



Two New Parasitic Copepod Species, *Clavella* (Lernaeopodidae) and *Haemobaphes* (Pennellidae), on the Nototheniid Fish *Patagonotothen cornucola* (Richardson, 1844) from the Strait of Magellan, Southern Chile

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Abstract

Purpose The parasitic diversity on the intertidal fish of the Southern American Cone is barely known. The present study describes two new parasitic copepod species, a *Clavella* and a *Haemobaphes* found on the nototheniid fish *Patagonotothen cornucola*.

Methods The fish were collected from the intertidal zone of the Strait of Magellan, Southern Chile. The copepods were found on the fins and in the gill chamber of the fish, which were morphologically analyzed using optical and electronic microscopy.

Results *Clavella cornucola* sp. nov. and *Clavella bowmani* are similar but differ in the number of setae found on the maxillule (two setae on the inner lobe vs. three on *C. bowmani*), and a pad of spinules on the dorsal margin as opposed to the outer lobe (no pad vs. one pad, respectively). *Haemobaphes puntaarenensis* sp. nov. is distinguished from its congeners based on the lobe shapes of the head and the clear separation between the pedigerous somites (first, second, and third). The maxilla on *H. puntaarenensis* sp. nov. lacks a pad of spinules on the second segment, but it is found in all the other congeneric species.

Conclusion *Clavella cornucola* sp. nov. is the 10th species of the genus in Chile, whereas *Haemobaphes puntaarenensis* sp. nov. is the first species of the genus recorded in Chile and the Southern Cone coasts.

Keywords Parasitic copepods · Siphonostomatoida · *Clavella* · *Haemobaphes* · Nototheniidae · Chile

Introduction

The Nototheniidae is a family of ray-finned fishes comprised by 15 genera and 56 species [1]. These fishes are distributed across the Southern Ocean, in both the Antarctic and

sub-Antarctic regions. The fauna of endoparasites is more diverse and better known than ectoparasites [2, 3]. In fact, mesoparasitic copepods, which are partly embedded in its host body, are largely unknown.

A study about the parasite communities of the intertidal fish *Patagonotothen cornucola* in Southern Chile (Punta Arenas) collected in summer 2017, a parasitic copepod, *Haemobaphes* sp. (Pennellidae), was found in the gill chamber with the head embedded in the muscles, close to the heart of the host [4]. Then, a year later in the same locality, another copepod species, a *Clavella* sp. (Lernaeopodidae) was found on the fins of the same host species. Until now, these species have not yet been formally identified.

The family Lernaeopodidae comprises 44 genera. Eight fish species have been identified in the Southern Ocean and Antarctica [5, 6]. The genus *Clavella* is one of the most complex and controversial groups among parasitic Copepoda. Approximately 116 species have been described in this group; however, over 50% of these species have been

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transferred to other genera. Thus, only 44 are considered valid species [7]. Original descriptions of many species are poor, which have not been improved over time. In addition, incomplete descriptions have been applied for appendages; however, detailed descriptions are required to distinguish these species. Taxonomic identification of *Clavella* species is challenging and there is still much to do in the genus. Nine *Clavella* species have been described on fish from Chile [3, 8]. Specifically, for the Southern Ocean, there are only two records of copepods, *Clavella bowmani* Kabata, 1963 and *Clavella adunca* (Strøm, 1762) on fish of *Patagonotothen* spp [6, 9].

The Pennellidae is a less diverse family compared to the Lernaepodidae, with 24 valid genera [7]. Some scarce parasitic pennellids have been noted on fish from the Southern Ocean: one copepod species of *PhrEXOcephalus* was found on *Patagonotothen cornucola* [10]; three other species, found on non-nototheniid fish from the South Pacific Chilean coast, are *Peniculus* cf. *fistula* von Nordmann, 1832; *Metapeniculus antofagastensis* Castro and Baeza, 1985; and *Trifur tortuosus* Wilson, 1917 (= *Lernaenicus tricerastes* Stuardo and Fagetti, 1961) [11–17]. The genus *Haemobaphes* globally comprises 9 species [7]. Thus, specimens of *Haemobaphes* represent an interesting finding.

The main objective of the present study is to describe a *Clavella* and a *Haemobaphes* species found on the *Patagonotothen cornucola* fish.

Materials and Methods

More than 200 specimens of *Patagonotothen cornucola* were collected, in summers of 2017 and 2018, from intertidal rocky pools at Rinconada Bulnes (Strait of Magellan), located 50 km South of Punta Arenas city, Southern Chile. Fish were caught using a diluted anaesthetic solution (1% isoeugenol) and hand nets. Fish were frozen at -20°C and transported to the laboratory. Then, they were dissected to reveal their parasites [4].

Clavella specimens were found on dorsal and caudal fins of the fish, and *Haemobaphes* specimens were found in the gill chambers of the fish with the head embedded in the muscles. The parasites were fixed in a 70% alcohol solution for morphological identifications and analysis. Morphological measurements were obtained with a reticulated eyepiece attached to the ocular of an optic microscope CH2 (Olympus, Japan). Mean and range between parentheses were used for the descriptions of the measurements. Copepod appendages were treated with lactic acid to clear some structures for observations and drawings. Drawings were made with a camera *lucida* attached to a light microscope CH2 (Olympus, Japan).

A scanning electron microscope (SEM) was used to analyze two *Clavella* specimens and one *Haemobaphes* specimen. These specimens were initially fixed in glutaraldehyde, dehydrated through an ethanol series (from 50 to 100%), and followed by a critical point drying in CO_2 using a Samdri 780A machine (Tousimis Research Corporations, Rockville, MD, USA). Then, they were sputter-coated with gold using an Ion JFC-1100 Sputter machine and finally examined with a Hitachi SU 3500 SEM (Hitachi, Japan).

The terminology used for *Clavella* follows that of Kabata [18], terminology for antenna followed that of Boxshall and Halsey [19] and that of *Haemobaphes* followed Gooding and Humes [20], Kabata [25] and Ho and Kim [22].

Descriptions

Family Lernaepodidae Milne-Edwards, 1840.

Genus *Clavella* Oken, 1815.

Species *Clavella cornucola* sp. nov. (Figs 1–4).

