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A new species of *Janolus* Bergh, 1884 from the Northeastern Pacific

(Gastropoda, Nudipleura, Proctonotidae)

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Scuba divers collected a new species of *Janolus* Bergh, 1884 from mud bottoms in the near shore fjords and inlets of southern British Columbia, Canada and Puget Sound, Washington, USA. This new species is sympatric with *Janolus fuscus* O'Donoghue, 1924 and morphologically similar to this species. *Janolus gelidus* Millen, spec. nov. is separated from the latter by its orange body and papillae and opaque white diamond shape spot, capping the top of the papillae and elongating into a streak, frosting the inner apex. It also differs in its possession of a white rim to the foot and white mid dorsal line posterior to the papillae. It lacks the orange subapical band on the papillae and red mid-dorsal line of *J. fuscus*. Internally, oral glands, found in *J. fuscus*, are lacking, and the jaw morphology, radular and reproductive features differ significantly. This new species is described and compared to other similar *Janolus* species worldwide.

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Introduction

The genus *Janolus* Bergh, 1884 is a widely distributed temperate and tropical genus in the nudipleuran family Proctonotidae Gray, 1853. Traditionally in the Arminina, they are presently considered unassigned Dexiarchia (Schrödl et al. 2001). Morphological phylogenies (Wägele & Willan 2000, Wägele & Klusmann-Kolb 2005) and molecular phylogeny (Wollscheid-Lengeling et al. 2001) suggest that the suborder Arminina is paraphyletic. Pola & Gosliner (2010) and Gosliner & Fahey (2011) also found that the Arminina was paraphyletic but that the Proctonotidae were monophyletic.

There are 21 described species (Bouchet & Gofas 2015) and a number of, mainly tropical, undescribed species of *Janolus*. The long, conspicuous papillae, which extend continuously along the edges of the notum and in front of the head, have slender branches of the digestive gland, which may ramify, but lack cidosacs and are therefore, not true cerata. These

papillae are easily autotomised and are often sticky. All *Janolus* species have a laterally folded sensory crest, the caruncle, which is located between the perfoliate, closely set, rhinophores. They are arborescent bryozoan feeders. Other characteristics are an oral veil, broad radula and a medial anus.

Gosliner (1981) combined the genera *Janolus* Bergh, 1884 and *Antiopella* Hoyle, 1902 and summarized our knowledge of 15 species recognized at the time, described an additional species of *Janolus* and erected a closely related genus *Bonisa*, which lacks digestive diverticulae. Gosliner (1982) redescribed and distinguished the two northeastern Pacific species *Janolus barborensis* (Cooper, 1863) and *Janolus fuscus*. Miller & Willan (1986) redescribed *J. hyalinus* (Alder & Hancock, 1854), synonymised *J. flagellatus* Eliot, 1906, described three new species and resurrected the family name Zephyrinidae. The family name has been replaced by the older name Proctonotidae Gray, 1853 (Bouchet et al. 2005). Schrödl (1996) described an additional species, *J. rebecca* from the Pacific coast

of Chile and Fischer et al. (1997) described a similar species, *J. chilensis* from Chile, which is possibly a junior synonym of *F. rebecca* (Cervera 1997; but provisionally considered separate (Schrödl 2003)). *Janolus costacubensis* Ortea & Espinosa, 2000 is considered a junior synonym of the poorly known *J. comis* Er. Marcus, 1955 (Valdés et al. 2006). *Janolus anulatus* Camacho-García & Gosliner, 2006 is described from the tropical eastern Pacific Ocean. The most recently described species, *Janolus savinkini* Martynov & Korshunova, 2012, which is common in the Indo-Pacific, is similar to a number of undescribed purple tipped species (see Gosliner et al. 2008, *Janolus* sp. 1, 2, 8). Unfortunately, the colour patterns and details of *Janolus australis* Bergh, 1884 are unknown and have made it impossible to assign one of several undescribed species found around Australia to this name. At least 7 additional undescribed species have been photographed in books (Coleman 1989, Debelius 1996, Coleman 2001, Behrens & Hermosillo 2005, Gosliner et al. 2008, Schrödl 2009). And several photos of additional undescribed species are found on the web. In this paper, a new species from the northeastern Pacific, is described and distinguished from all similar species in the genus.

