

## A new species of the zephyrinid nudibranch genus *Janolus* (Mollusca: Nudibranchia) from North America and Costa Rica

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**Abstract:** A new species of zephyrinid nudibranch of the genus *Janolus* Bergh 1884 is described from the Pacific Coast of North America and Costa Rica. *J. anulatus* sp. nov. differs from other species of *Janolus* by its external and internal morphology. *J. anulatus* has a brown or white body with pink, white, and brown spots, smooth papillae epithelium at the base and papillated in the distal part, unbranched digestive gland ducts, smooth jaws, and smooth rachidian and lateral teeth. The species is compared with other species from the Panamic Province and the Western Atlantic. A new extension range of *J. barbarentis* is documented. Rev. Biol. Trop. 54(4): 1295-1305. Epub 2006 Dec. 15.

**Key words:** mollusca, Nudibranchia, Costa Rica, *Janolus*.

The genus *Janolus* Bergh (1884) is comprised of 22 valid species that are distributed in tropical and temperate waters. Six species of the genus *Janolus* have previously been described from the Atlantic and Pacific coasts of the Americas. Two of these species are present in the Panamic Province and/or Western North America, *J. barbarentis* (Cooper 1863) from California and Costa Rica and *J. fuscus* (O'Donoghue 1924) from Canada and California. *J. rebecca* (Schrödl 1996) has been described from Chile. Three other species have been described from the Western Atlantic and Caribbean: *J. comis* Marcus, 1955 from Florida, Curaçao and Brazil, *J. mucloc* Marcus 1958 from Florida and Brazil and more recently *J. costacubensis* Ortea and Espinosa 2000 from Costa Rica and Cuba. The present material (a new species and *J. barbarentis*), constitute two new records of the genus along the Pacific Coast of Costa Rica.

### SPECIES DESCRIPTION

#### Genus *Janolus* Bergh 1884

##### *Janolus anulatus* sp. nov. (Figs 1A;2-5)

**Type material:** –Holotype– Isla Ballena, Parque Nacional Marino Ballena, Área de Conservación Osa, Puntarenas, Costa Rica (9°06'24" N, 83°43'35" W), 16 January 2000, 1 specimen, 4mm preserved length, 6 meters depth, leg. M. Calderón (UCR-INB0001495772); bar code of holotype associated with three components: SEM stub with radula (UCR-INB0003764987), SEM stub with a piece of jaw (INB0003764958) and a slide preparation with a piece of jaw (UCR-INB0003765066); PARATYPES. – Isla Ballena, Parque Nacional Marino Ballena, Área de Conservación Osa, Puntarenas, Costa Rica (9°06'24" N,

83°43'35" W), 16 January 2000, 1 specimen, 5 mm preserved length, 6 meters depth, leg. M. Calderón (UCR-INB0003764915). Isla Plata, SW side, Guanacaste, Costa Rica (10°26'48" N, 85°48'20" W), 17 April 2004, 1 specimen, 4 mm preserved length, 10 meters depth, leg. Y. Camacho (UCR-INB0003836171); La Jolla California, 1 specimen, 4 mm preserved length, leg. J. Hamann (CASIZ 170029), La Jolla California, May 1982, 1 specimen 4 mm preserved length (CASIZ 170028).

**Geographic range:** This species is known from La Jolla, California (Behrens 1991) and the Pacific Coast of Costa Rica (present study).

**Etymology:** The name of the species “anulatus” refers to a ring that is found near the middle of each dorsal papilla that separates the smooth from the papillate portion.

**External morphology:** The body is broadest anteriorly, tapering to the acute posterior end of the foot. The rhinophores are perfoliate with about 10 complete or incomplete transverse lamellae. There is a small, convoluted inter-rhinophoral crest (caruncle) between the rhinophores (Fig 2A). The large, bulging cardiac area is located near the middle of the notum. A pair of short, broad, digitiform oral tentacles extends from either side of the head. The dorsal papillae are stout and cup-shaped