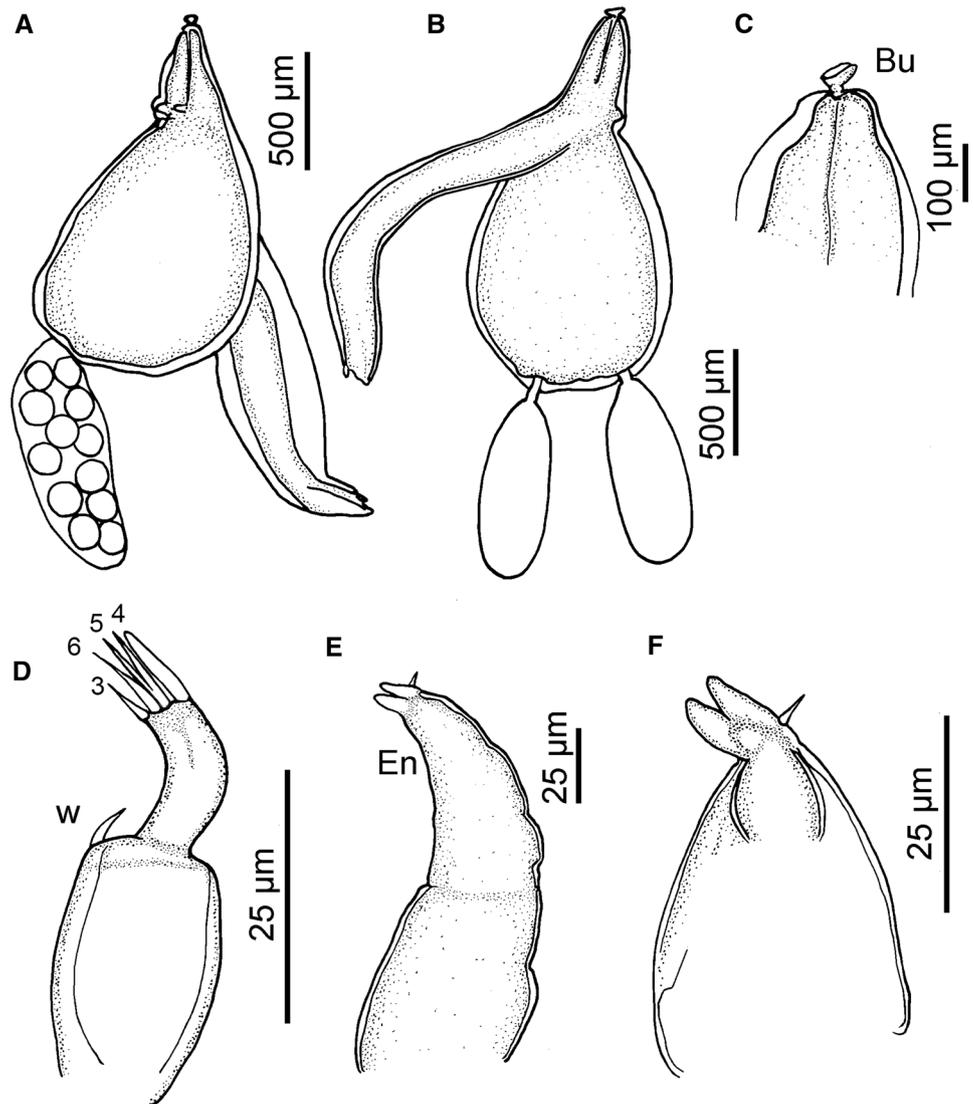
Measurements in micrometers (based on 5 females). Cephalothorax length: 1,980 (1540–2440) \times width 256 (230–308); trunk length 1380 (1250–1800) \times width 876 (560–1000); maxilla length 507 (440–560) \times width 184 (130–250). Egg sac oval, length 806–924 (measurements from 2 ovigerous specimens).

Cephalothorax longer than trunk (Figs. 1A–B, 2A). Trunk elongated, pyriform, posterior margin lacking genital process, no showing anal slit. Cephalothorax 3.9 times longer than maxilla length. Maxilla arms short fused (Figs. 1A–C). Bulla very short, 51 of length (Figs. 1C, 2A–B), cup shaped. Egg sacs elongated. Caudal rami absent.

Antennule bisegmented (Figs. 1D, 2C–D). First segment, wider and longer than second, distally with a whip. Second segment with four elements (4, 5 and 6 and 3); setae 1 and 2 not observed. Antenna uniramous (Figs. 1E, 2C, 2E); endopod with three setae separated (one basal and two distal). Distal end with two small, flat, blunt lobes (Figs. 1E–F, 2E). Endopod base inflated, with no projection nor process.

Buccal cone almost cylindrical shape (Figs. 2C, 3A–B). Labrum dorsally, simple, subtriangular (Fig. 4A), with a short rostrum smooth surface. Labium (Fig. 2C) with a cleft in the distal medial surface (Fig. 3A). Sensilla present at each side, arising from pore, just at short distance below the base of the crown of setules (Fig. 3B). Buccal aperture surrounded with crown of setules (Figs. 3A–B). Mandible (Fig. 4B) without secondary dentition. Dental formula P1, P1, P, B4. Maxillule biramous (Figs. 2C, 4C), inner lobe (endite) with two setae of equal length. Outer lobe ventrally armed with two short setae of equal length. No other armature present. Maxilliped consist of basal corpus, shaft, and claw. Corpus strong, longer than wide (Fig. 2F), its myxal area armed with a spine and a pad of spinules, distributed

Fig. 1 Drawings of *Clavella cornucola* sp. nov. **A** Female ventral view, **B** female dorsal view, **C** maxilla distal tip plus bulla, **D** antennule, **E** entire antenna, and **F** antenna distal tip of endopod (Bu: bulla, W: whip, 3, 4, 5, 6; armature elements of antennule)



in at least four rows. Shaft slender, with spine on basal third outer surface. Shaft with row of denticles on disto-ventral surface, with a barb $\frac{1}{2}$ of the claw length. Claw slightly curved.

Male specimens: not found.

Taxonomic Summary

Type host: *Patagonotothen cornucola* (Richardson, 1844).

Type locality: Strait of Magellan, Punta Arenas, Southern Chile (53°9'17.4" S; 70°54'40.7" W).

Infection site: dorsal and caudal fins.

Material examined: 5 females (2 ovigerous).

Infection descriptors: 122 fish analyzed in 2018. Prevalence = 0.9%; mean abundance = 0.080 copepods per fish; intensity range = 9 copepods in only one fish.

Etymology: the specific name *cornucola* refers to the host specific name.

Type Material: specimens deposited in the Museo Nacional de Historia Natural, Santiago, Chile. MNHNCL COP-15132 (holotype) and MNHNCL COP-15133 (paratype).

Remarks

Clavella cornucola sp. nov. morphologically resembles *C. bowmani* as it also parasitizes a *Patagonotothen* species. However, the two species have some distinct features: *C. cornucola* sp. nov. is larger, and the trunk is more elongated and oblong than that of *C. bowmani*, as it has a subrounded distal margin. The joint between trunk and cephalothorax base is narrower in *C. cornucola* than in *C. bowmani*. The armature of the antenna comprises two setae that are well defined and distally positioned in *C. cornucola* sp. nov., and the apex has two short flat, blunt projections. However, *C. bowmani* only bears one seta dorsally, and its apex ends in