Taxonomy

Genus *Janolus* Bergh, 1886

Janolus gelidus Millen, spec. nov.

Etymology. The species name *gelidus* is Latin for frosty, referring to the opaque white streak marking the inner apices of the papillae.

Material examined. Holotype: CASIZ172657, Sakinaw Rock, Porpoise Bay, Sechelt Inlet, British Columbia, Canada (49°34'01"N, 123°48'23"W), 17 November, 2001, 30 m mud bottom, 23 mm live length, Coll. Sandra Millen. Paratypes: BCPM 005-00014-001, 1 specimen, Sakinaw Rock, Porpoise Bay, Sechelt Inlet, 17 November, 2001, 30 m mud bottom, Coll. Sandra Millen. CA-SIZ172658, 2 specimens, Porpoise Bay, Sechelt Inlet, 21 June, 2000, from 20–26 m, silty bottom, Coll. Andy Lamb. 1 dissected, collected with the holotype, CA-SIZ172659, 1 specimen, Sakinaw Rock, Porpoise Bay, Sechelt Inlet, 17 November, 2001, 30 m mud bottom, light colour, 12 mm live length, Coll. Donna Gibbs. Not deposited: 1 specimen, dissected, Porpoise Bay, Sechelt Inlet, 21 June, 2000, from 20–26 m, silty bottom, Coll. Andy Lamb. 3 specimens, 1 dissected, Sakinaw Rock, Porpoise Bay, Sechelt Inlet, 17 November, 2001, mud bottom, Coll. Donna Gibbs and Sandra Millen.

Description

External Morphology

The largest measured living specimen was 23 mm in live length, with papillae up to 10 mm. Other specimens were estimated to be up to 5 cm long. The shape (Fig. 1A) is elongate, wider in front, rounded anteriorly and tapering gradually to a pointed posterior end with a small keel. The perfoliate rhinophores (Fig. 2A) can extend slightly beyond the papillae. They have a flat tip and an elongate clavus. There are 10–21 complete lamellae plus a few posterior half lamellae. The sloping lamellae are joined to a narrow midrib posteriorly and meet at an angle anteriorly. The lower, almost half, of the rhinophores is smooth. Between the rhinophores is a small caruncle, only a little longer than the diameter of the rhinophores and slightly raised (Fig. 2A). It is composed of 6–10 wavy folds. Numerous irregular rows of papillae are around the entire notal margin including in front of the rhinophores. Each row is ramified, bears 3–6 papillae and is bifid at the outer edge. Papillae are smooth, elongate, or inflated with an elongate pointed tip (Fig. 2B). The tips are slightly flattened and curled a little inward although they can straighten. The digestive gland has one slender branch into each papilla, which does not divide and ends just before the opaque white tip. Papillae are easily autotomised. The head (Fig. 2C) is rounded and bears two short, flattened and bluntly tipped, digitiform oral tentacles. They are 2 mm long, located on the sides of the head and dorsal to the oral surface. The foot is widest anteriorly and extends into short propodial tentacles. The anterior margin is bilabiate and widely notched in the upper lip at the midline where it connects to the mouth opening. The foot is wider than the body with a wide flange. It ends in a short point beyond the papillae. The gonopore opening is on the right side, slightly below the notum about one halfway down the body. The renal pore is slightly posterior to the gonopore and closer to the notum. The anus is on a tall papilla with slightly lobate edges, located just right of center, a short distance from the posterior edge of the notum.

Colour. The body is translucent orange, ranging from very pale, almost white to medium orange. The dorsal surface is flushed with reddish-orange pigment. The caruncle is dusky yellow even on darkly pigmented specimens. The posterior foot has a broad, median, opaque white line and often a broken white line appears along the midline of the body, sometimes represented only by spots on the cardiac area. Rhinophores have white tips, which extend as a thin white line down the posterior surface. The clavus is dusky yellow, below the clavus the shaft is