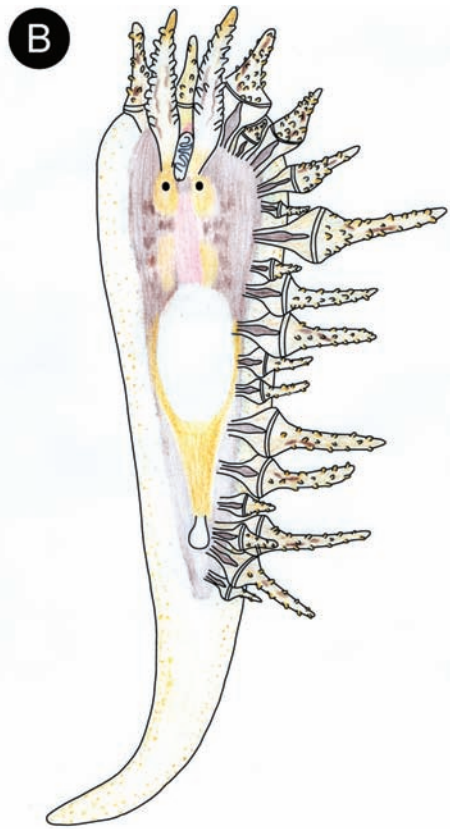
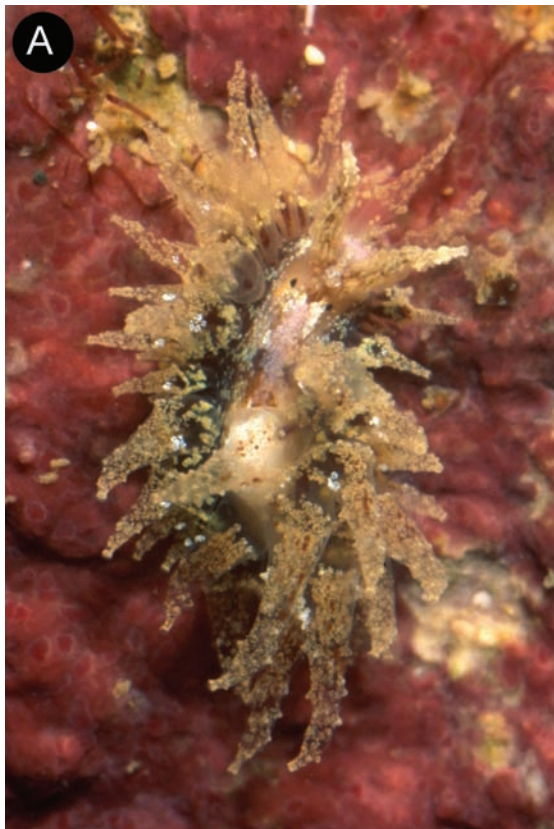


Fig. 1A. Photograph of the living animal of *J. anulatus* sp. nov., Costa Rica (INB0001495772). B. Drawing of the living animal of *J. anulatus* sp. nov., Costa Rica (INB0001495772). Photograph of the living animal of *J. barbarendis*, Costa Rica (INB0001496134). B. Drawing of the living animal of *J. barbarendis* Costa Rica (INB0001496134).

with a long prolongation at the apex. The base of each papilla is smooth, followed by a ring and numerous small papillae that extend the length of each papilla (Fig 2C). The papillae are arranged in two longitudinal rows of up to 25 papillae. The digestive gland inserts into the papillae at a point just below or just above the ring of the papilla. The digestive gland does not branch. The anus is located mid-dorsally near the posterior end of the dorsum (Fig 2D). A large anal gland is present below the anus. The gonopore is located on the right side in the middle of the body, while the nephroproct is situated more posteriorly.

In some specimens, the background color of the dorsum bears two colors: the anterior half dark brown, the posterior half light brown. In others, the background color is white with

some brown spots (Fig 1A). Around the eyes, there is a translucent light cream mask. A pink spot extends from behind the rhinophores to the anterior part of the cardiac area. There is another pink spot in front of the rhinophores with two opaque white spots to the sides. The cardiac area is opaque white in color. The anus is opaque white with a small stalk. Rhinophores are dark cream with light apices and some central dark brown spots. The inter-rhinophoral crest is opaque white with a few cream spots. The digestive gland within the papillae is chocolate brown. The background color of the papillae is light cream with some large brown and opaque white spots. The smaller papillae on the digestive gland are yellow. There are some green reflective specks distributed homogenously on the body. Dorsally, the foot