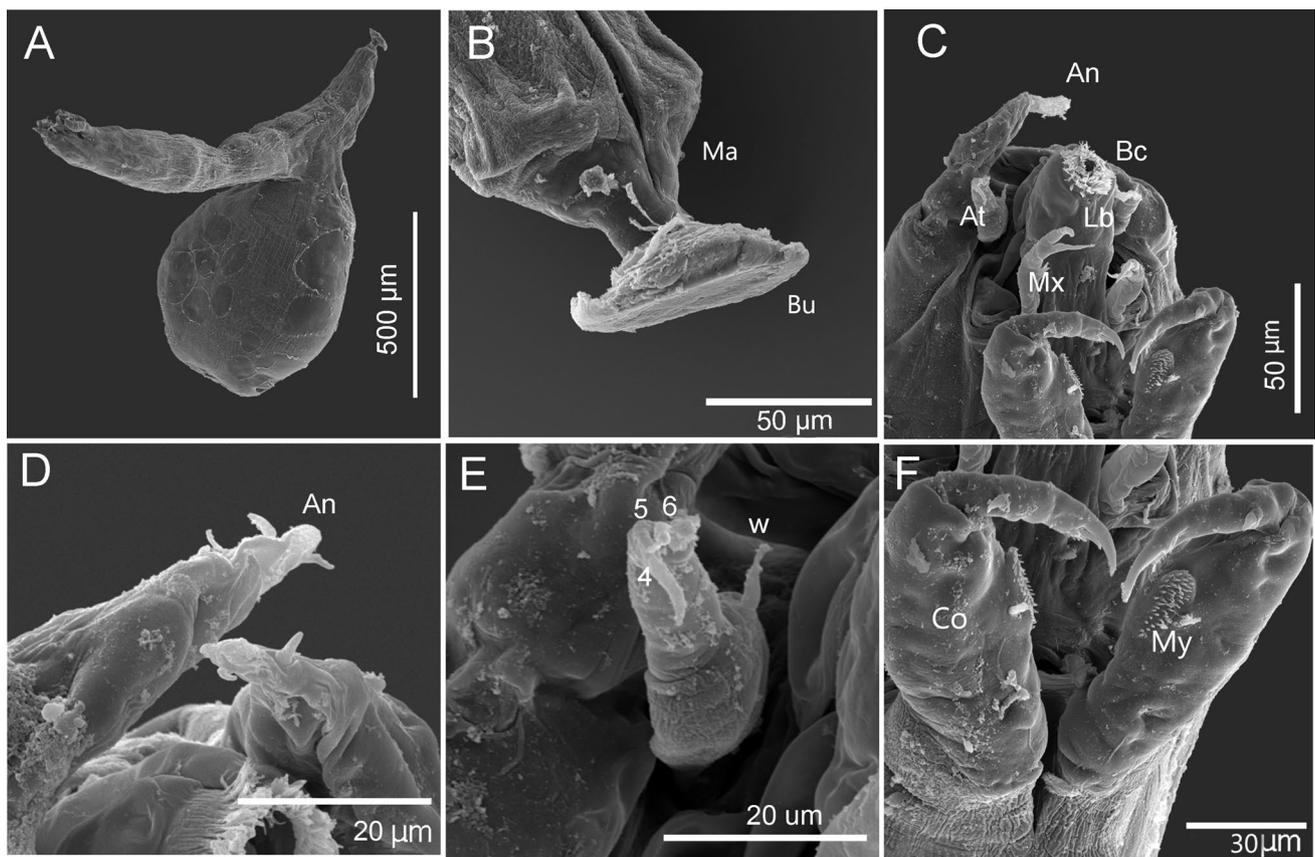


Fig. 2 SEM photographs of *Clavella cornucola* sp. nov. **A** Entire female body, **B** maxilla distal end and bulla, **C** ventral view of cephalosome, **D** antennule, **E** antenna, and **F** maxilliped (At: antennule,

An: antenna, Bc: buccal crown, Co: corpus, Lb: labium, Ma: maxilla, Mx: maxillule, My: myxal area, W: whip; 4, 5, 6: armature elements of antennule, other setae are not visible in the picture)

three short, blunt projections [6]. In addition, the medial dorsal part of the endopod of *C. bowmani* is small, and annexed tubercular protuberance is absent in *C. cornucola* sp. nov. Moreover, the maxillule shows differences: the outer lobe with two setae in the *C. cornucola* sp. nov., whereas only one seta is found in *C. bowmani* [6]. Additionally, the inner lobe in the specimens studied here bears only two distal setae of equal length, whereas in *C. bowmani*, there is also a third short seta at the base of the papillae Fig. 1G in [18]. Both copepod species parasitize fish fins and are from the Strait of Magellan: *C. cornucola* on *Patagonotothen cornucola* from the South Pacific coast and *C. bowmani* on *Patagonotothen sima* from the South Atlantic coast [6].

The copepod specimens on *Patagonotothen sima* were initially confused with *Clavella insolita* Wilson, 1915 [23]. Afterwards, Kabata [6] designated these specimens as *C. bowmani*, revealing that a comparison of these species with *C. insolita* is crucial.

Kabata [6] pointed out that *C. insolita* has a small genital process, largely withdrawn into the trunk and not prominent. This feature differs from *C. bowmani* and *C. cornucola* sp. nov. The maxilliped of *C. insolita* has the terminal claw

without spines and accessory claws [23]. Whereas, in the present specimens, the shaft bears a distal barb, and a short spine is at the base of the distal barb. The body of *C. insolita* is larger than that of *C. cornucola* sp. nov.; the length of the maxilla and cephalothorax length is 3 and 2.48 mm, respectively. However, the trunk is 2.1 mm vs. 1.37 mm, respectively. *Clavella insolita* has a small genital process, but this is not present in *C. cornucola* sp. nov.

Clavella stichaei (Kroyer, 1863) shares the same habitus with the *C. cornucola* sp. nov., but it has a pronounced anal area, which is not developed in the latter species. The cephalothorax is as long as the trunk in *C. stichaei*; whereas in the present specimens, it is longer than the trunk. The second antenna of *C. stichaei* bears a bifid apex with a seta; whereas in *C. cornucola* sp. nov., it shows three setae and two short blunt projections distally (slightly separated from each other).

Clavella cornucola sp. nov. also has a uniramous antenna, and the congeneric species of this feature are identified by Ho [24]: *Clavella gadomi*, *C. sokodara*, *C. longicauda*, *C. okamurai*, *C. collaris*, and *C. diversia*. Of this group, *C. collaris* has a pronounced anal region plus a maxilla, forming

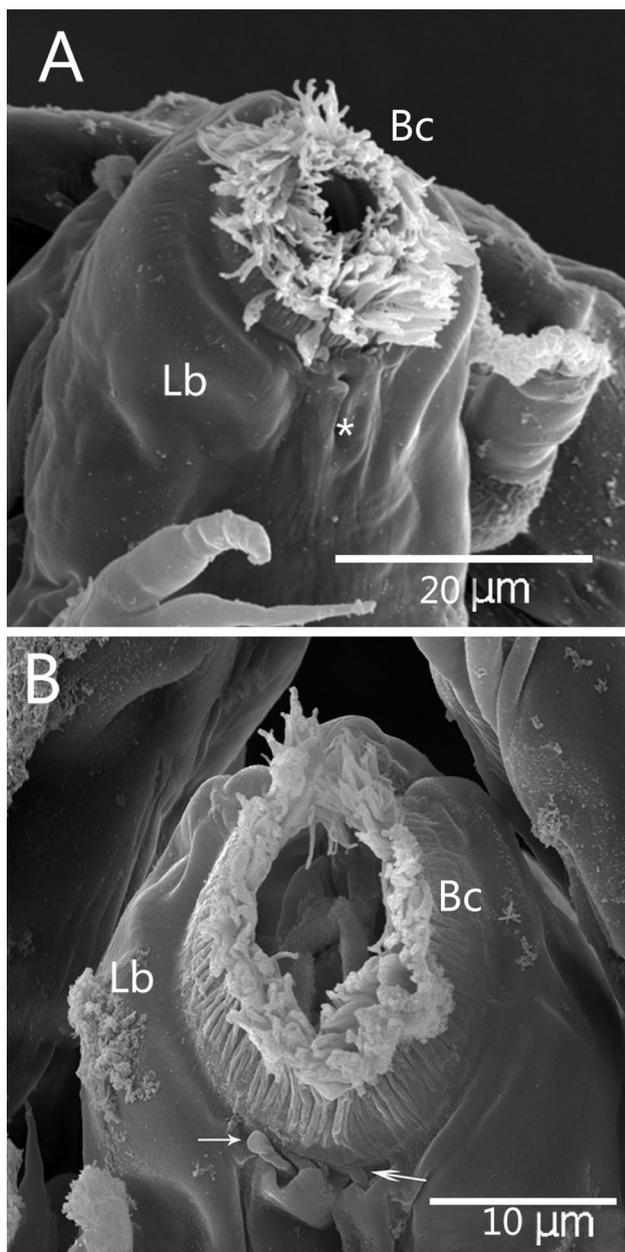


Fig. 3 SEM of buccal structures of *C. cornucola* sp. nov. **A** Buccal area, and **B** buccal crown and labium (Bc: buccal crown, Lb: labium, *marks the cleft on labium, arrow points to the sensilla on the distal part of labium)