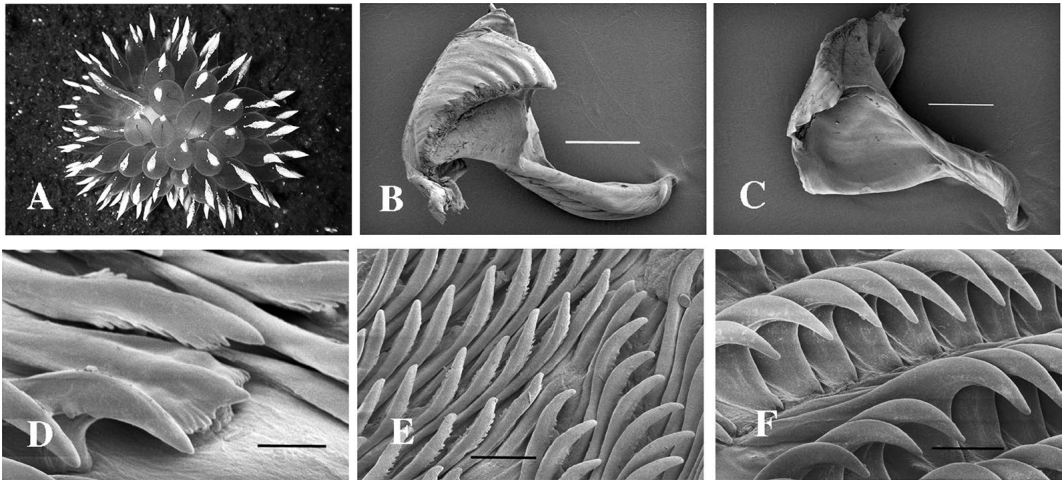


Fig. 1. A. Living animal from Sechart Inlet, B.C., Canada. Length = 19 mm. B. Jaw masticatory margin showing denticles. Scale bar = 500 μ m. C. Jaw, inside view showing inner shelf joining masticatory margin with both dorsal and ventral sides of the jaw. Scale bar = 500 μ m. D. Rachidian and first few lateral teeth showing denticulation. Scale bar = 10 μ m. E. Inner lateral teeth showing denticulation. Scale bar = 25 μ m. F. Mid lateral smooth teeth. Scale bar = 20 μ m.

pale to dark orange. The papillae are overlaid with orange pigment, which is darker towards the tips sometimes forming a dark orange suffusion below the opaque white tips. An opaque white, elongate, diamond shaped spot lies on the inner surface and caps the papillae at the tip. It covers the entire inner tip and extends in a streak or series of spots a short distance down each papilla. There are sometimes a few opaque white spots scattered on the papillae. The digestive gland ducts are thin and orange-brown. In pale specimens, the masticatory area of the jaws show dark brown, the rest of the buccal mass is white with small dark eyes showing through the notum. The oral tentacles have a short white dorsal line and there are a few white specks on the anal tubercle. The edges of the foot have a thin opaque white line sometimes broken into a series of spots. Photographs of this species have been published in Behrens & Hermosillo (2005: 103), Lamb & Hanby (2005: 267), Prud'homme G neroux (2005: 18).

Internal Anatomy

Digestive system. The mouth has a thin muscular disk with few simple oral glands. The buccal mass is elongate-oval, narrowing posteriorly (Fig. 2D). The jaws are very large, pale yellow except for the anterior portion, which is dark reddish brown. The jaws are wide and wing-like when viewed dorsally, with dark articular knobs joined by a clear connective hinge. A thin vertical flange is set at an angle on the dorsal surface. From the anterior view, each

dark, triangular masticatory flange has an edge with approximately seven ridge-like pointed denticles of which the ventral four are best developed (Fig. 1B). This edge is supported by a smooth inner brace, which is also darkly pigmented and is attached with a fold to the medial edge of the jaw (Fig. 1C). The marginal denticles project beyond the fold. Muscles insert in the triangular space between the brace and the masticatory flange. Posterior to the masticatory area, from the lateral view (Fig. 2E), the jaw expands dorsally with a thin flange for muscle attachment and ventrally in a curve. It then tapers abruptly to less than half its height, and ends in a narrow rounded lobe. Along the widest, outer mid-lateral line of the jaw is a distinct ridge.

