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Nippoparasitus unoashicola, a new genus and species of philoblennid copepod (Cyclopoida) parasitic on the Pacific sugar limpet, *Patelloida saccharina* (Linnaeus, 1758) (Patellogastropoda: Lottiidae) from the intertidal zone of eastern Japan

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Abstract

Nippoparasitus unoashicola, a new genus and species of mesoparasitic copepod, is described based on specimens of both sexes collected from the mantle cavity of the Pacific sugar limpet, *Patelloida saccharina* (Linnaeus, 1758) (Patellogastropoda: Lottiidae), in the intertidal zone of the Uraga Channel (North Pacific Ocean), Japan. *Nippoparasitus* **gen. nov.** differs from other philoblennid genera by two unique characters: the labium is bloated and branched into multiple digitate lobes in female, and the antenna has three claw-like spines on the terminal segment. *Nippoparasitus* is probably closely related to *Myzotheridion* Laubier & Bouchet, 1976 with which it shares a series of processes on the terminal segment of the maxilla.

Key words: parasitic copepod, coastal waters, temperate zone, *Nippoparasitus unoashicola* **gen. et sp. nov.**

Introduction

The Philoblennidae is a small family of parasitic copepods, accommodating ten nominal species in four genera (Boxshall & Halsey 2004; Salmen *et al.* 2010), all of which utilize marine gastropods as hosts (Table 1). So far, members of this family have been reported from various prosobranchs and opisthobranchs in the Indo-West Pacific (Bergh 1876; Bassett-Smith 1903; Monod 1928; Monod & Dollfus 1932; Izawa 1976; Laubier & Bouchet 1976; Ho 1981; Ho & Kim 1992; Avdeev *et al*. 1986; Kim 1998; Salmen *et al*. 2010) and the Bay of Biscay in the northwestern Atlantic (Laubier & Bouchet 1976). Philoblennids are often difficult to find and their study requires careful examination of the host gastropod. Species of *Philoblenna* Izawa, 1976 and *Myzotheridion* Laubier & Bouchet, 1976, for example, attach to obscured infection sites which are covered by the shell of their prosobranch hosts (Izawa 1976; Laubier & Bouchet 1976). Conversely, members of *Briarella* Bergh, 1876 are largely embedded in their hosts, exposing only the distal part of the urosome and the egg sacs (Monod 1928; Salmen *et al*. 2010). This parasitic style is similar to that of Splanchnotrophidae rather than Philoblennidae. Actually, the phylogenetic analysis based on morphological characters by Anton & Schrödl (2013) indicated that *Briarella* is a sister group of genera of Splanchnotrophidae. Not surprisingly, with only one species described during the last two decades (Salmen *et al*. 2010), our knowledge of the diversity and biology of this family remains fragmentary. In this study, a new species of philoblennid copepod is described based on specimens of both sexes collected from the Pacific sugar limpet, *Patelloida saccharina* (Linnaeus, 1758) (Patellogastropoda: Lottiidae), in Japanese waters. Since the new species does not fit the diagnosis of any of the four known philoblennid genera, a new genus, *Nippoparasitus* **gen. nov.** is herein established to accommodate it.

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Materials and methods

The Pacific sugar limpets infected by *Nippoparasitus unoashicola* **gen. et sp. nov.** were collected during low tide from the rocky shore of the Uraga Channel (North Pacific Ocean) at Kaneya in Futtsu City, Chiba Prefecture, Japan. Copepod parasites were carefully removed from the hosts, fixed in 70% ethanol or 10% formalin, and preserved in 99% ethanol or 10% formalin. Specimens were subsequently soaked in lactophenol for about 10 hours, dissected, and examined using the wooden slide method of Humes & Gooding (1964). Drawings were made with the aid of a drawing tube. The copepod body parts were measured using an ocular micrometer and are given as a range followed by the mean and standard deviation in parentheses. Types are deposited in the crustacean collection of the National Museum of Nature and Science, Tsukuba, Ibaraki Prefecture Japan (NSMT).

Results

Family Philoblennidae Izawa, 1976

Genus *Nippoparasitus* gen. nov.

Diagnosis of adult female. Body cyclopiform; external segmentation indistinct. Cephalothorax consisting of cephalosome and first pedigerous somite, with one anterior, lobate protrusion. Second to fourth pedigerous somites and urosomites free, progressively narrower posteriorly. Genital double-somite quadrangular. Abdomen consisting of three free somites. Caudal ramus bearing seven setae. Egg sac multiseriate.