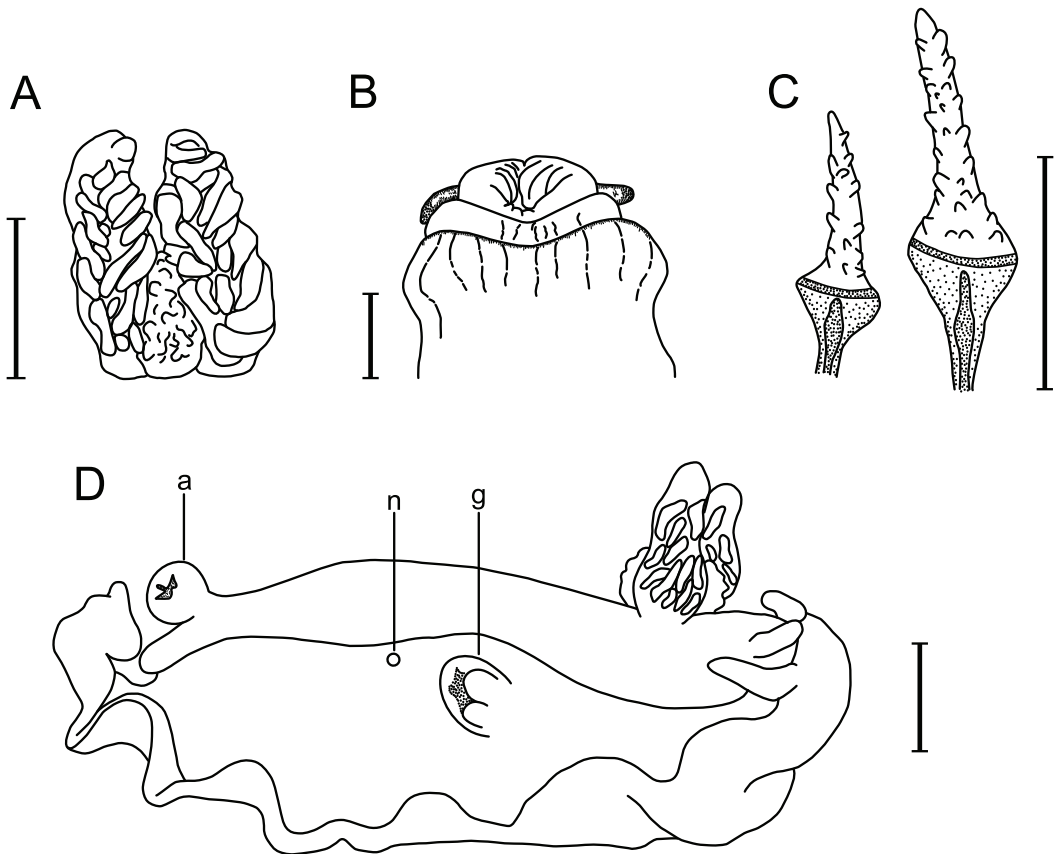


Fig. 2A. Rhinophores and inter-rhinophoral crest of *J. anulatus* sp. nov., scale bar= 1 mm. B. Mouth, scale bar= 1 mm. C. Detail of dorsal papillae of *J. anulatus* sp. nov., scale bar= 1 mm. D. Lateral view of body, scale bar= 1 mm, Abbreviations: a= anus, g= gonopore ,n= nephroproct, scale bar= 1 mm.

is translucent with very small cream-colored spots around the margins. Ventrally, the mouth has numerous light brown specks, the oral tentacles are opaque white, and the foot bears cream specks.

**Anatomy:** The buccal mass is large and muscular with an oval opening and with small anterior oral glands in front of it (Fig. 3A). The strong jaws are amber in color. They are joined together and are devoid of any serial denticles (Fig 3B, 5D). The inner masticatory border is thick and smooth.

The radular formula is 13 x (19.1.19) in a 4 mm preserved length specimen. The rachidian teeth are small and somewhat amorphous in shape, without denticles (Fig. 5A). The inner lateral teeth are hook shaped, smooth, and arched (Fig. 5B). They gradually become larger from the innermost to the mid-laterals, then become smaller from the mid-laterals to the hook-shaped outermost teeth (Fig 5C).

The ampulla is thick and convoluted. It narrows into the bifurcation of the vas deferens

and the thin oviduct. The distal vas deferens is short and enlarges into a much thicker, curved prostate. The prostate narrows into a convoluted ejaculatory duct that connects to the large, conical, unarmed penis (Fig 4). The oviduct is short and expands into a tubular serial seminal receptacle. This duct again narrows and widens into the muscular, kidney-shaped vagina. A tubular bursa copulatrix enters the female atrium near its junction with the oviduct. The female gland mass is oval and exits into the female atrium.

**Remarks:** *J. anulatus* sp. nov. differs from other species of the genus *Janolus* from the Panamic Province and the Western Atlantic in its internal and external morphology (Table 1). *J. anulatus* is characterized by having a brown or white body with pink, white, and brown spots, smooth papillae epithelium at the base and papillated in the distal part of each papilla, unbranched digestive gland ducts within the dorsal papilla, smooth jaws, and smooth rachidian and lateral teeth.

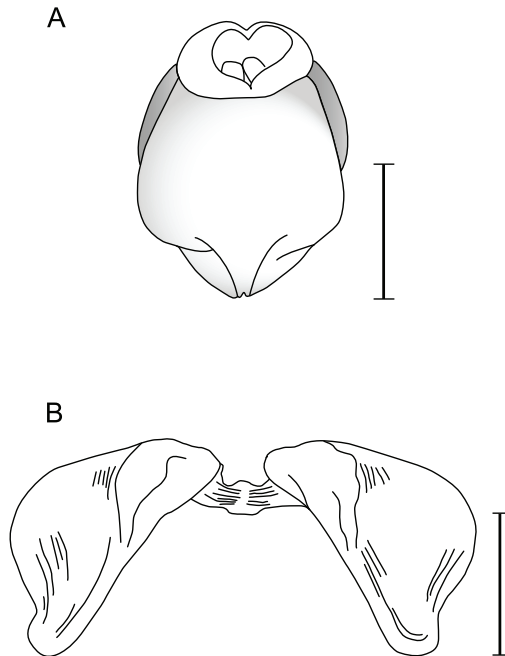


Fig. 3A. Buccal mass of *J. anulatus* sp. nov., scale bar= 1mm. B. Jaw of *J. anulatus* sp. nov., scale bar= 1 mm.