The radular sac is short and rounded. The radulae have the formula 24-25 (34-45.1.45-34) on the smallest and largest preserved specimens examined (6 and 18 mm). The rachidian tooth is rectangular, indented behind and wider in front, with a short cusp and two lateral flanges each bearing 5-6 minute denticles (Fig. 1D). The lateral teeth have a hook-shaped arched cusp, which is approximately as long as the long base. The innermost 7-12 lateral teeth bear 5-9 or more small, irregular denticles on the inner edge and the first 2-6 lateral teeth may bear irregular denticles on the outer edge (Fig. 1E). The teeth become smooth and increase only slightly in size to the mid-row (Fig. 1F) and the outermost 12 teeth diminish gradually, the last 2-3 being considerably smaller.

Salivary glands are flat and highly ramified, located antero-lateral to the stomach and inserting with long ducts into the buccal mass on either side of the esophagus. The tubular esophagus leads to the left side of the rounded stomach. The right and left branches of the digestive ducts each split into anterior and posterior ducts. Posteriorly, the stomach has a medial posterior duct, which branches to the post cardiac papillae. From the posterior most portion of the stomach exits the striated intestine, which lacks a typhlosole, and twists in a loop to the right and runs posteriorly on the right side, then medially to open just to the right of center close to the posterior end of the notum. There are no anal glands and the anus opens on a tall, striated papillae.

Central nervous system. The central nervous system has fused cerebropleural ganglia with separate, short nerves to the caruncle medial to the long rhinophoral nerves. The eyes are on short stalks. The statocysts bear several otoconia and are located between the cerebropleural and large round pedal ganglia. The pedal ganglia are lateral and slightly ventral to the cerebropleural ganglia and are connected by a ventral commissure. The long buccal commissure leads to large, round, widely separated buccal ganglia each connecting to a small gastroesophageal ganglion.

Pericardial and renal system. The heart is in a rounded, elevated pericardium in the central area of the body. It has a small triangular atrium connected to a large muscular, round ventricle. The renal syrinx is ovoid, white and folded internally. It lies on the right side of the atrium and is connected to the pericardium and the kidney. The kidney is thin walled and highly ramified. A short, wide, thin walled duct connects the syrinx to the renal pore located high on the body wall, a short distance posterior to the reproductive openings.

Reproductive system (Fig. 2F). The ovotestis is located posterior to the stomach and under the posterior branches of the digestive gland. The ovotestis is divided into several slightly flattened lobules, which have clusters of peripheral female ancini and central male ancini, connected to a thin duct. These ducts connect together and form the hermaphroditic duct, which leads to a curved ampulla. A short post-ampullar duct, buried in the folds of the female gland mass, bifurcates into the vas deferens and an oviduct. The vas deferens forms a long tubular prostatic portion followed by a shorter, muscular ejaculatory duct that enters an elongate penial sheath. The penis is flagelliform, unarmed and exits a slightly projecting external sheath. The oviduct has a swollen distal portion containing eggs, which narrows and inserts on the junction of the vagina and duct to the seminal

receptacle. The oviduct and seminal receptacle are buried in the folds of the female gland mass. The seminal receptacle has a small round sac and thick duct inserting onto the vagina, which gradually widens and distally joins into a common atrium with the female gland mass. Opposite this junction is a small round sac, the distal bursa, which appears too small to be functional as a copulatory bursa, but may expand when mature. The reproductive system is androdiaulic.

Natural history

This species has been found on mud bottoms in fjords and inlets of the near shore waters of southern British Columbia and northern Washington. The known northern sighting is Winter Harbour, in Quatsino Sound on the northwest coast of Vancouver Island (50°30'48" N, 128°30'39" W). It has also been found in several locations in the Strait of Georgia, Sechelt Inlet, Howe Sound, Burrard Inlet, the Hood Canal and Puget Sound. The southernmost known location is off Redondo Dr. south Des Moines, Washington (47°20'54" N, 122°19'24" W).

It has been found on rocks and most often on silty sand and mud bottoms at depths from 17–37 m during every month. It is most abundant in the winter, October to February, less abundant March to May and rarely seen June to September. Presumably this species eats arborescent bryozoans, which is the only known food of other *Janolus* species. A photo suggests that they eat bryozoans encrusting *Phyllochaetopterus* worm tubes protruding from the mud. Spawn was laid in the lab by a freshly collected specimen in November. The egg mass is a white string, 3 mm high with one highly undulating row of egg capsules, Type B (Hurst 1967). There are 30 to 70 white eggs per capsule.