Rostrum present. Antennule 5-segmented; second segment incompletely subdivided; armature formula 2, 7, 3 + 1 aesthetasc, 3 + 1 aesthetasc, 8 + 1 aesthetasc; all setae naked. Antenna 3-segmented, consisting of coxobasis and 2-segmented endopod; second endopodal segment bearing three claw-like spines and styliform element. Labrum broad, bearing paired lateral lobes with bifurcated tips. Mandible with one subterminal, serrated blade. Maxillule represented by simple lobe armed with three naked setae. Maxilla 2-segmented; proximal segment unarmed; distal segment bearing pointed tip with four sharp processes and two setae. Maxilliped 2-segmented, consisting of unarmed syncoxa and rod-shaped basis. Labium massive, swollen, forming eight large lobate processes.

Legs 1 to 2 biramous, bearing incompletely 2-segmented rami. Intercoxal sclerite of legs 1 and 2 unarmed. Leg 3 represented by one protrusion bearing one outer seta and one inner spine. Leg 4 absent. Leg 5 single seta on small depression. Leg 6 represented by three small elements at genital opening.

Diagnosis of adult male. Body cyclopiform; external segmentation indistinct. Cephalothorax, ovoid, and consisting of cephalosome and first pedigerous somite. Second to fourth pedigerous somites and urosomites free progressively narrower posteriorly. Fifth pedigerous somite fused with genital somite with paired genital opercula located posteroventrally. Abdomen consisting of four free somites. Caudal ramus as in female.

General shape of rostrum, antennule, antenna, mandible, maxillule, maxilla as in female. Labrum broad, bearing paired lateral lobes with blunt tip. Maxilliped 3-segmented, highly developed as grasping organ; proximal segment (syncoxa) and second segment (basis) large rod-like; terminal (endopodal) segment claw-like, incompletely 2-segmented. Labium bearing swellings.

General shape of legs 1 to 3 as in female. Leg 4 absent. Leg 5 represented by conical protrusion with single seta. Leg 6 represented by three setae on genital opercula.

Type species. *Nippoparasitus unoashicola* **sp. nov.** by original designation.

Remarks. *Nippoparasitus* **gen. nov.** differs from three other philoblennid genera (*Briarella* Bergh, 1876, *Myzotheridion* Laubier & Bouchet, 1976, *Philoblenna* Izawa, 1976) based on female specimens by having the labium developed into large branched digitate lobes and the antenna bearing three distal claw-like spines and a styliform element.

Etymology. The generic name is a combination of “Nippo” (= Japan’s) and a Latin “parasitus” (= parasite), refers to a parasite of the Pacific sugar limpet, one of the common and well-known marine gastropods in Japanese waters.

***Nippoparasitus unoashicola* sp. nov.**
(Figs. 1–4)

Type material. Holotype: adult female (NSMT-Cr 24086), ex *Patelloida saccharina* (Linnaeus, 1758) (Patellogastropoda: Lottiidae), intertidal zone, Uraga Channel (North Pacific Ocean), Kaneya (35°11'N, 139°49'E), Futtsu City, Chiba Prefecture, 1 November, 2013, leg. D. Uyeno and R. Ogasaka. Allotype: adult male (NSMT-Cr 24087), collection data same as those of holotype. Paratypes: eight adult females and five adult males (NSMT-Cr 24088), collection data same as those of holotype.

Description of holotype adult female. Body (Fig. 2A–C) cyclopiform, 2,303 × 805 µm, slightly curved in lateral view with greatest width at second pedigerous somite; external segmentation indistinct. Cephalothorax (Fig. 2A–B) slightly wider than long, 530 × 734 µm, consisting of cephalosome and first pedigerous somite, forming an anterior, lobate protrusion. Second to fourth pedigerous somites and urosomites free, progressively narrower posteriorly; second and third pedigerous somites with ventral conical protorusions. Genital double-somite quadrangular with one pair of lateral lobes at level of genital apertures (Fig. 3M). Abdomen consisting of three free somites; anal somite bearing one pair of lateral protrusions and irregular rows of minute spinules on ventral surface (Fig. 2D). Caudal ramus (Fig. 2D–E) 2.40 times longer than wide, 60 × 28 µm, with seven setae. Egg sac (Fig. 2F) multiseriate, sausage-shaped, slightly curved.