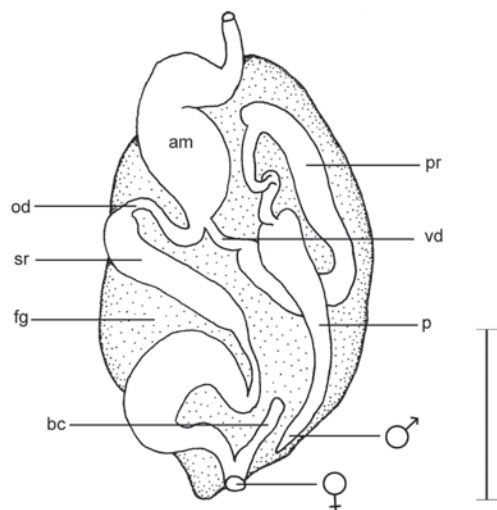


Fig. 4. Reproductive system of *J. anulatus* sp. nov. (INB0001495772), scale bar= 1mm. Abbreviations: am=ampulla, bc=bursa copulatrix, fa = female atrium, fg=female gland, mg= male gonopore, ov= oviduct, p= penis, pr=prostate, sr=seminal receptacle, vd= vas deferens.

TABLE 1

Comparative morphology of the valid species of the genus *Janolus* from the Panamic Province and Western Atlantic

Species	<i>Janolus barbansensis</i> (Cooper, 1863)	<i>Janolus fuscus</i> (O'Donoghue, 1924)	<i>Janolus comis</i> Marcus, 1955	<i>Janolus mucloec</i> (Marcus, 1958)	<i>Janolus rebecca</i> Schrödl, 1996	<i>Janolus costacubensis</i> Ortega & Espinosa, 2000	<i>Janolus anulatus</i> sp. nov. Camacho-García & Gosliner
Description source	Gosliner, 1981; Gosliner 1982	Gosliner, 1981; Gosliner 1982	Marcus, 1955; Gosliner, 1981	Marcus, 1958; Gosliner, 1981	Schrödl, 1996	Ortega & Espinosa, 2000	present paper
Geographic range	California, Costa Rica (Pacific coast)	Alaska, Canada (Pacific coast), California	East Florida, Curacao, Brazil	East Florida, Brazil	Chile	Costa Rica (Atlantic coast), Cuba	California, Costa Rica (Pacific coast)
Dorsal color	translucent white, gold and blue papillae	translucent white with brown lines	light brown with dark brown stipples	translucent white with opaque white lines	translucent with opaque white spots on notum	cream, with a longitu- dinal white line in the middle and white spots	brown or white with pink, white and brown spots
Rhinophoral sheaths color	with a lemon yellow band of pigment, and an apical band of blue	pink with an opaque white apex	with brown spots	-	white apices above a subapical light blue marking	with a reddish spot in the apices	dark cream with light apices and central dark brown spots
Papillae color	with gold subapical ring and blue apices	yellow and white	-	papillae has orange spot and opaque white lines	with a subapical golden brown ring and white apices	with a subapical red spot	light cream with some large brown and opaque white spots
Papillae epithelium	smooth	smooth	papillate	smooth	smooth	papillate	papillate distally
Papilla ducts	branched	unbranched	unbranched	branched, bifurcate below middle	branched	branched	unbranched
Anal glands	present	absent	absent	present	present	unknown	present
Oral glands	small anterior	small anterior, large posterior	unknown	unknown	small subepidermal	unknown	small anterior
Seminal receptacle	short, spherical, serial	proximal, semi-serial	proximal, serial	proximal, semi-serial within female gland mass	stalked and elongate	unknown	serial
Bursa copulatrix	large, saccate	distal	absent	absent	absent	unknown	short, tubular
Penis	large, muscular and thick	conical	conical, flagellar	thick	thick and conical covered by muscular wall	unknown	conical, thin

TABLE 1 (Continued)  
Comparative morphology of the valid species of the genus *Janolus* from the Panamic Province and Western Atlantic

