

Two new species of gymnosomatous pteropods from the Gulf of California (Gymnosomata: Pneumodermatidae)

Dos nuevas especies de pterópodos gimnosomados del Golfo de California (Gymnosomata: Pneumodermatidae)

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RESUMEN

Antecedentes: Los Gymnosomata es un grupo de moluscos adaptado a la vida pelágica, que incluye unas 47 especies válidas en todo el mundo. En arrastres de zooplancton realizados en el Golfo de California durante enero de 2007, se recolectaron especímenes de dos especies diferentes de Gymnosomata con características morfológicas que no pertenecían a ninguna de las especies previamente descritas. **Objetivos:** Describir con base en las características de la rádula, dos nuevas especies de moluscos gimnosomados recolectados en la porción central del Golfo de California, México. **Métodos:** Diez especímenes de Gymnosomata fueron obtenidos de arrastres de zooplancton usando un Sistema de redes Bongo. Todos los organismos descritos se identificaron en estadio adulto. Tres especímenes fueron disectados y su masa bucal fue removida y disuelta en hidróxido de sodio al 10% hasta que la rádula quedara sin el tejido que la rodea. Posteriormente, la rádula fue montada para fotografías de microscopía electrónica. **Resultados:** Se describieron dos nuevas especies, *Pneumoderma cicimarensis* sp. nov. y *Pneumodermopsis tacoi* sp. nov. **Conclusiones:** *Pneumoderma cicimarensis* sp. nov., tiene una morfología similar a *Pneumoderma pacificum* Dall, 1871, pero difiere en la presencia de un lóbulo en la porción media del ala, la ausencia de cromatóforos en el cuerpo y en la forma de los dientes radulares. *Pneumodermopsis tacoi* sp. nov., tiene una rádula similar a la de *Pneumodermopsis ciliata* (Gegenbaur, 1855), pero difiere significativamente en el número de hileras de la rádula y en la forma de los dientes centrales.

Palabras clave: moluscos holoplanctónicos, nuevas especies, Gymnosomata, *Pneumoderma*, *Pneumodermopsis*

ABSTRACT

Background: The Gymnosomata is a group of mollusks adapted to pelagic life, which includes about 47 valid species worldwide. Zooplankton tows in the Gulf of California during January 2007 led to the collection of specimens of two different species of Gymnosomata with morphologic characters that did not belong to any species previously described. **Goals:** To describe, based on radular characteristics, two new species of gymnosomatous mollusks collected at the central portion of the Gulf of California, Mexico. **Methods:** Ten specimens of Gymnosomata were obtained with zooplankton tows using a Bongo net system. All the organisms described were identified as adult stages. Three specimens were dissected, and their buccal mass was removed and dissolved in 10% sodium hydroxide until the radula was isolated from the surrounding tissue. Posteriorly the radula was mounted for scanning electron micrographs. **Results:** Two new species were described, *Pneumoderma cicimarensis* sp. nov. and *Pneumodermopsis tacoi* sp. nov. **Conclusions:** *Pneumoderma cicimarensis* sp. nov. has a similar morphology to *Pneumoderma pacificum* Dall, 1871, but differs in the presence of one lobe on the median portion of the wing, a lack of chromatophores in the body and the shape of the radular teeth. *Pneumodermopsis tacoi* sp. nov. has a similar radula to *Pneumodermopsis ciliata* (Gegenbaur, 1855), but differs significantly in the number of rows of the radula and the shape of the central tooth.

Keywords: holoplanktonic molluscs, new species, Gymnosomata, *Pneumoderma*, *Pneumodermopsis*

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INTRODUCTION

The Gulf of California is a hydrographically complex region. It possesses strong environmental gradients and latitudinally is associated with convergence in its central region, which results in highly diverse environments due to the mix of temperate, subtropical, and tropical species in a relatively small area (Riginos, 2005). With its high number of microhabitats, the region also has a high number of endemic marine species (Briggs, 1974, Brinton & Townsend, 1980; Brusca & Findley, 2005). For poorly known groups the possibility of finding new species increases, such in the case of gymnosomatous pteropods.