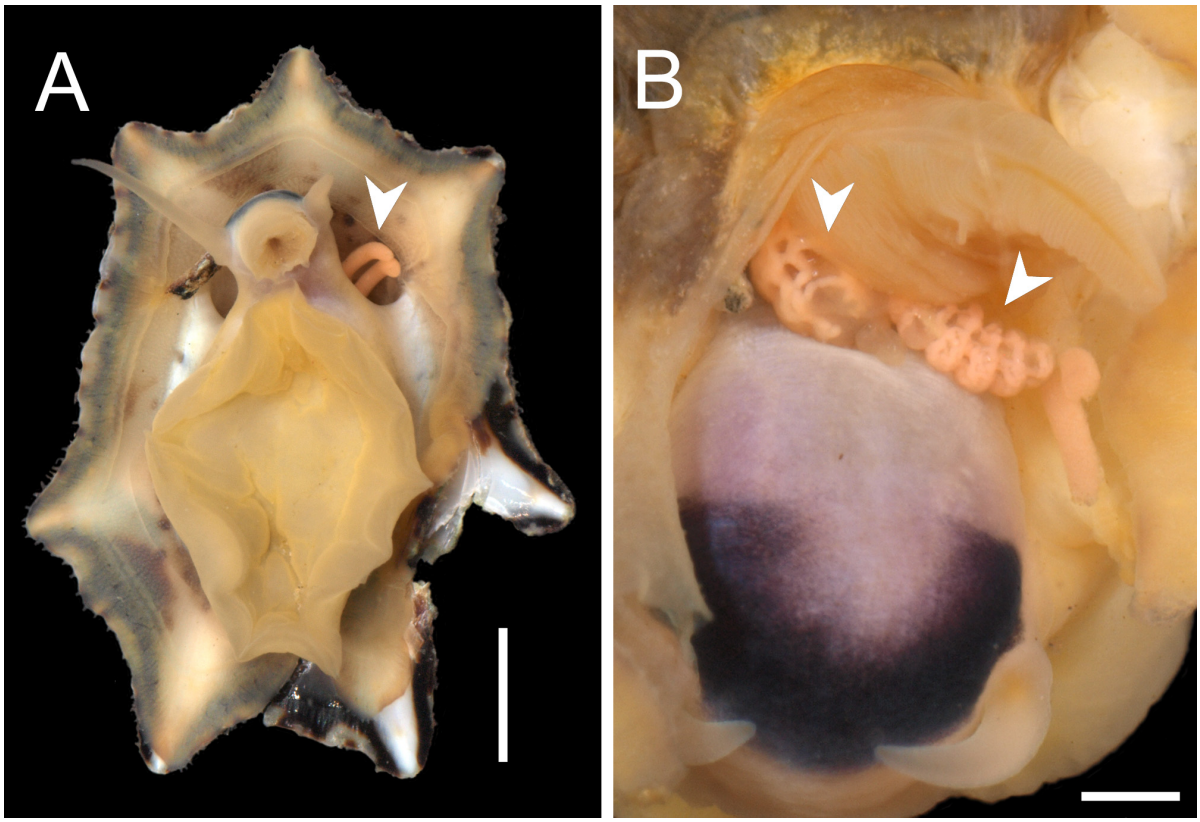

FIGURE 1. Adult females of *Nippoparasitus unoashicola* **gen. et sp. nov.** attached to the host. A, ventral side of a specimen of *Patelloida saccharina* (Linnaeus, 1758) carrying an adult female with egg sacs behind the head (arrowhead = egg sacs of the copepod); B, head of the host with two paratype female specimens (arrowheads) (NSMT-Cr 24088) attached to the gill. Scale bars: A = 4 mm; B = 1 mm.

Rostrum (Fig. 2G) triangular, with blunt frontal margin. Antennule (Fig. 3A) 5-segmented; second segment incompletely subdivided; armature formula 2, 7, 3 + 1 aesthetasc, 3 + 1 aesthetasc, 8 + 1 aesthetasc; all setae naked. Antenna (Fig. 3B) 3-segmented, consisting of coxobasis and 2-segmented endopod; coxobasis large, bearing one distal seta; first endopodal segment bearing setal vestige on inner distal margin; second endopodal segment bearing two setae along lateral margin, and three claw-like spines and one styliform element on distal tip. Labrum (Fig. 3C, D) broad, bearing paired lateral lobes with bifurcated processes. Mandible (Fig. 3E) with one subterminal, serrated blade. Maxillule (Fig. 3F) represented by simple lobe armed with three naked setae. Maxilla (Fig. 3G) 2-

segmented; proximal segment unarmed; distal segment with two naked setae and pointed apical tip with four sharp processes. Maxilliped (Fig. 3H) 2-segmented, consisting of unarmed syncoxa and rod-shaped basis. Labium (Fig. 3A) massive, swollen, forming eight large lobate extensions.

Legs 1–2 (Fig. 3I–J) biramous, bearing incompletely 2-segmented rami. Leg armature formula as follows:

	Protopod	Exopod	Endopod
Leg 1	1-0	I-0; III, I, 3	0-0; I, 4
Leg 2	1-0	I-0; II, I, 3	0-0; III, 2

Intercoxal sclerite (Fig. 3I–J) of legs 1 and 2 unarmed. Leg 3 (Fig. 3K) represented by one protrusion bearing one outer naked seta and one inner spine. Leg 4 absent. Leg 5 (Fig. 3L) single seta arising from small depression. Leg 6 (Fig. 3M) represented by three small elements at genital opening.