Species	<i>Janolus barbarentis</i> (Cooper, 1863)	<i>Janolus fuscus</i> (O'Donoghue, 1924)	<i>Janolus comis</i> Marcus, 1955	<i>Janolus mucloc</i> (Marcus, 1958)	<i>Janolus rebecca</i> Schrödl, 1996	<i>Janolus costacubensis</i> Ortea & Espinosa, 2000	<i>Janolus anulatus</i> sp. nov. Camacho-García & Gosliner
Prostatic vas deferens	short, muscular	throughout	proximal to penis only	throughout	thick and convoluted	unknown	short
Reproductive ducts	diaulic	diaulic	triaulic	triaulic	androdiaulic	unknown	diaulic
Jaws	7-9 denticles	8-14 denticles	smooth	8 denticles	10 to 12 denticles	smooth	smooth
Radular teeth	rachidian smooth, laterals: inner 2 denticulate, outer smooth	rachidian denticulate, laterals: inner 2 denticulate, outer smooth	rachidian denticulate, laterals: denticulate, variable	rachidian denticulate, laterals: inner denticulate, outer smooth	rachidian smooth, laterals smooth, outer smooth	rachidian with a groove, laterals smooth	rachidian smooth, laterals smooth
Radula	16 x (27.1.27)	21 x (22.1.22) 26 x (25.1.25)	16 x (12-20.1.12-20) 25 x (41.1.41)	18 x (24.1.24)	26 x (30.1.30) 20 x (26.1.26) 22 x (25.1.25)	11 x (11.1.11)	13 x (19.1.19)

- No information available

*J. barbarentis* and *J. costacubensis*, two species present along the Pacific and Caribbean coasts of Costa Rica, respectively, differ from *J. anulatus*. *J. barbarentis* has a translucent white body with gold and blue cerata, markings on the dorsal papillae with branched digestive gland ducts, jaws with denticles, and lateral teeth with denticles. *J. costacubensis* has a cream body with a longitudinal white line, rhinophores with papillae on the bases, and lamellae in the distal part of the rhinophores. In this species, the entire epithelium of the dorsal papillae bears papillae, while in *J. anulatus* only the apical portion above the ring bears papillae. The digestive gland in the papillae of *J. costacubensis* extends for more of the length than does that of *J. anulatus*.

Of the six species of *J.* described from the Americas, only *J. comis* and *J. costacubensis* have dorsal papillae with a papillate rather than smooth surface. These two species, together with *J. anulatus*, are also the only American taxa with a smooth margin on the jaws.

*J. fuscus* differs from *J. anulatus* on the basis of its radular, external, and internal morphology. *J. fuscus* has a translucent white body with brown lines, yellow and white papillae, smooth papilla epithelium, jaws with 8 to 14 denticles, and denticulate rachidian and lateral teeth. This species lacks anal glands, which are present in *J. anulatus*.

Behrens (1991) and Camacho-García *et al.* (2005) published a photo of a species of *Janolus* from La Jolla, California (as *Janolus* sp. 1, page 82) and from México and Costa Rica (as *Janolus* sp., page 98). This species corresponds to the same species we are describing in this paper.

*J. comis* resembles *J. anulatus* in that its epithelium of the dorsal papillae is papillated, but differs in that it lacks an anal gland and has denticulated rachidian and lateral teeth. It also lacks a bursa copulatrix.

*J. rebecca* differs externally from *J. anulatus* by the presence of a white line on the posterior end of the foot, branched digestive gland ducts, and numerous smooth dorsal papillae, which have a golden brownish ring below the