The Gymnosomata is one of two groups within Pteropoda (Jörger *et al.*, 2010, Schrödl *et al.*, 2011) that has adapted for pelagic life (Lalli & Gilmer, 1989): The Gymnosomata, which have no shells, and the Thecosomata, most of which have shells. The division between these two holoplanktonic groups of molluscs is justified by other anatomical characteristics as well (Pelseneer, 1887). The absence of a shell in gymnosomes results in most of the specimens contracting into indistinguishable forms after preservation and all taxonomic features are altered. Despite this problem, the Gymnosomata include about 47 valid species contained in four families (Gofas, 2018). Pneumodermatidae (Pelseneer, 1857) is the most speciose with 18 species worldwide (5 *Pneumoderma*, 13 *Pneumodermopsis*) (Spoel *et al.*, 1997, Bouchet & Gofas, 2018a, b). The distinctive characteristics of Pneumodermatidae are the presence of suckers on the ventral side of the protrusile on the anterior portion of the buccal cavity, a lateral gill on the right side of the body, a jaw and pigmented skin (Pelseneer, 1887). Only four species are registered in the Gulf of California, one belonging to the genus *Pneumoderma* (Cuvier, 1805). These are *Pneumoderma pacificum* Dall, 1871 and three belong to *Pneumodermopsis* Keferstein, 1862, i.e., *Pneumodermopsis canephora* Pruvot-Fol, 1924, *Pneumodermopsis ciliata* (Gegenbaur, 1855) and *Pneumodermopsis macrochira* Meisenheimer, 1905 (Angulo-Campillo *et al.*, 2011).

Zooplankton tows in the Gulf of California were performed to obtain a collection of specimens of Gymnosomata with morphologic characteristics that did not belong to any species previously described. Two new species of gymnosomes collected from the central portion of the Gulf of California, Mexico, were described here based on radular characteristics.

MATERIALS AND METHODS

Ten specimens of Gymnosomata were obtained from the central region of the Gulf of California during an oceanographic survey in January 2007. The specimens were captured using oblique tows with Bongo nets of 505 µm mesh. Tows were made at a maximum depth of 200 m. The specimens were preserved in 95% ethanol and deposited at the Department of Invertebrate Zoology and Geology of the California Academy of Sciences, San Francisco (CASIZ). The external features were examined and drawn using a dissecting microscope with a camera lucida. All the organisms described here were identified as adult stages using as indicative the presence of a well-developed lateral gill as well as the presence of a developed gonad. Three specimens were dissected, two specimens for *Pneumoderma cicimarensis* sp. nov. and one for *Pneumodermopsis tacoi* sp. nov. The buccal mass was removed and dissolved in 10% sodium hydroxide until the radula was isolated from the surrounding tissue (Geiger *et al.*, 2007); later, the radula was

mounted for scanning electron micrographs (SEMs) produced on a Hitachi S-3000N scanning electron microscope at CIBNOR.

RESULTS

Family Pneumodermatidae Pelseneer, 1857

Genus *Pneumoderma* Cuvier, 1805

***Pneumoderma cicimarensis* sp. nov.** (Figs 1a-f)

Type Species: *Pneumodermon pacificum* Dall, 1871: 139; 37°8' N 136°10' W, Coll.: Dall, reg. no. 301.

Previous references: *Pneumoderma* sp. Angulo-Campillo *et al.*, 2011.

Etymology: The specific name *cicimarensis* is taken from the acronym CICIMAR (Centro Interdisciplinario de Ciencias Marinas), which refers to the institution where the authors completed their Ph.D.

Type Material: Holotype: Central portion of the Gulf of California (27°49'22" N, 111°24'4" W), 4.3 mm body length, collected by Orso Angulo and Gerardo Aceves, 21 January 2007. (CASIZ 178438).