Variation of female morphology. The morphology of the female paratypes is as in the holotype. The measurements of the body parts of paratypes (n = 8) are as follows: body length 1,906–3,315 μm (2,558 ± 477 μm); body width (first pedigerous somite width) 512–1,099 μm (850 ± 193 μm); cephalothorax length 380–619 μm (504 ± 70 μm); cephalothorax width 480–810 μm (666 ± 94 μm); caudal ramus length 44–64 μm (49 ± 6 μm); caudal ramus width 22–29 μm (26 ± 2 μm). Caudal ramus 1.53–2.45 μm (1.88 ± 0.32 μm) times longer than wide.

Description of allotype adult male. Body (Fig. 4A–C) cyclopiform, 1,302 μm, slightly curved in lateral view with greatest width at second pedigerous somite; external segmentation indistinct. Cephalothorax (Fig. 4A–C) longer than wide, 435 × 339 μm, ovoid, and consisting of cephalosome and first pedigerous somite. Second to fourth pedigerous somites and urosomites free, progressively narrower posteriorly; second and third pedigerous somites with ventral conical protrusions. Fifth pedigerous somite fused with genital somite, with paired genital opercula located posteroventrally (Fig. 4A). Abdomen consisting of four free somites. Caudal ramus (Fig. 4A–C) longer than wide, 56 × 19 μm, with seven setae.

Rostrum (Fig. 4C), antennule, mandible, maxillule (Fig. 4D), maxilla (Fig. 4D) as in female. Antenna as in female, except for setal vestige on proximal endopodal segment being replaced by naked seta (Fig. 3B'). Labrum (Fig. 4D) broad, bearing paired lateral lobes with blunt tip. Maxilliped (Fig. 4E) 3-segmented, highly developed as subchelate grasping appendage; proximal segment (syncoxa) large, unarmed; second segment (basis) bearing one sharply pointed process and two naked setae along inner margin; terminal (endopodal) segment claw-like, incompletely 2-segmented, bearing two pointed sub-basal processes and weekly serrated sub-terminal, inner margin. Labium (Fig. 4D) bearing swellings.

Legs 1–2 as in female, except for presence of one inner seta on proximal endopodal segment of leg 2. Leg 3 (Fig. 4F) represented by protrusion bearing one outer seta and one inner spine. Leg 4 absent. Leg 5 (Fig. 4G) represented by conical protrusion with single plumose apical seta. Leg 6 (Fig. 4H) represented by two plumose and one small naked setae on genital opercula.

Variation of male morphology. The morphology of the male paratypes is as in the holotype. The measurements of the body parts of paratypes (n = 5) are as follows: body length 905–1,153 μm (1,025 ± 111 μm); cephalothorax length 302–386 μm (340 ± 32 μm); cephalothorax width 279–302 μm (293 ± 9 μm); caudal ramus length 48–66 μm (57 ± 8 μm); caudal ramus width 22–34 μm (28 ± 4 μm).

Attachment site. Mantle cavity. Females were attached around the gills of the host with the massively developed labium embedded in the host's tissue (Fig. 1). Males were attached to the host in the vicinity of females using their antennae.

Etymology. The specific name of the new species, *unoashicola*, is a combination of "unoashi" (Japanese name of the Pacific sugar limpet) and the Latin suffix "-*cola*" (= dwelling in).

Newly established Japanese name for the new genus and species. Unoahi-no-mikoto-zoku and Unoashi-no-mikoto.

Discussion

Izawa (1976) established the family Philoblennidae to accommodate *Philoblenna arabici* Izawa, 1976 and considered the genus *Briarella* Bergh, 1876 as a possible candidate for inclusion in this family, an opinion that was subsequently endorsed by Ho (1981). Huys (2001) confirmed that *Briarella* belongs to the Philoblennidae and also included *Chondrocarpus* Bassett-Smith, 1903 as a *genus incertae sedis*. Finally, Boxshall & Halsey (2004) added