a collar distally; features that are absent in *C. cornucola* sp. nov. However, *C. okamurai*, *C. longicauda*, and *C. sokodara* is not considered for further comparison, because they bear a genital process, which is absent in *C. cornucola* sp. nov. In addition, *Clavella gadomi* bears a short genital process and has a wing-like protrusion at the base of the maxilla; both structures are absent in *C. cornucola* sp. nov.

Clavella diversia Ho, 1993 has six elements on the apical part of the antennule, which differs from *C. cornucola*

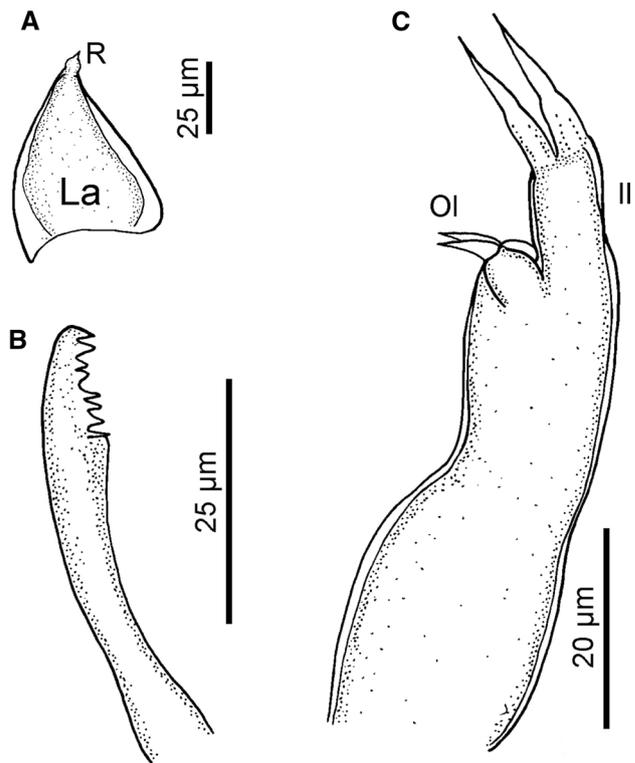


Fig. 4 Drawings of the buccal structures of *C. cornucola* sp. nov. **A** Labrum, **B** lateral view of the mandible, and **C** maxillule (II: inner lobe, La: labrum, R: rostrum, Ol: outer lobe)

sp. nov. [24] that has only four elements. The endopod of the antenna bears a spiniform process distally not present in *C. cornucola* sp. nov.; instead, *C. diversia* has a bifid blunt process. The maxillule has a denticulate pad on the surface not present in *C. cornucola* sp. nov. The mandibles have different dentary formulas (P3, P1, B2 in *C. diversia*, contrasting in the present specimens, P1, P1, P1, P1, B4). Finally, the maxilla has a collar in *C. diversia*, which is absent in *C. cornucola* sp. nov.

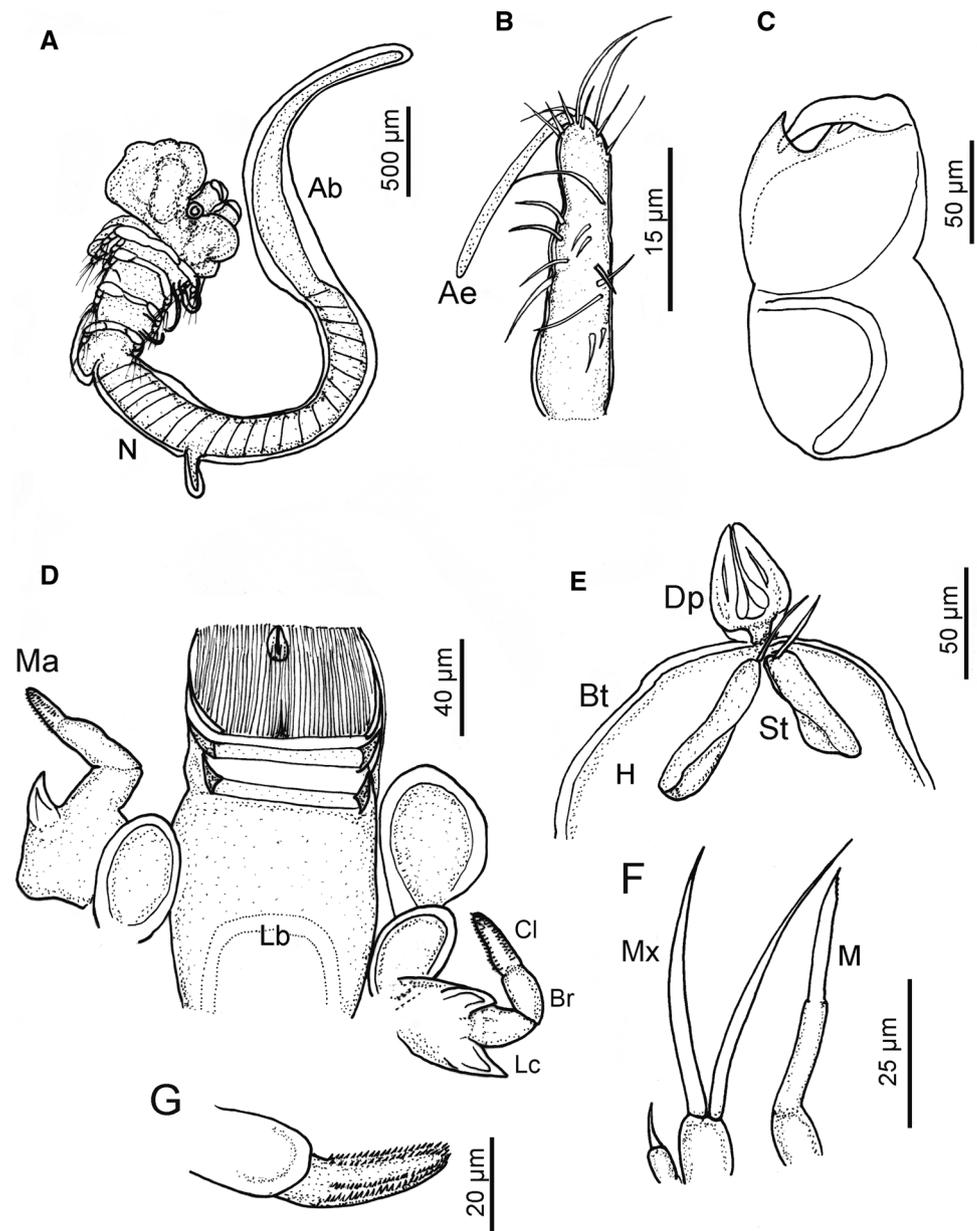
Other *Clavella* species on nototheniid fish that have been reported as parasites are *C. adunca* (Strøm, 1762) and *C. bowmani* on *Patagonotothen sima* [9]. *Clavella adunca* has a genital process, which is absent in *C. cornucola* sp. nov. Both *C. adunca* and *C. bowmani* have a maxillule with an inner lobe, which bears two long setae and another short one at its base. In contrast, the present species bears only two setae. The outer lobe in *C. bowmani* bears only one seta, whereas *C. adunca* has two setae, like in the present specimens of *C. cornucola* sp. nov.