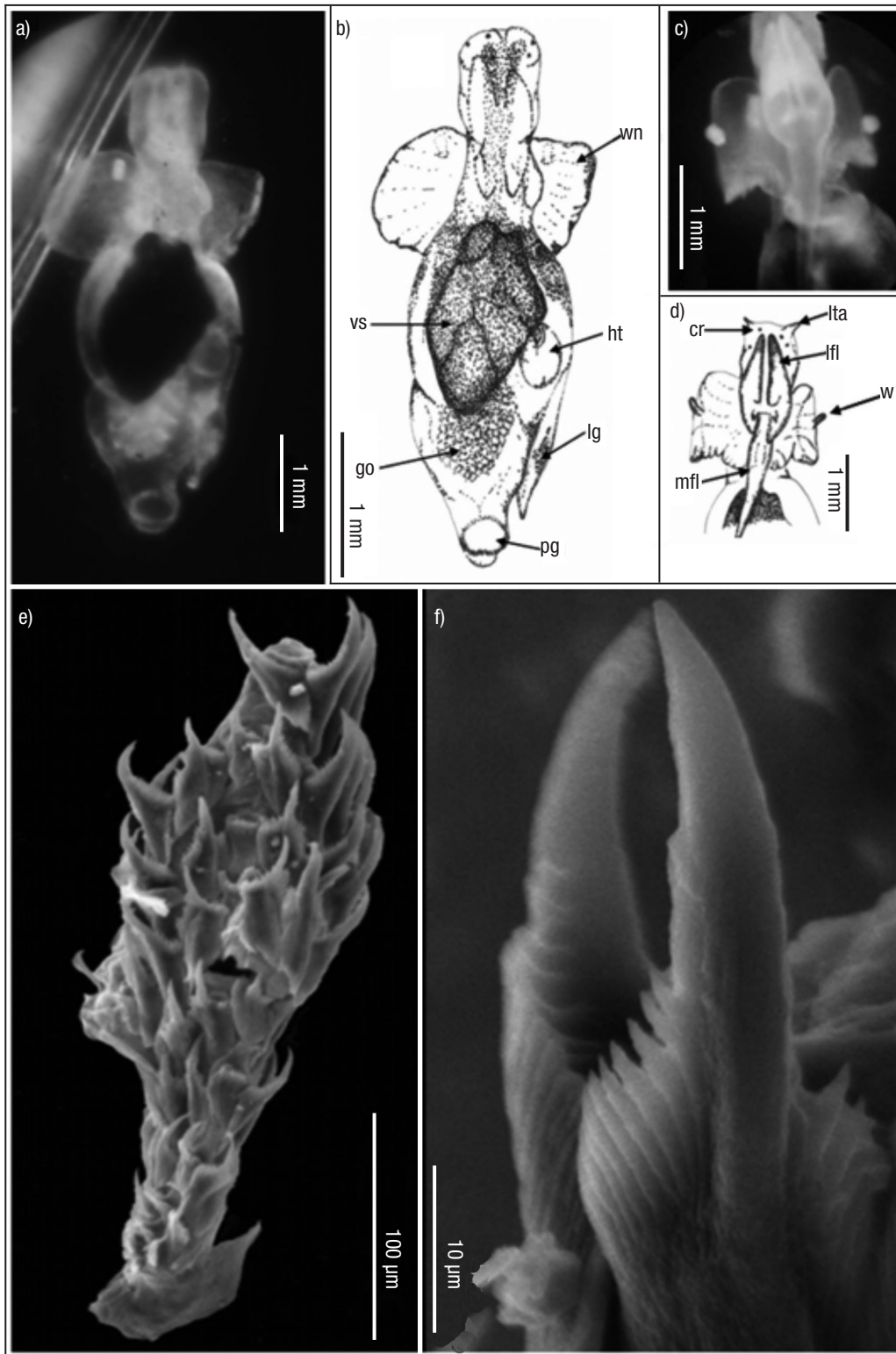
Paratypes: two specimens, 4.2 and 2.8 mm body length (CASIZ 178439), central portion of the Gulf of California (26°45'2" N, 110°53'4" W), one specimen 3.1 mm body length, collected by Orso Angulo and Gerardo Aceves, 22 January 2007. (CASIZ 178440).

Additional material: two specimens 3.1 and 3.0 mm (dissected), collected on 22 January 2007 from near shore waters west of Santa Rosalía, Baja California Sur, Mexico (26°25'22" N, 110°32'12" W), by Orso Angulo and Francisco Dominguez.

Type locality: Central portion of the Gulf of California (27°49'22" N, 111°24'4" W), caught in tows made between 200 m depth and the sea surface.

Geographic distribution: Known only to inhabit in the Gulf of California.

Description: External morphology: Body color: translucent; head: cream colored. Visceral mass: dark. Body: cylindrical; rounded anteriorly when extended, and barrel shaped when contracted (Fig. 1a). Head differentiated from the body. Wings subquadrate, slightly notched at their inner posterior edge with one lobe on the median portion of the wing (Fig. 1b). Small chromatophores in the head. Two lateral arms with two suckers each on the mouth region. Lateral footlobes short, reaching 1/4 length of the median footlobe, which is long and pointed when extended, reaching one third the length of the trunk. The viscera can be seen through the body walls, reaching two-thirds the length of the trunk. A long lateral gill with a dorsal spot situated on the upper portion. The lateral gill extends up to two thirds the length of the body where it reaches the margin of the posterior gill, which is simple (without ornamentations) and fringed, well-marked regular undulations (Figs 1c-d). Radula (Figs 1e-f): The radula formula is 3.0.3 with nine rows (Fig. 1e). The radular teeth have a large, curved, and pointed central cusp. On each side of the central cusp there are 11 to 13 smooth, shorter denticles (Fig. 1f). Denticles are slightly curved inwards, with long ridges that extend to the base of the central cusp.