Discussion

Most of the 21 currently known species of *Janolus* can be easily separated from *Janolus gelidus* spec. nov. because they have tubercles on the papillae or pigment colours other than orange and white. Similarly pigmented species, *Janolus praeclarus* (Bouchet, 1975), *J. capensis* Bergh, 1907, *J. rebecca* Schrödl, 1996, *J. longidentatus* Gosliner, 1981 and *J. australis* Bergh, 1884, whose colour is unknown, have smooth rather than denticulate inner lateral radular teeth. Of those with denticulate laterals, *Janolus cristatus* (Delle Chiaje, 1841) has digestive ducts that branch at the apices of the papillae and in *J. mucloc* (Marcus, 1958), *J. barbarensis* (Cooper, 1803), *J. chilensis* Fischer et. al, 1997, they branch medially,

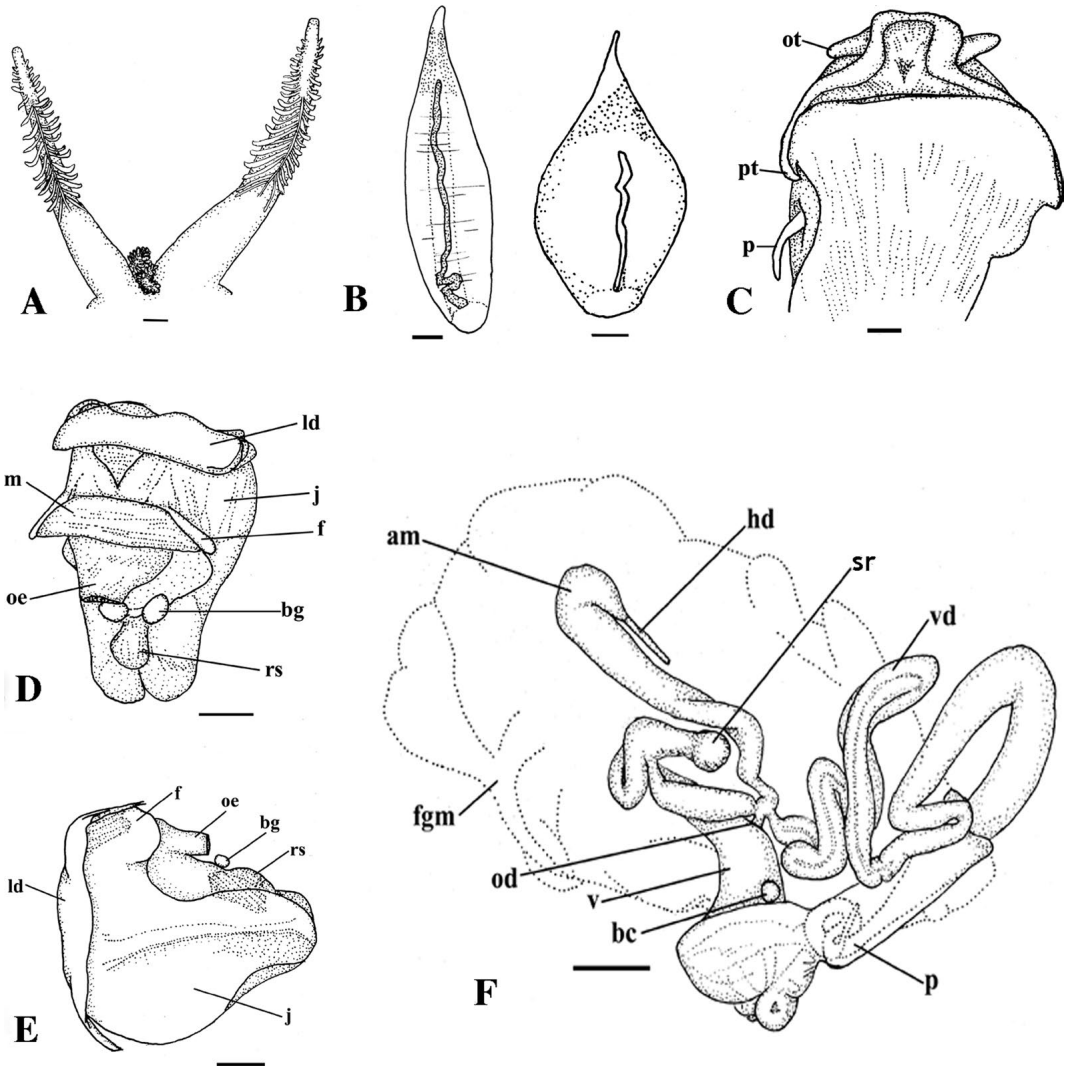


Fig. 2. A. Caruncle and rhinophores. B. Papillae, elongate and inflated, showing digestive diverticulum. C. Ventral view of head. D. Buccal bulb, dorsal view. E. Lateral view of buccal bulb. F. Reproductive system. All scale bars = 1 mm. Key: **am**, ampulla; **bc**, bursa copulatrix; **bg**, buccal ganglion; **f**, flange; **fgm**, female gland mass; **hd**, hermaphroditic duct; **j**, jaw; **ld**, labial disk; **m**, muscle; **od**, oviduct; **oe**, esophagus; **ot**, oral tentacles; **pt**, propodial tentacle; **p**, penis; **rs**, radula sac; **sr**, seminal receptacle; **v**, vagina; **vd**, vas deferens.

whereas they are unbranched in *J. gelidus* spec. nov. and *J. fuscus* O'Donoghue, 1924. An undescribed orange species, Coleman's *Janolus* (Coleman 1989: 58, Coleman 2001: 104–105, Debelius 1996: 104, Gosliner et al. 2008: 318, sp. 4) has darker pigment, shorter, less inflated papillae, more white spots on the body and the papillae have yellow towards the tips. A second undescribed orange species, the ringed *Janolus* (Debelius 1996: 296, as *J. canuncta* and *J. carinate*, Coleman 2001: 104) has larger, and more

numerous white spots on the body and foot, and shorter papillae with a broad white or yellow ring, ending in clear tips. Both of these undescribed species lack the characteristic diamond shaped white spot found on the papillae tips of *J. gelidus*.