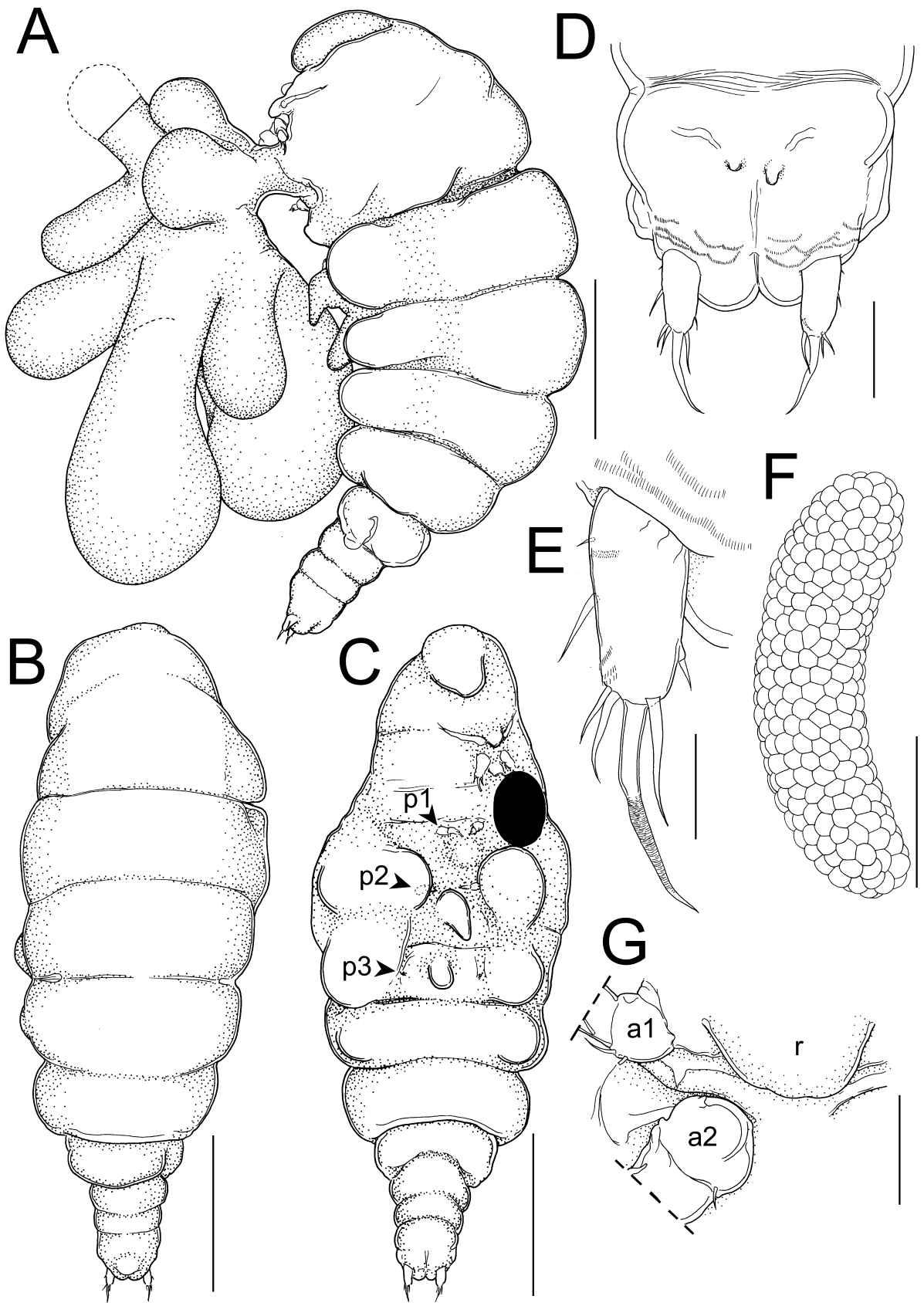

FIGURE 2. *Nippoparasitus unoashicola* **gen. et sp. nov.**, adult females [holotype NSMT-Cr 24086 (A–E, G) and paratype NSMT-Cr 24088 (F)]. A, habitus, lateral; B, same, dorsal; C, same, ventral (p1 = leg 1, p2 = leg 2, p3 = leg 3); D, posterior part of urosome, ventral; E, right caudal ramus, ventral; F, egg sac; G, frontal view of head (r = rostrum, a1 = antennule, a2 = antenna). Scale bars: A–C, F = 500 μm; D = 70 μm; E = 30 μm; G = 50 μm.