Figures 1a-f. *Pneumoderma cicimarensis* sp. nov. a) Ventral view of live specimen, holotype, 4.3 mm long (CASIZ 178438). b) Anatomical sketches drawn with the aid of a camera lucida. c) Close-up of the dorsal portion showing the footlobes and wing lobes. d) Anatomical sketches of the dorsum. e) Radula. f) Detail of teeth. Cr = Cromatophore; go = Gonad; ht = Heart; lfl = Lateral foot lobe; lg = Lateral gill; lta = Lateral arm; mfl = Median foot lobe; pg = Posterior gill; vs = viscera; wl = Wing lobe; wn = Wing.

Remarks: The placement of *Pneumoderma cicimarensis* sp. nov. in the Pneumodermatidae is based on the presence of a lateral gill, differentiation of the cephalic region and presence of chromatophores, while the presence of a dorsal glandular spot is characteristic of the genus (Pelseneer 1857). The other four species are not found in the eastern Pacific and they do not have a wing lobe (Table 1). *P. cicimarensis* sp. nov. is unique within the genus with the presence of one lobe on each wing; this characteristic has not been described in any other member of the family or gymnosome. Another characteristic feature is the absence of chromatophores on the trunk. *P. pacificum* differs from *P. cicimarensis* sp. nov. in coloration; *P. pacificum* is purple, and chromatophores extend through the entire body. In addition, the form of the teeth and radula formulae is different; in *P. cicimarensis* sp. nov. the radula formula is 3.0.3 and teeth are hook-shaped with serrated edges that extend to the base of the central cusp, while in *P. pacificum* it is 4.0.4, and teeth are also hook-shaped, but slender with no serrations or edges (Spoel *et al.*, 1997) (Table 1).

Genus *Pneumodermopsis* Keferstein, 1862

***Pneumodermopsis tacoi* sp. nov.** (Figs 2a-d)

Type species: *Pneumodermon ciliatum* Gegenbaur, 1855: 74. Type locality: not located.

Previous references: *Pneumodermopsis* sp. Angulo-Campillo *et al.*, 2011, Moreno-Alcántara *et al.*, 2014.

Etymology: The specific name *tacoi* is given in honor to Enrique González, teacher and mentor of both authors, who is known among his friends as Taco.

Type Material: Holotype: northwest of Guaymas, Sonora (27°29'42" N, 111°24'38" W), 3.1 mm body length, collected by Orso Angulo and Francisco Domínguez. January 21, 2007. (CASIZ 178441).

Paratypes: two specimens, 2.9 mm and 2.6 mm body length (CASIZ 178442), same locality as the holotype.

Additional material: one specimen 2.5 mm body length (dissected), same locality.

Type locality: Northwest of Guaymas, Sonora (27°29'42" N, 111°24'38" W), caught in tows made between 200 m deep and the sea surface.

