duct. The penis contains several rows of elongate penial hooks (Fig. 3d). The short vagina connects to the large, oval bursa copulatrix and a much smaller seminal receptacle. A short uterine duct connects the seminal receptacle with the female glands. The reproductive morphology is consistent between the two specimens here dissected.

DNA sequence data

Two genes, the mitochondrial COI and the nuclear 18S of this new species, were sequenced by Shields et al. and will be published in a separate paper. The sequences are available in GenBank with the accession numbers GQ292044 (COI) and GQ326879 (18S).

Etymology

The species name is dedicated to the members of the Antarctic NUDibranch Eggmass project, led by Amy Moran and Art Woods.

Discussion

Taxonomy of *Armodoris*

Armodoris was described by Minichev (1972) based on the single species *Armodoris antarctica* Minichev 1972, originally collected in Tokarev Island, Davis Sea. Subsequently, Millen and Martynov (2005) described additional specimens from King George Island in La Guardia National Bay, Antarctic Peninsula. Millen and Martynov (2005) also provided a comprehensive diagnosis of *Armodoris*, which is characterized by having a spiculose notum with rounded tubercles, a posterior part of the notum round and fully covering the tail, branchial leaves in a semicircle, head with a small four-corned oral veil, anus dorsal, buccal pump oval and prominent, radular formula 4–8.4–6.1.4–6.4–8, rachidian tooth plate-like with a slightly prominent central cusp, lateral teeth with a rectangular base and a long cusp to the inside of center, denticles on the first 6 teeth, outer 4–8 teeth with one reduced cusp or reduced to rectangular bases, and penis with simple spines.

Millen and Martynov (2005) stressed the differences between *Armodoris* and other related groups such as *Akiodoris*, *Prodoridunculus* and *Doridunculus*, which include the fact that *Armodoris* has at least four to six well-developed inside lateral teeth and no clear border between inner and outer laterals. The material here examined has only three well-developed inside lateral teeth but there is no clear border between inner and outer laterals, which is consistent with Millen and Martynov's (2005) observations.

The specimens here studied generally match the diagnosis of *Armodoris* but differ from *Armodoris antarctica* in several respects. Because the color of *A. antarctica* is unknown, it is not possible to compare it to that of *A. anudeorum*; however, many other anatomical details are available for comparison.

Armodoris antarctica has larger, more densely packed tubercles than those of *A. anudeorum*, which are more conical and more distant from one another. Both species have larger tubercles surrounded by smaller ones; in *A. antarctica*, all the smaller tubercles are similar in size, whereas in *A. anudeorum*, there are two classes of small tubercles, some smaller than the rest.

Anatomically, the descriptions of *Armodoris antarctica* by Millen and Martynov (2005) are very similar to the original description by Minichev (1972). Although Minichev (1972) misinterpreted some organs of the reproductive system (for example, he labeled the bursa copulatrix as the albumen gland), the size and proportions of all the organs are very similar to the drawings by Millen and Martynov (2005). This is particularly important because those descriptions clearly differ from the material here examined. For example, the bursa copulatrix of both specimens of *A. anudeorum* is round, whereas it is oval in *A. antarctica*; the seminal receptacle of *A. anudeorum* is proportionally larger than that of *A. antarctica* and narrower in the middle, whereas in *A. antarctica* it is oval shaped. The prostate of *A. anudeorum* is comparatively much longer than that of *A. antarctica*. This is consistent in both specimens of *A. anudeorum* examined.

The radular morphology of these two species is also consistently different with *A. antarctica* having narrower rachidian teeth with conspicuous cusps and two denticles, whereas in *A. anudeorum* the rachidian teeth are much broader and lack cusps or denticles. In addition, the lateral teeth of *A. antarctica* have more pronounced cusps than those of *A. anudeorum*. Finally, for similar size animals, *A. anudeorum* has more rows of teeth (57–60 rows) in 16- to 19-mm preserved length specimens compared to *A. antarctica* (36–52 rows) in 13- to 16-mm preserved length. The radular morphology of *A. anudeorum* is consistent among all three specimens examined (LACM 3118, LACM 3119, MNA 786).

Biogeography and other records

Both species of *Armodoris* are externally very similar and had possibly been confused in the past. For instance, Cattaneo-Vietti et al. (2000) reported a specimen of *Armodoris antarctica* collected from the stomach of the fish species *Trematomus bernacchii*, caught in the Ross Sea, Terra Nova Bay. Millen and Martynov (2005) studied a SEM image of the radula of this specimen and concluded that it was similar to those of other specimens of *A. antarctica*. We had access to the SEM image of this specimen (MNA 786) that shows a radula with a broad rachidian tooth lacking cusps or denticles, very similar to that of *A. anudeorum* and different from that of *A. antarctica*. We therefore conclude that the Cattaneo-Vietti et al. (2000) specimen is *A. anudeorum*. It appears that whereas *A. anudeorum* has been found only from the Ross Sea, *A. antarctica* has a broader distribution including the Antarctic Peninsula and the Davis Sea.

Broader significance of this new species description

Prior to this species identification, *Armodoris* was known from only one species; thus, the description of *A. anudeorum* doubles the known diversity of this group.

The genus *Armodoris* appears to be an entirely Antarctic taxon and, like many endemic Antarctic taxa, it is a poorly known group with regard to its ecology, distribution, and evolutionary history. The description of *A. anudeorum* as a separate species is important for scientists conducting ecological and evolutionary studies in the Antarctic, because failing to recognize morphologically similar species can

lead to the misinterpretation of important biological data on range limits, ecological interactions, biogeographic patterns, and phylogeographic history (Knowlton 1993).

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