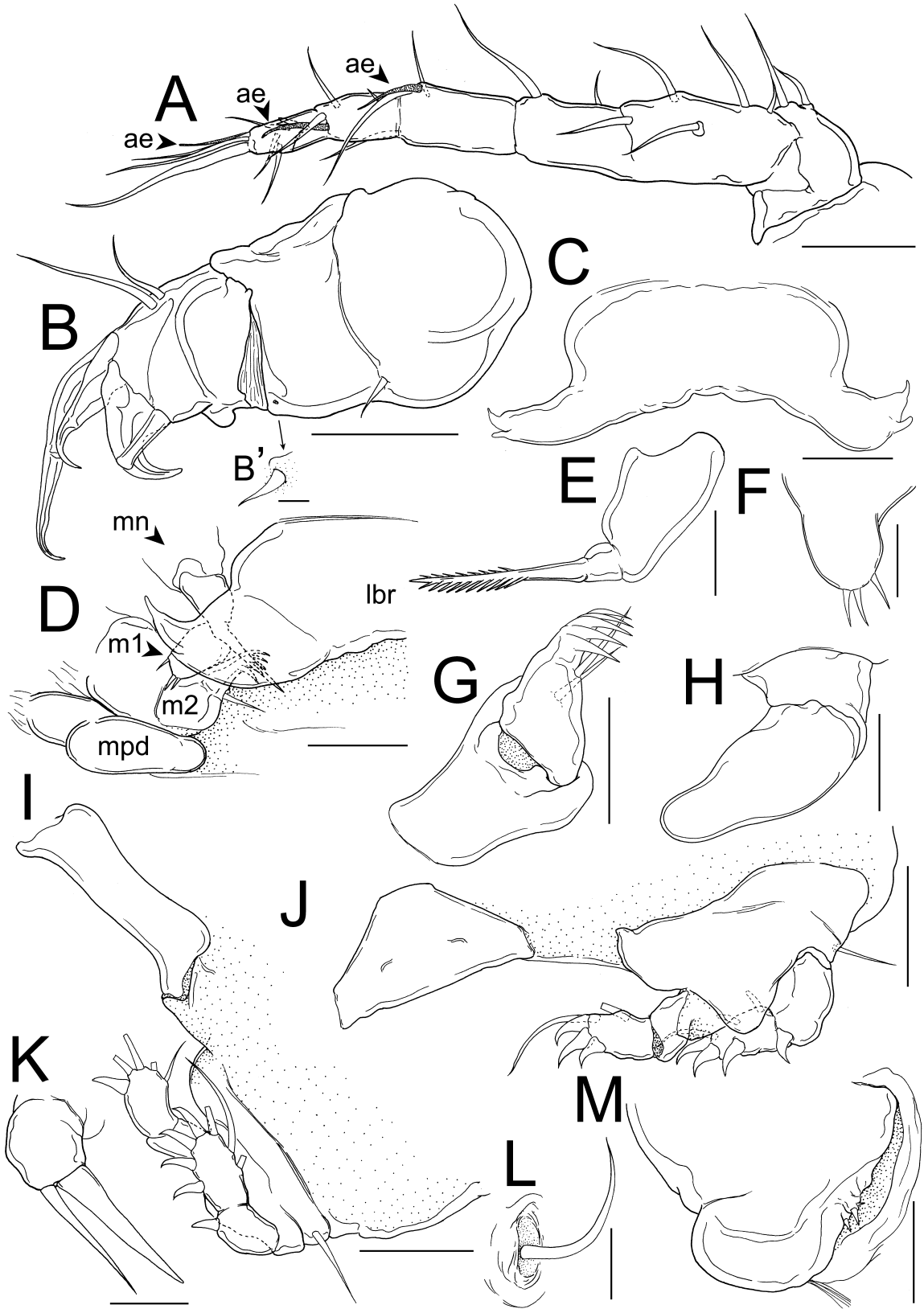

FIGURE 3. *Nippoparasitus unoashicola* **gen. et sp. nov.**, adult females [holotype NSMT-Cr 24086 (A–C, G, I–K, M) and paratype NSMT-Cr 24088 (D–F, H, L)] and adult male [allotype NSMT–Cr 24087 (B')]. A, left antennule, anterior (ae = aesthetascs); B, right antenna, anterior; B', distal seta on second segment of antenna; C, labrum; D, oral area (lbr = labrum, mn = mandible, m1 = maxillule, m2 = maxilla, mpd = maxilliped); E, left mandible, anterior; F, left maxillule, anterior; G, right maxilla, anterior; H, left maxilliped, anterior; I, right leg 1, posterior; J, left leg 2, anterior; K, right leg 3, anterior; L, left leg 5; M, left genital opening with leg 6. Scale bars: A–D, I, J = 30 μm; E, F, L = 10 μm; G, H = 20μm; B', K = 5 μm; M = 50 μm.