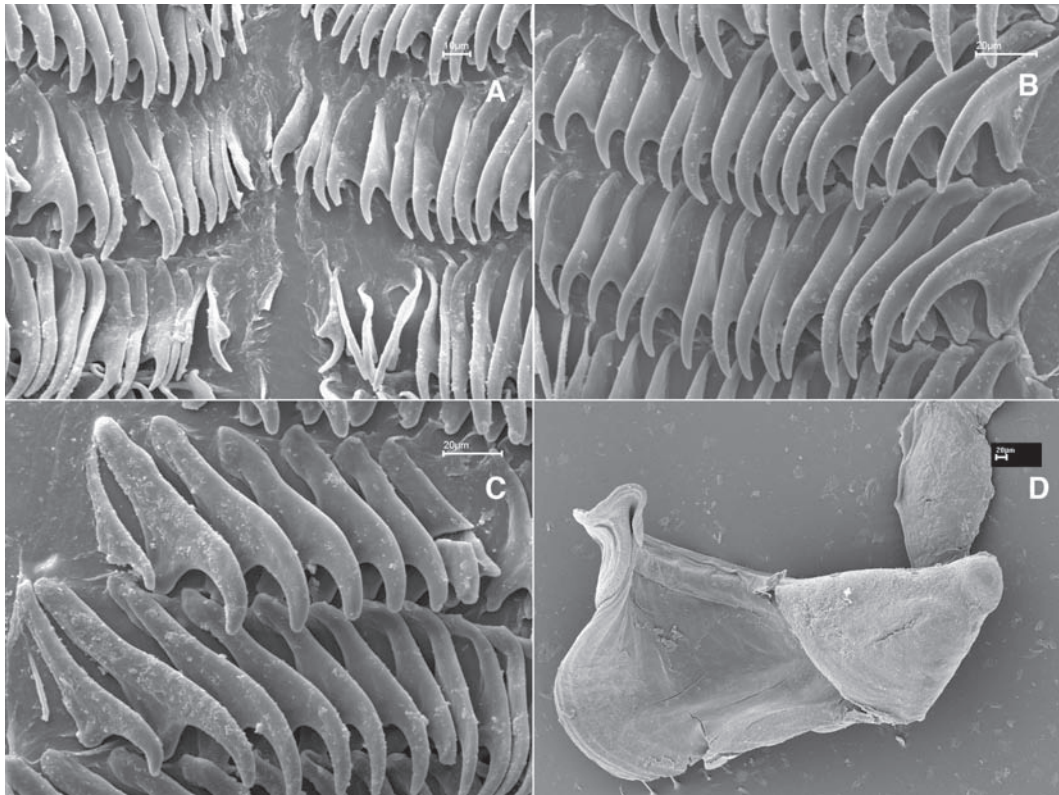


Fig. 5. Scanning electron micrographs of *J. anulatus* sp. nov. (INB0001495772). A. Innermost radular teeth, scale bar= 10 µm. B. Midlateral radular teeth, scale bar= 20 µm. C. Outermost radular teeth, scale bar= 20 µm. D. Jaw, scale bar= 20 µm.

white-tipped papilla. *J. rebecca*e externally resembles *J. barbarentis* but differs to some extent in internal morphology and radular features discussed in detail by Schrödl (1996).

*J. chilensis* Fischer, Cervera and Ortea 1997, another species described from Chile, is considered a junior synonym of *J. rebecca*e (Cervera 1997). However, Schrödl (2003) considered both species different due to differences in their reproductive system. More material from Chile needs to be examined.

*J. hyalinus* (Alder and Hancock 1854), a species present in the Atlantic and Mediterranean waters of Europe, also resembles *J. anulatus* because of the presence of papillae on the dorsal papillae. However, this species has many more dorsal papillae and these are more elongated and evenly shaped than those of *J. anulatus*, which has unevenly tapered papil-

lae with more prominent tubercles. *J. hyalinus* also has a semiserial receptaculum seminis, while *J. anulatus* has a serial one and a distal bursa copulatrix, which is absent in *J. hyalinus* (Schmekel 1970).

*Janolus barbarentis*  
(Cooper 1863)  
(Figs 1B, 6-7)

*Aeolis barbarentis* Cooper 1863:59.

*Antiopella coeruleopictus* Cockerell and Eliot 1905, O' Donoghue 1922.

*Antiopella aureocincta* Johnson and Snook 1927; Steinberg, 1963, *nomen dubium*.

*Antiopella aureotincta* MacGinitie and MacGinitie 1949; Steinberg 1963, *nomen dubium*.

*Antiopella aureocincta* MacFarland 1966, in part.

*J. barbarentis* (Cooper, 1863); O' Donoghue 1922.

**Material examined:** West side of Isla Ballena, Parque Nacional Marino Ballena, Área de Conservación Osa, Puntarenas, Costa Rica (9°06'24" N, 83°43'35" W), 16 January 2000, 1 specimen, 4 mm preserved length, 6 meters depth, leg. M. Calderón (INB0001496134).

**Geographic range:** Central California to Bahía San Quintín, Baja California, the Gulf of California, México, and Costa Rica (present study).

**Natural History:** It has been found on the upper surface of rocks in 6 meters deep.

**External morphology:** The body is broadest anteriorly, tapering to the acute posterior end of the foot. The rhinophores are smooth basally and perfoliate distally with about 13 complete or incomplete transverse lamellae. The inter-rhinophoral crest located between the rhinophores is hourglass shaped, and moderately convoluted (Fig 1D and 6A). A pair of short, broad, digitiform oral tentacles extends from either side of the head (Fig 6B). The smooth dorsal papillae are stout, wider in the middle, and have a short prolongation at the apex (Fig 2C). In the specimen examined, the papillae are arranged in about two rows on either side of the body, with two papillae per row. The digestive gland inserts into the papillae at the base and branches irregularly within the papilla. The anus is located mid-dorsally near the posterior end of the dorsum (Fig 6D). The large gonopore is located on the right side in the middle of the body. A large anal gland is present below the anus.

The living animal of the specimen examined is translucent orange with a number of small brown specks homogeneously distributed over the dorsum. The inter-rhinophoral crest is pinkish. The light brown greenish pigment of the digestive gland is visible within the cerata. The ceratal surface bears an orange-yellow subapical band and a bluish white apical band. The middle part of each rhinophore is light yellow with black spots; a number of minute brownish spots is located at the base of each rhinophore. The anus has a white ring around

it. Dorsally, the foot is translucent white with a light blue line extending to the posterior end. Ventrally, the foot is light orange.

**Anatomy:** The buccal mass is large and muscular with an oval opening and small anterior oral glands (Fig. 6E). The strong jaws are amber in color. They are joined together and have at least 7 strong and wide rectangular denticles around the masticatory border (Fig 7D).