Geographic distribution: Known in the Gulf of California and Gulf of Tehuantepec

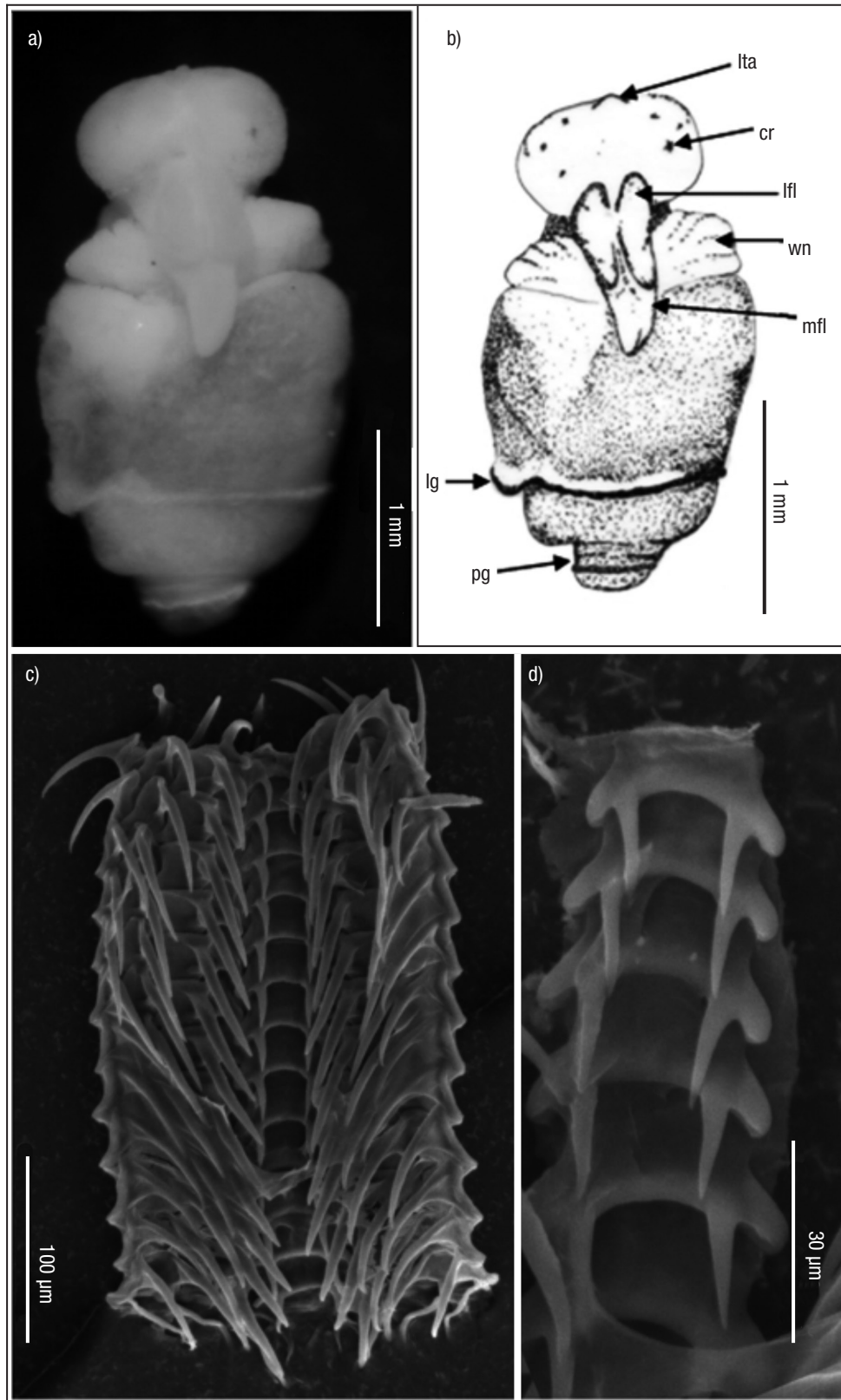
Description: External morphology: Body color: cream, semi-translucent. Visceral mass: brown. Body cylindrical and barrel shaped (Fig. 2a). Head differentiated from the body. Small wings. Small chromatophores in the head. Two lateral suckers arms. Lateral footlobes: short, reaching 1/4 the length of the median footlobe, which is long and thick. Viscera visible through the body wall. A well-developed lateral gill present with a dorsal spot situated on the upper portion. Posterior gill: simple and clearly fringed (Fig. 2b). Radula (Figs 2c-d): The radula formula 3.1.3 (in 13 rows). Lateral teeth: long, slender, and hook-shaped (Fig. 2c). Median teeth: bicuspid (Fig. 2d); base: simple with no ornamentations.

Remarks: The placement of *Pneumodermopsis tacoi* sp. nov. in the Pneumodermatidae is based on the presence of a lateral gill, differentiation of the cephalic region and presence of chromatophores. Due to preservation effects, it was impossible to determine the number of suckers on the lateral arms, thus the description is based on the radula formula. Presence of central teeth accommodates within the *Pneumodermopsis*. A previous report of *Pneumodermopsis* from the North Pacific includes *P. ciliata* and *P. paucidens* (Boas, 1886) (Spoel *et al.*, 1997). In *P. ciliata* the number of lateral teeth varies from 5.1.5 to 6.1.6, with 18 to 25 rows, and with tricuspid median teeth (Spoel & Pafort-Van Lersel, 1982). The teeth shape of *P. paucidens* is similar to that of *P. tacoi* sp. nov., both species have bicuspid median teeth without a central cusp. However, the radula of *P. paucidens* as illustrated in Spoel *et al.* (1997) compared with the radula of *P. tacoi* sp. nov. shows differences between them since the lateral teeth in *P. tacoi* sp. nov. are larger and slender, and the bicuspid teeth are larger. In addition, *P. paucidens* has only a median arm with a large sucker, whereas *P. tacoi* sp. nov. has two lateral arms with small suckers. Remaining species of this genus have a higher number of lateral teeth, except *P. polycotyla* (Boas, 1886) and *P. spoeli* Newman & Greenwood, 1988, which have 2 lateral teeth. However, *P. spoeli* has 24 lateral arms suckers and *P. polycotyla* is distributed only in the Atlantic and Mediterranean (Table 2).