Family Pennellidae Burmeister, 1835.

Genus *Haemobaphes* Steentrup and Lütken, 1861.

Species *Haemobaphes puntaarenensis* sp. nov. (Figs. 5–7)

Fig. 5 Drawings of *Haemobaphes puntaarenensis* sp. nov. **A** Young female entire ventral, **B** antennule, **C** antenna, **D** buccal cone and maxilla in situ, **E** intrabuccal stylet and dorsal plate, **F** maxillule and mandible, and **G** armature of maxilla claw (Ab: Abdomen, Ae: aesthete, Br: branchium, Bt: buccal tube, Cl: claw, Dp: dorsal plate, H: head, Lc: lacertus, Lm: labium, M: mandible, Ma: maxilla, Mx: maxillule, N: neck, St: intrabuccal stylet)



Premetamorphic Female

Measurements in millimeters (based on three specimens): total length: 4,34 (212–809) (Fig. 5A). Head completely developed, wider than following pedigerous somites, with ventral lobe at each side, expanding anterior and posteriorly. Both antennule and antenna remain free, not covered by lobes. Buccal cone visible from frontal view. Thoracic segments free, bearing legs, without lobe. Neck up to fourth thoracic free segment, narrower than the thoracic segments. Neck width decreases posteriorly to the distal end, with wrinkled surface, bearing short simple process (horn), at each side, on the first third. Trunk,

straight or slightly curved, without process; abdomen not differentiated.

Antennule three-segmented (Fig. 5B), with 12 setae on surface and distally with 9 setae and one long aesthete, reaching 60% of antennule length. Antenna subchelate (Fig. 5C), three-segmented; medial segment with concave inner distal margin, opposing distal tip of claw; claw base with seta.

Buccal cone (Fig. 5D) with small lobes at both sides, and other bigger lobe, at the inner side of position of maxilla. Buccal tube armed [sensu 25], as usual, with three rings, distal ring more developed, with series of rows of fine setules (buccal crown). Setules longer than the rings. Labrum

Fig. 6 Drawings of *H. puntaarenensis* sp. nov. **A** Young female leg 1, **B** leg 2, **C** leg 3, **D** leg 4, and **E** abdomen posterior margin and caudal rami (Ex: exopod, En: endopod, Cr: caudal rami)

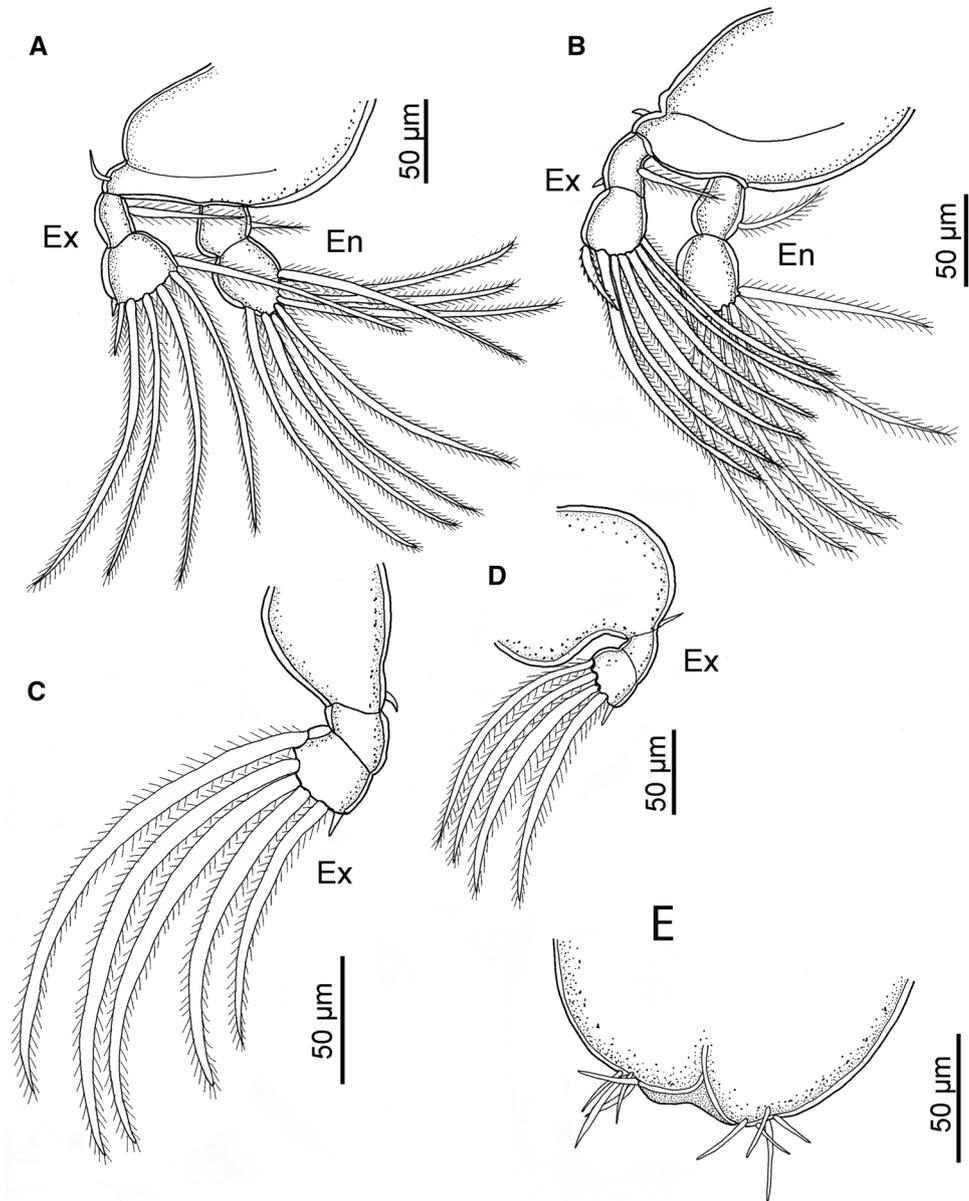


Table 1 Armature of legs of *Haemobaphes puntaarenensis* sp. nov. (seg. = segment)

Leg	Protopod	Exopod		Endopod	
		1st seg	2nd seg	1st seg	2nd seg
L1	1-0	0-I	6-I	0-1	7
L2	1-0	1-I	6-I	0-1	7
L3	1-0	0-0	5-I	-	-
L4	1-0	0-0	5-I	-	-

Arabic numerals represent the number of setae, and Roman numerals represent the number of spines

short (Fig. 5E), as a simple plate but difficult to see in adult specimens. Dorsal plate usually oblong (Fig. 5E), shorter than intrabuccal stylet. Intrabuccal stylet sub-rectangular (Fig. 5E), wider at base, each one with a simple sensilla distally. Mandible forming a simple blade (Fig. 5G), distally with ill-defined dentition. Maxillule bilobed (Fig. 5F); inner lobe (endite) with two setae of similar lengths on large inner lobe plus small seta on outer lobe (palp). Maxilla three-segmented (Fig. 5D), basal segment (lacertus) wide with two strong processes, middle segment (brachium), and a distal claw armed with usual bilateral rows of setules (Fig. 5G).