The radular formula is 14 x (15.1.15) in a 4 mm preserved length specimen. The rachidian teeth are narrow with a pointed cusp, without denticles (Fig. 7A). The inner lateral teeth are hook shaped, smooth, and arched (Fig. 7B). They gradually become larger from the innermost to the mid-laterals, then become smaller from the mid-laterals to the hook-shaped outermost teeth (Fig 7C).

The reproductive system of the specimen was studied. However, some of the parts were not well developed because the specimen was immature. The ampulla is tubular and short. It narrows to the bifurcation of the vas deferens and oviduct. The vas deferens is short and convoluted. It narrows into a pear-like shaped penis (Fig 6F). The oviduct is short and expands into a tubular duct where the seminal receptacle is not clearly differentiated. This duct again narrows and widens into a globular bursa copulatrix and a globular vagina. The female gland mass is amorphous in shape and exits near into the female atrium.

**Natural History:** This species was found in the subtidal zone around 6 meters depth where it feeds on ramified bryozoans.

**Remarks:** The internal and external morphology of the single specimen collected in Costa Rica perfectly fits with the description of *J. barbarentis* (Cooper 1863) in Gosliner (1982). Gosliner found and discussed in detail several consistent differences in the external morphology, coloration, digestive system and reproductive system that confirms that *J. barbarentis* is a distinct species from *J. fuscus*, another species found along the California coast.