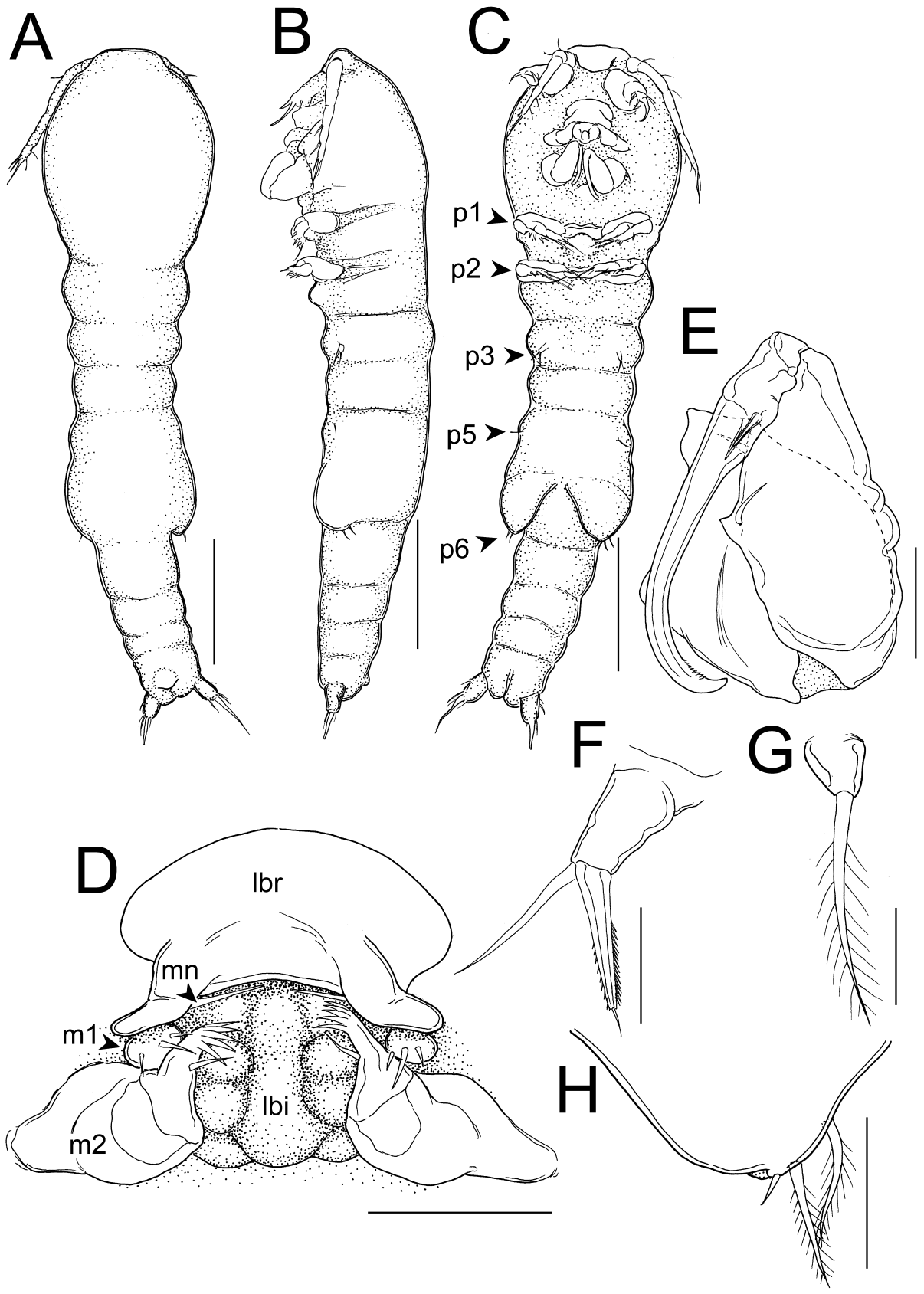

FIGURE 4. *Nippoparasitus unoashicola* **gen. et sp. nov.**, adult male [allotype NSMT-Cr 24087]. A, habitus, dorsal; B, same, lateral; C, same, ventral (p1 = leg 1, p2 = leg 2, p3 = leg 3, p5 = leg 5, p6 = leg 6); D, oral area (lbr = labirum, mn = mandible, m1 = maxillule, m2 = maxilla, lbi = labium); E, left maxilliped; F, right leg 3, anterior; G, left leg 5, anterior; H, left leg 6. Scale bars: A–C = 250 μm; D = 50 μm; E, H = 30 μm; F = 20 μm; G = 10 μm.

TABLE 1. Records of philoblennid copepods, hosts utilized and locality data.

Philoblennid species	Host	Locality	References
Briarella microcephala Bergh, 1876	*Ceratosoma trilobatum* (Gray, 1827)	Red Sea	Bergh (1876)
	? *Sclerodoris coriacea* Eliot, 1904	Zanzibar	Eliot (1904) [1]
B. sp. *sensu* Bergh (1877)	*Asteronotus cespitosus* (van Hasselt, 1824) [2]	Philippines	Bergh (1878) [3]
	Chromodoris elisabethina Bergh, 1877	Philippines	Bergh (1877) [4]
B. risbeci Monod, 1928	*Hexabranchus sanguineus* (Rüppell & Leuckart, 1830) [5]	New Caledonia	Monod (1928), Risbec (1928)
B. disphaerocephala Monod & Dollfus, 1932	*Platydoris cruenta* (Quoy & Gaimard, 1932)	New Caledonia	Monod (1928) [6], Risbec (1928) [6]
	P. inframaculata (Abraham, 1877) [7]	New Caledonia	Risbec (1930) [8], Monod & Dollfus (1932)
B. doliaris Salmen, Anton, Wilson & Schrödl, 2010	*Cer. trilobatum* (Gray, 1827)	Australia	Salmen *et al.* (2010), Anton & Schrödl (2013)
Chondrocarpus reticulosus Bassett-Smith,1903	"large pleurobranchid"	Zanzibar	Bassett-Smith (1903)
C. sp. *sensu* Bassett-Smith, 1903	unidentified pleurobranchid	Zanzibar	Bassett-Smith (1903)
Myzotheridion seguenziae Laubier & Bouchet, 1976	*Carenzia carinata* (Jeffreys, 1877) [9]	Gulf of Biscay	Laubier & Bouchet (1976)
Nippoparasitus unoashicola **gen. et sp. nov.**	*Patelloida saccharina* (Linnaeus, 1758)	Japan	Present study
Philoblenna arabici Izawa, 1976	*Mauritia arabica* (Linnaeus, 1758) [10]	Japan	Izawa (1976, 1986)
P. tumida Ho, 1981	*Cellana grata* (Gould, 1859)	Japan	Ho (1981)
		Korea	Kim (1998)
	Cel. toreuma (Reeve, 1855)	Japan	Ho (1981)
P. littorina Avdeev, Tsimbaljuk & Lukomskaya, 1986	*Littorina brevicula* (Philippi, 1844)	Sea of Japan	Avdeev *et al.* (1986)
	L. mandshurica (Schrenck, 1861)	Sea of Japan	Avdeev *et al.* (1986)
	L. squalida Broderip & Sowerby, 1829	Sea of Japan	Avdeev *et al.* (1986)
P. bupulda Ho & Kim, 1992	*Cer. burnetti* (Adams & Reeve, 1849)	Korea	Ho & Kim (1992)
	Fusinus forceps (Perry, 1811)	Korea	Kim (1998)
	Fusitriton oregonensis (Redfield, 1846)	Korea	Ho & Kim (1992)
	Ocenebra inornata (Récluz, 1851) [11]	Korea	Ho & Kim (1992)