Legs. First and second pairs biramous (Figs. 6A–B); each ramus bisegmented. Third and fourth pairs uniramous (Figs. 6C–D); each ramus bisegmented. All legs characterized by bearing scale-like minute marginal serrations on

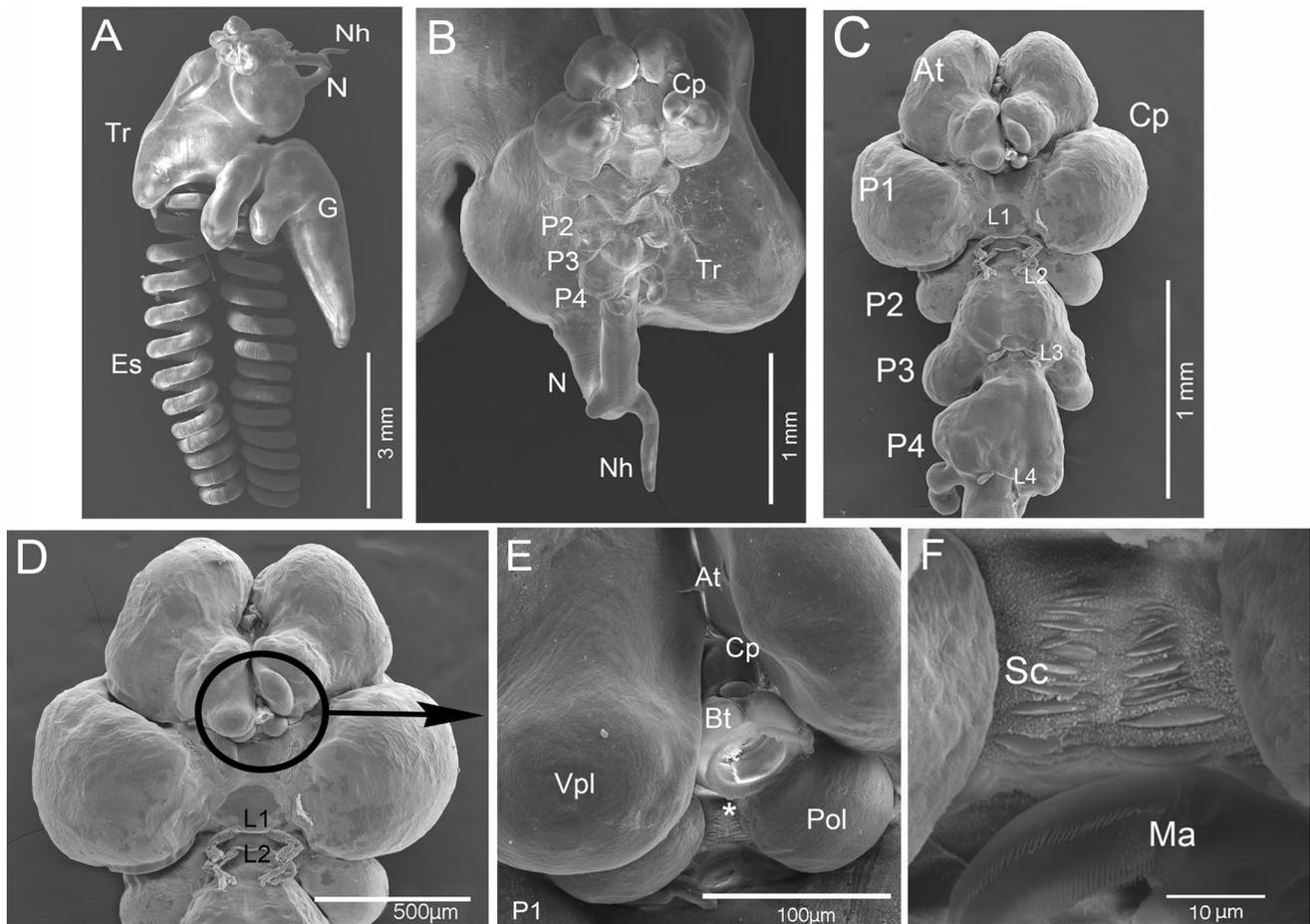


Fig. 7 SEM photographs of *Haemobaphes puntaarenensis* sp. nov. **A** Whole body of ovigerous female, **B** anterior part of the head and pedigerous somites, **C** detail of head and pedigerous somites, **D** head and buccal area (inside the circle), first and second pedigerous somites, **E** buccal tube position, between the ventral posterior lobes of the head, **F** labium ventral (At: antennule, Bt: buccal tube,

Cp: cephalic process, Es: egg sac, G: genital region, Ma: Maxilla, N: neck, Nh: neck horn (one horn broken), La: labrum, Lb: labium, Pol: posterior oral lobe, P1–P4: pedigerous somites, Sc: scale-like structures, Tr: trunk, Vpl: ventral posterior lobes, *position of scale-like structures)

protopod, exopod, and endopod. Armature of legs is shown in Table 1.

Caudal ramus reduced (Fig. 6E), not projecting outside of abdomen; armed with 5 setae, one longer than other four subequal setae.

Adult Female

Measurements in millimeters (based on 5 specimens): total length 14 (12.5–15.3). Head length 0.78 (0.5–1.03) × width 1.19 (1.02–1.30); first thoracic somite. Length 0.81 (231–1.548) × width 1.63 (1.03–2.17); second thoracic segment length 0.394 (0.25–0.61) × width 1.12 (0.97–1.36); third thoracic somite length 0.6 (0.39–0.97) × width 0.95 (0.85–1.03); fourth thoracic segment length 0.55 (0.51–0.64) × width 0.78 (0.77–0.79); neck length 1.5 (0.98–2.048) × width 0.32 (0.23–0.46); trunk length 4.89

(4.49–5.6) × width 3.17 (2.56–3.93); abdomen length 4.48 (2.95–5.44) × width 1.21 (1.03–1.54).

Head comprising pair of large lobes ventrally (Figs. 7A–D), each projecting anteriorly into pair of short lobes (antenna and antennules located between the bases of lobes). Buccal area (buccal cone and tube) located between short distal lobes. Maxilla not easy to see in adult specimens. Labium ventrally (Fig. 7E) with scale-like structures aligned in two columns with 10 scales each, most basal scales largest (Fig. 7F).