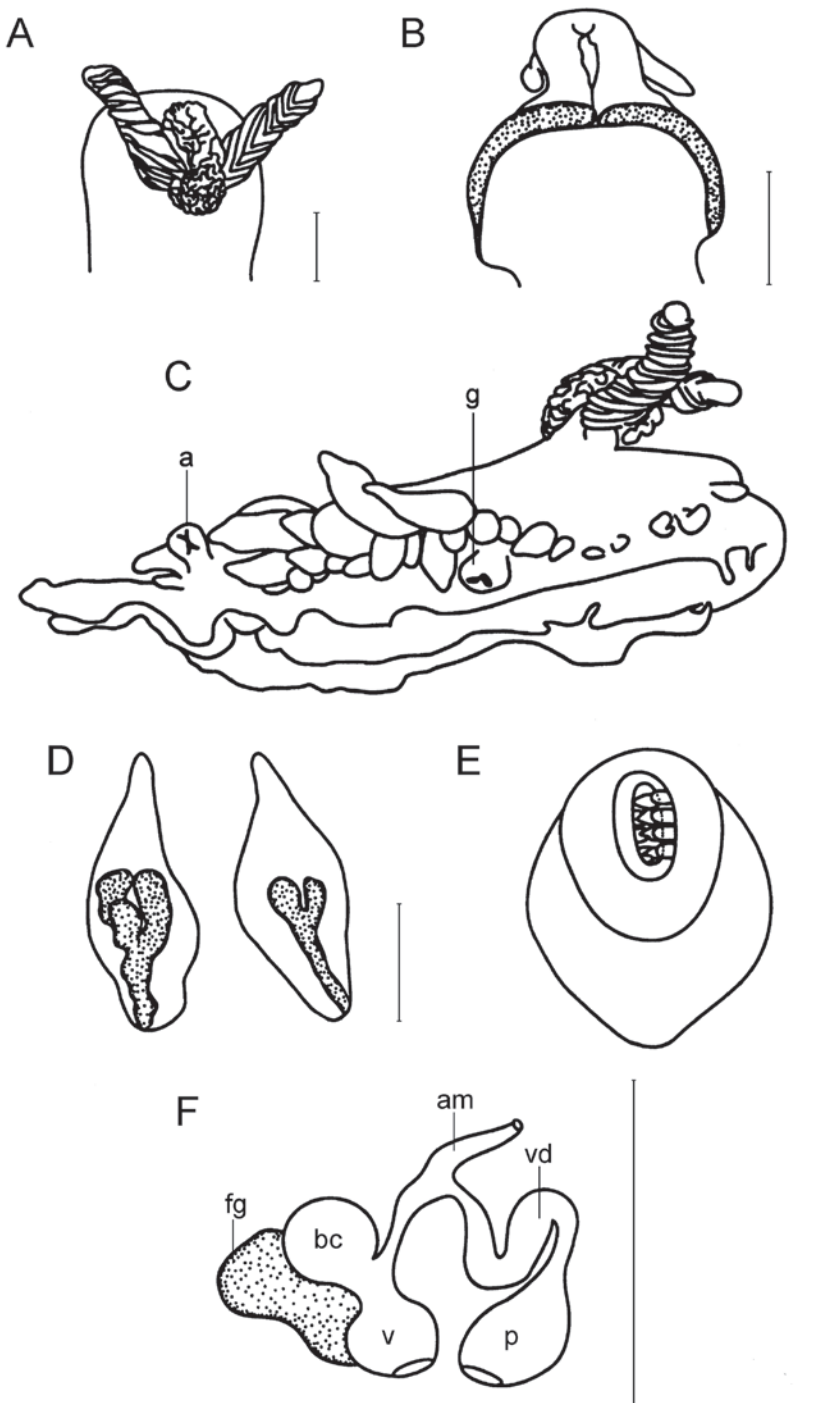


Fig 6. Rhinophores and inter-rhinophoral crest of *J. barbarensis* (INB0001496134), scale bar= 1 mm. B. Mouth, scale bar= 1 mm. C. Lateral view of body, scale bar= 1 mm, Abbreviations: a= anus, g= gonopore, scale bar= 1 mm. D. Detail of dorsal papillae, scale bar= 1 mm. E. Buccal mass, scale bar= 1mm. F. Reproductive system, scale bar= 1mm. Abbreviations: am=ampulla, bc=bursa copulatrix, fg=female gland, p= penis, v= vagina, vd= vas deferens.

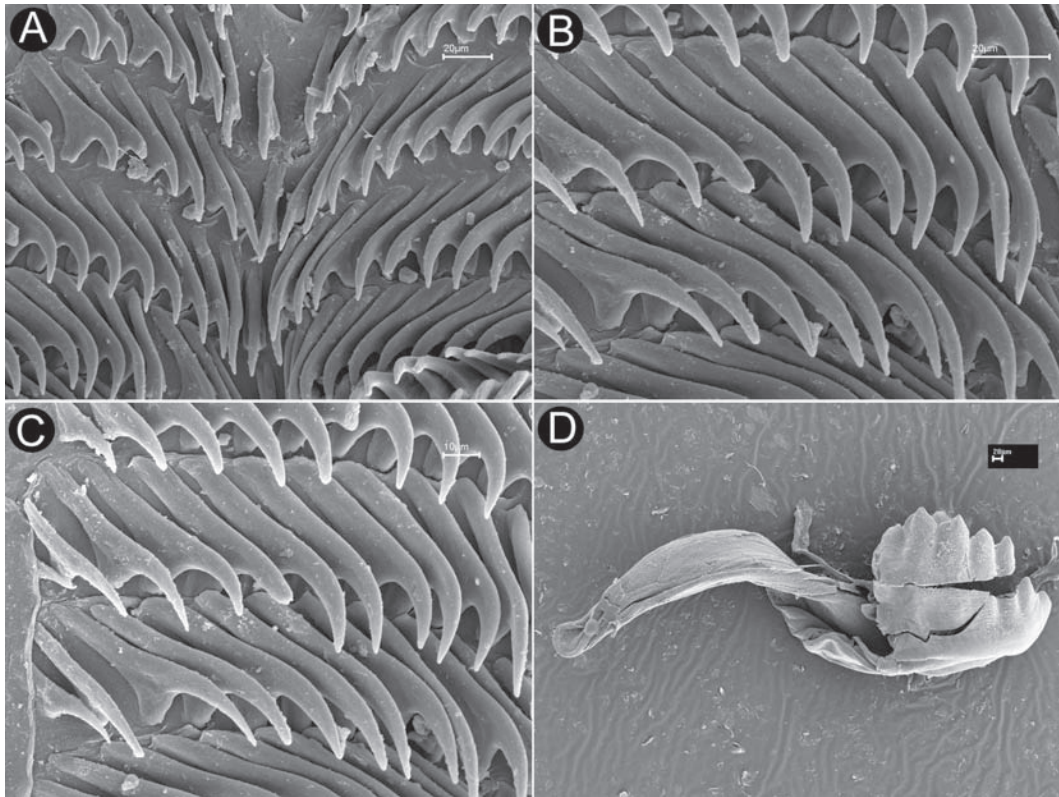


Fig. 7. Scanning electron micrographs of *J. barbarentis* (INB0001496134). A. Innermost radular teeth, scale bar= 20 µm. B. Midlateral radular teeth; scale bar= 20 µm. C. Outermost radular teeth, scale bar= 10 µm. D Jaw, scale bar= 20 µm.

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#### RESUMEN

Una nueva especie de nudibranquio zefirínido del género *Janolus* Bergh 1884 es descrita de la costa pacífica de Norte América y Costa Rica. *J. anulatus* sp. nov. difiere de otras especies de *Janolus* por su morfología externa

e interna. *J. anulatus* tiene un cuerpo café o blanco con manchas rosadas, blancas o café, papila del epitelio lisa en la base y con papilas en la parte distal, ductos de la glándula digestiva no ramificados, mandíbulas lisas y dientes laterales y raquidos lisos. La especie es comparada con otras especies de la Provincia Panámica y el Atlántico Oeste. Una nueva extensión de ámbito de *J. barbarentis* es documentada.

**Palabras clave:** Mollusca, Nudibranchia, Costa Rica, *Janolus*.

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