Table 1. Meristic characteristics of *Pneumoderma* species. Lt = Length (mm); Lam = Lateral arm suckers; RF = Radula formula; HH = Number hooks in hook sac; Chr = Chromatophores; WI = Wing lobe; p = present; a = absent.

Species	Lt	Lam	RF	HH	Chr	WI	Distribution
<i>P. cicimarensis</i> sp. nov	45	2	3-0-3	p	p	p	Gulf of California
<i>P. pacificum</i> (Dall, 1871)*	25	50	4-0-4	?	p	a	Cosmopolitan of warm waters
<i>P. violaceum</i> d'Orbigny, 1834*	7	40	?	?	a	a	Warm waters Atlantic and Mediterranean
<i>P. degraaffi</i> Spoel & Pafort-van Lersel, 1982	12	6-8	3-0-3	200	p	a	N Atlantic
<i>P. heronensis</i> Newman & Spoel, 1989	11	12	6-0-6	100	p	a	Australia
<i>P. mediterraneum</i> Van Beden, 1838*	20	7	7-0-7	40	p	a	Atlantic, Mediterranean, Indo-Pacific

* Data obtained from Spoel *et al.* (1997), number of valid species based from Bouchet and Gofas (2018a).



Figures 2a-d. *Pneumodermopsis taci* sp. nov. a) Dorsal view of preserved specimen holotype, 3.1 mm length (CASIZ 178441); b) Anatomical sketches; c) Radula; d) Rachidian. Cr = Cromatophore; lfl = Lateral foot lobe; lg = Lateral gill; lta = Lateral arm; mfl = Median foot lobe; pg= Posterior gill; wn = Wing.

Table 2. Meristic characteristics of *Pneumodermopsis* species. Lt = Length (mm); Lg = lateral gill; Pg = posterior gill; Lam = Lateral arm suckers; RF = Radula formula; HH = Number hooks in hook sac; p = present; a = absent.

Species	Lt	Lg	Pg	Lam	RF	HH	Distribution
<i>P. tacoi</i> sp. nov.	3	p	p	2	3-1-3	-	Gulf of California, Gulf of Tehuantepec
<i>P. brachialis</i> Minichev, 1976*	15	a	p	12	4-1-4	40	Antarctic
<i>P. canephora</i> Pruvot-Fol, 1924*	12	p	a	1	5-1-5	30-60	Atlantic, Mediterranean, Indo-Pacific,
<i>P. ciliata</i> (Gegenbaur, 1855)*	15	p	a	7-8	7-1-7	30-40	N-Atlantic, Mediterranean, N-Pacific
<i>P. macrochira</i> (Meisenheimer, 1905)*	8	p	p	55	6-1-6	16-20	N-Atlantic, N-Pacific and Tasman Sea
<i>P. macrocotyla</i> Zhang, 1964*	8	p	a	4	7-17	40	China Sea and Yellow Sea
<i>P. michaelsarsi</i> Bonnevie, 1913*	11	p	p	8	6-1-6	20-50	N-Antarctic
<i>P. minuta</i> Pelseneer, 1887	3	p	a	8	?	?	Tropical Pacific
<i>P. paucidens</i> (Boas, 1886)*	5	p	p	10-12	2-3-1-2-3	5-6	Indo & N- Pacific, Atlantic, Mediterranean
<i>P. polycotyla</i> (Boas, 1886)*	5	p	p	?	2-1-2	6	Atlantic and Mediterranean
<i>P. pupula</i> Pruvot-Fol, 1926*	2	a	a	5	8-1-8	12	Atlantic and Mediterranean
<i>P. simplex</i> (Boas, 1886)*	5	p	a	-	6-1-6	40-50	South Atlantic
<i>P. teschi</i> Spoel, 1973	9	p	a	12-20	3-7-1-3-7	10	NE-Atlantic and Mediterranean
<i>P. spoeli</i> Newman & Greenwood, 1988	27	a	p	24	2-1-2	6	Great Barrier Reef, Australia

* Data obtained from Spoel *et al.* (1997), number of valid species based from Bouchet and Gofas (2018b).

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