First pedigerous somite not fused with head (Figs. 7B–D), with wide lateral lobes. This pedigerous somite wider and longer than head. First pair of legs located ventrally at posterior margin of first pedigerous somite. Second pedigerous somite (Figs. 7B–D) short, narrower than first, bearing second pair of legs (at anterior ventral limit), and short lateral lobes. Third pedigerous somite with triangular shape, with

third pair of legs located near posterior boundary of somite (Figs. 7B–C), and with pronounced posteriorly directed lobes. Fourth pedigerous somite subtriangular (Figs. 7B–C), shorter than third, with short slender lobes laterally, bearing fourth pair of leg posteriorly. Head and pedigerous somites composed cephalothorax [sensu 20, 21]. Neck narrower than anterior segments (Figs. 7A–B), with pair of short slender horns, not bifurcated. Swollen section of trunk curved (with eggs sacs), distally forming lobes, right lobe simple and left lobe bifid. Post genital region long, cylindrical and narrow posteriorly. At junction with anterior part, bearing pair of sub-rectangular lobes laterally, shorter than more anterior lobes. Egg sacs spirally coiled (Fig. 7A).

Male specimens: not found.

Taxonomic Summary

Type host: *Patagonotothen cornucola* (Richardson, 1844).

Infection site: gill chamber.

Type locality: Strait of Magellan, Punta Arenas, Southern Chile (53°9'17.4" S 70°54'40.7" W).

Material examined: Four adult females (ovigerous) and two metamorphosing females.

Infection descriptors: In 2017, 119 fish specimens analyzed. Prevalence = 5.8%; mean abundance = 0.067 parasites per fish; intensity range = 1–2 parasites per fish. In 2018, 112 fish specimens analyzed. Prevalence = 3.6%; mean abundance = 0.053 parasites per fish; intensity range = 1–3 parasites per fish.

Etymology: “*puntaarenensis*” refers to the sampling locality where the hosts were collected.

Type material: specimens deposited in Museo Nacional de Historia Natural Santiago, Chile. MNHCL COP-15129 (holotype adult ovigerous female), MNHCL COP-15130 (paratype adult female), and MNHNCL COP-15131 (paratype premetamorphic female).

Remarks

The genus *Haemobaphes* includes 9 species: *H. ambiguus* Scott, 1900, *H. cresseyi* Kazachenko, 1995, *H. cyclopterina* Muller, 1776, *H. diceraeus* Wilson, 1917, *H. disphaerocephalus* Grabda, 1976, *H. enodis* Wilson, 1917, *H. intermedius* Kabata, 1967, *H. pannosus* Kabata, 1979, and *H. parvus* (Wilson, 1917). However, *Haemobaphes theragrae* Yamaguti, 1939 was considered an uncertain species [25]. Afterwards, Ho and Kim [22] agreed with Grabda [26] that *H. theragrae* was synonymous with *H. diceraeus* Wilson, 1917.

Haemobaphes puntaarenensis sp. nov. has a medium-sized neck; however, *H. intermedius* has a short neck, a simple head and thoracic segments bearing legs. Both *H. diceraeus* and *H. disphaerocephalus* have long necks with head and pedigerous somites with reduced lobes. Other species

(*H. ambiguus*, *H. cyclopterina*, *H. cresseyi*, *H. enodis*, *H. pannosus*, and *H. parvus*) have a medium-sized neck [20, 22, 25–27] similar to the present specimens.

Haemobaphes ambiguus has large suborbicular lobes in the head, small anterior projections and ramified lobes enclosing the buccal cone. Contrarily, *H. puntaarenensis* sp. nov. has large lobular, simple ventral projections, with one anterior and one posterior lobe. The posterior lobe encloses the buccal cone. Several differences are remarked in the pedigerous somites; *H. ambiguus* has a large lobe, which is posterior-ventrally oriented and a bifid lobe oriented posteriorly on the first pedigerous somite. The second and third pedigerous somites are similar in shape but different in size. However, the first pedigerous somite in *H. puntaarenensis* sp. nov. is a large globose lobe; the second pedigerous somite is short with laterally oriented short blunt lobes, and the third pedigerous somite is subtriangular, bearing projecting blunt lobes oriented latero-posteriorly. In addition, the trunk of *H. ambiguus* has an antero-ventral lobe and another posterolateral lobe. The abdomen has several processes on the lateral surface and another dorsally, different from that of *H. puntaarenensis* sp. nov. which has only one long ventral lobe and only one process (lobe or swelling) at the junction of the trunk.

Haemobaphes cyclopterina has a head with small suboval lobes that do not conceal the antenna [20]. In contrast, *H. puntaarenensis* sp. nov. has a large lobe that widens posteriorly, enclosing the antenna and carrying two lobes distally. The small lobe is positioned anteriorly, and the large lobe is posteriorly and ventrally positioned. The latter conceals the buccal cone. The first pedigerous somite in *H. cyclopterina* has a kidney-like lobe, projecting anterolaterally from the head. This lobe extends ventrally beyond the position of legs; whereas in *H. puntaarenensis* sp. nov., the first pedigerous somite has a globular lobe, which projects ventrally and does not extend to cover the legs. The second pedigerous somite in *H. cyclopterina* is fused with the first, so that the two pairs of legs are very close to each other, whereas, in *H. puntaarenensis* sp. nov., the second somite is very short but well separated from the first. The third pedigerous somite in *H. cyclopterina* is small, with rounded margins. A small lobe is remarked on each side of the leg, located in the middle of the somite [20]. Contrarily, the pedigerous somite in *H. puntaarenensis* sp. nov. is subtriangular carrying a latero-posterior lobe, and the legs are located at the posterior margin of the somite. The fourth pedigerous somite in *H. cyclopterina* is more elongate than the third, and it is sub-rectangular, bearing a lobe laterally with a smaller lobe at its base of the inner side. In contrast, the fourth pedigerous somite of *H. puntaarenensis* sp. nov. has a subtriangular shape and small latero-posterior lobes. The abdomen in *H. cyclopterina* has a short antero-ventral lobe and another ventrally at the junction with the trunk; whereas the present

specimens bear a lobe at that junction. In this study, the maxilla of *H. cyclopterina* bears a middle segment with a pad of spinules, which is absent in the present specimens. *Haemobaphes cyclopterina* is also longer (25 mm) than *H. puntaarenensis* sp. nov. (14 mm).

Haemobaphes cresseyi has a slender cephalic holdfast, and lobes are not developed on the first pedigerous somite. The second pedigerous somite is small with slender lobes, and the third pedigerous somite is not developed [28]. All these features differ from those of *H. puntaarenensis* sp. nov., which has a wide and globose cephalic holdfast. The first pedigerous somite has a large globose lobe, widening ventrally. However, the second pedigerous somite has poorly developed rounded lobes, and the third pedigerous somite is well developed, with subtriangular lobes. In addition, the lobes below the trunk are less developed in *H. cresseyi*; whereas they are well developed in the present specimens.

Haemobaphes enodis cannot be considered conspecific with the present specimens because of the appearance of the prosome, with its “cauliflower”-like lobes. In addition, the head and pedigerous somites are not well separated [13]; whereas in *H. puntaarenensis* sp. nov., the head borders and somites are well defined. *Haemobaphes enodis* have a cephalothorax and three free somites of similar width. However, the cephalothorax of *H. puntaarenensis* sp. nov. is wider than the other three free somites. The neck is armed with a single pair of short horns in front of the flexure; whereas the neck horns are longer in *H. puntaarenensis* sp. nov. Other morphological differences are that *H. enodis* has a nearly straight trunk without lobes, and the genital region has the same width and length, without lobes. In contrast, *H. puntaarenensis* sp. nov. has a bent trunk with posterior-ventral lobes, and the genital region is narrower posteriorly, with a lobe at the junction of the trunk.