The species that is closest to *Janolus gelidus* is the sympatric *J. fuscus*, which can be distinguished externally by the fact that the papillae in *J. fuscus* bear white caps followed by a discrete orange band. On *Janolus gelidus*, the white is primarily on the in-

ner side of the apex and the orange gradually fades into a blush over the entire papillae. *Janolus fuscus* does not have orange pigment on the body except for a thin medial streak, which covers the caruncle. *Janolus gelidus* has a faint to intense reddish-orange blush on the entire notum, excluding the caruncle, which is sometimes intensified on the bases of the rhinophores. Internally (Gosliner 1982; personal observation), *Janolus fuscus* has a large oral gland under the esophagus, which is lacking in *J. gelidus*. The jaws are more slender anteriorly, approximately equal to the masticatory flange vs. twice the height, due to the ventral expanded portion in *J. gelidus*. It was noted that the masticatory flange on both species tended to dissolve when the jaws were cleaned with potassium hydroxide. The radula has fewer laterals in *Janolus fuscus* (22–25 vs. 34–45) and the teeth have much longer cusps. In the reproductive system, a more mature *Janolus fuscus* was dissected than that illustrated by Gosliner (1982). It had a swollen, saccate ampulla and an oviductual swelling containing eggs. The female systems of both species were similar, although *Janolus gelidus* had a proportionally longer duct to the seminal receptacle. In the male systems, the prostate of *Janolus fuscus* was much longer than that of *J. gelidus* (24.2 vs. 9.8 mm). The muscular ejaculatory duct was shorter on *Janolus fuscus* (3.3 vs. 6.8 mm). The penial sac of *Janolus fuscus* was much wider proximally than that of *J. gelidus* (1.2 vs. 0.7 mm) to accommodate the conical penis. The penis of *Janolus gelidus* is flagelliform, protruding up to 2 mm in preserved specimens.

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