Haemobaphes pannosus differs from *H. puntaarenensis* sp. nov. in several ways. The former has a suborbicular head with short, slender, and simple anterior lobes. The first pedigerous somite has a large lobe at each side projecting anteriorly around the head; the second pedigerous somite has bifid lobes projecting anteriorly and posteriorly, and the third thoracic segment has a wide lobe with short anterior lobes. The trunk has three pairs of lobes: one anterior ventral, another posterior-ventral, and the last short and posteriorly located [22]. These features differed from that of *H. puntaarenensis* sp. nov., because the head of this species has a large lobe projecting simple anterior and posterior lobes. The first thoracic segment is a wide suborbicular lobe, not projecting any lobes; the second thoracic segment is subtriangular, lacking lobes laterally; the trunk surface has no lobes. It is also worth noting that the ratio of the aesthete to antennule length is 79% in *H. pannosus* and 60% in the present specimens. In addition, the second maxilla segment in *H. pannosus*, similar

to other *Haemobaphes*, bears two pads of spinules ventrally, which are not seen in *H. puntaarenensis* sp. nov.

Several differences are also noted between *Haemobaphes parvus* and *H. puntaarenensis* sp. nov. *Haemobaphes parvus* head consists of an anteriorly oriented pair of lobes, which does not enclose the antenna, and ventral lobes are trifid in appearance and enclose the buccal cone [13]. However, *H. puntaarenensis* sp. nov. has a large lobe expanded into two short lobes, antero-ventral and posterior-ventral; the latter encloses the buccal cone. The first pedigerous somite of *H. parvus* has rounded margins and is not well developed. In addition, the second pedigerous somite is shorter than the first, approximately the same width, and the third is longer than the first, with rounded margins [13]. Contrarily, *H. puntaarenensis* sp. nov. has the first pedigerous somite, which is big and wider than the head; the second is small with rounded margins and narrower than the head. The third is subtriangular, longer than the second and has projecting lobes posterior-laterally. In *H. parvus*, the neck is slender, apparently without processes [13], which differs from *H. puntaarenensis* sp. nov. with a pair of horns.

Complete descriptions of the legs are available for five species (*H. cresseyi*, *H. cyclopterina*, *H. diceraus*, and *H. disphaerocephalus*, including the present species). Although the appendage armature has been considered homogeneous for pennellid species [22], some small differences are remarked between *H. cyclopterina* and *H. puntaarenensis* sp. nov. in terms of the exopod of the first leg and the endopod of the second legs. Nevertheless, the second segment of the exopod of the third leg differs in setae number, which is similar to the second segment of the exopod of the fourth leg. In *H. cresseyi*, the leg armature is considered similar to that of the present specimens. According to Grabda [27], the protopod in *H. disphaerocephalus* leg armature bears two setae; whereas in *H. puntaarenensis* sp. nov., no inner setae are found. Another difference is found in the second exopodal segment of the first leg (namely in the number of setae).

The size of adult specimens *H. puntaarenensis* sp. nov. ranged 12–15 mm, smaller than other species (*H. cyclopterina* 25.2 mm, *H. intermedius* 25 mm, *H. disphaerocephalus* 30 mm, and *H. diceraus* 30 mm).

Discussion

Clavella

Clavella cornucola sp. nov. can be distinguished from other species in a combination of different features, such as morphology of trunk and cephalothorax, absence of genital processes, presence of four elements on the antenna, presence of barb and spine on the maxillule claw, mandible dentary formula, absent of collar on the maxilla, and several other

details. It is worth to note that *C. cornucola* sp. nov. has a cleft at the labium ventro-distal surface and sensilla near the buccal tube, not previously seen in any *Clavella* species. All these characteristics support the description of the new species *Clavella cornucola*.

This study increases the number of *Clavella* species to 10 in the South Pacific coast of Chile [8, 29, 30], and it is the first reported research on a nototheniid fish. Of this group, four live on deep-sea fishes (*C. fortis*, *C. singularis*, *C. convergentis*, and *C. adunca*), and the remaining species (*C. chilensis*, *C. applicata*, *C. caudata*, *C. simplex*, *C. parva*, and *C. cornucola* sp. nov.) are on coastal fishes.

Haemobaphes

Kabata [25] suggested that the best way to discriminate the *Haemobaphes* species is the shape of the “head” and the lateral outgrowths of the “neck”. Both features prevail due to the specific site of attachment in the host (restricted to the bulbous arteriosus of the fish). Ho and Kim [22] noted some morphological variations among specimens of *H. pannosus*; however, the characteristics of the head and neck of this species remain distinct.

Haemobaphes puntaarenensis sp. nov. has features that distinguish it from other congeneric species. For example, the head and the thoracic free pedigerous somites are well defined and separated from one another, and they comprise big and lobe shapes. In addition, the labium had a special armature in this new species, revealing two columns of at least ten scale-like plates on each column. This differed from the armature previously reported in other genera of Pennellidae, and the diagnostic features were as follows: a pair of scale-like plates in *Metapeniculus*, several rows of small scale-like plates in *Trifur* [11, 15, 16], two pairs in *Peniculus*, some spines on *Propeniculus*, several rows of spines in *Lernaenicus sprattae* (Sowerby, 1806) [31, 32], and no armature in *Pennella* [33] and *Pseudopeniculus* [15].

Several characteristics are considered when differentiating species, which include antennule aesthete length, the presence or absence of a pad of spinules on the maxilla, and the degree of fusion of the first pedigerous somite with the head. The maxilla in *H. puntaarenensis* sp. nov. lacks a disto-ventral pad of spinules on the second segment, but two pads are present in *H. diceraeus* [13], *Haemobaphes* sp. [25], and *H. cycloptera* [20]. The maxilla of *H. cresseyi* lacks such pads according to Fig. 9 of Kazachenko [28]. The separation or fusion of the first pedigerous somite with the head is unclear in adults of some species. However, it can be used to define their status in others, e.g., if the first pedigerous somite is fused to the head or separated from the head (e.g., *H. diceraeus* [25]).

Haemobaphes species are commonly known in the Northern Hemisphere, in the Atlantic, and the Pacific. However,

no records of *Haemobaphes* in South Pacific waters (for distribution, see 27, 28, 34, 35). *Haemobaphes cycloptera* (type species) and *H. ambiguus* are known only in the North Atlantic; though some claims that they are also present on fish species in the North Pacific. *Haemobaphes diceraeus* and *H. enodis* are known in the North Pacific; *H. diceraeus* are found on the Asian and *H. enodis* on the American side. Thus, the presence of the *Haemobaphes* on the fish *Patagonotothen cornucola* is new in the South American Cone and the Chilean fauna.

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Availability of data and Materials It can be requested to the corresponding author.

Declarations

Conflicts of Interest The authors declare that they have no conflict of interest.

Ethical Approval The procedures of capture and dissection of fish were approved by the Bioethic committee of the Universidad de Valparaíso (certificate N° 058/2016).

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