[1] recorded as a "degenerate copepod parasite found in the liver"; most probably *Briarella microcephala* according to Monod & Dollfus (1934).
[2] as *Asteronotus bertrana* Bergh, 1878.
[3] based on a single egg sac found inside the kidney; provisionally identified as belonging to *Briarella microcephala*.
[4] originally identified as *Briarella microcephala* (*cf.* Monod & Dollfus 1932).
[5] as *Hexabranchus marginatus* (Quoy & Gaimard, 1932).
[6] originally identified as *Briarella risbeci* (*cf.* Monod & Dollfus 1932: 168–169).
[7] erroneously listed as a different combination and under the wrong authorship as "*Centrodoris inframaculata* (von Jhering)".
[8] recorded as an unidentified parasitic copepod.
[9] as *Seguenzia carinata* Jeffreys, 1877.
[10] as *Peribolus arabica* (Linnaeus, 1758).
[11] as *Ocenebra japonica* (Dunker, 1860).

Myzotheridion Laubier & Bouchet, 1976, a genus of uncertain position. *Nippoparasitus* **gen. nov.** is the fifth genus in the Philoblennidae and can be differentiated from the others by two unique characters, *i.e.*, the labium of the female extremely developed into multi-branched lobes (Fig. 2A) and the antenna (Fig. 3B) bearing three distal claw-like spines (see Izawa 1976; Laubier & Bouchet 1976; Ho 1981; Ho & Kim 1992; Huys 2001). Further, the maxilla bearing terminal segment with four processes and two setae differs from that of *Briarella* and *Philoblenna* (vs. without processes, see Izawa 1976; Ho 1981; Ho & Kim 1992; Huys 2001). Although Laubier & Bouchet (1976: figs. 2D, 4D) provided illustrations of the mandible of both sexes in their original description of *Myzotheridion*, Boxshall & Halsey (2004) pointed out that these appendages in reality represent the maxillae. The maxilla bearing series of processes on the margin is similar to that of *Nippoparasitus* **n. gen.** Therefore, *Nippoparasitus* **n. gen.** is considered to be most closely related to *Myzotheridion*. However, female of the new genus clearly differs from *Myzotheridion* by having not transformed labrum, highly transformed labium and more primitive legs 1 and 2 with 2-segmented rami. Although the shape of female labrum of *Myzotheridion* is similar to the female labium of *Nippoparasitus* **n. gen.**, it may be a kind of convergence to infect hosts.

The discovery of a new genus and species of parasitic copepod associated with this common limpet, *Patelloida saccharina*, distributed in the intertidal zone of Japanese waters illustrates that our knowledge of symbiotic copepods associated with marine invertebrates is still fragmentary. More field surveys aiming at the diversity and distribution of parasitic copepods of marine invertebrates are required globally.

Key to genera of Philoblennidae (based on adult females)

1	Large digitate labral lobes; antenna bearing one distal spine	*Myzotheridion*
-	Small simple labral lobes or absent; antenna bearing more than two distal spines	2
2	Labium developed into large digitate, multi-branched lobes; antenna bearing three distal claw-like spines; maxilla bearing pointed apical tip and four sharp processes on terminal segment	*Nippoparasitus* **gen. nov.**
-	Labium small, typical shaped; antenna bearing two distal spines; maxilla without sharp processes	3
3	Trunk bearing paired lateral processes	*Briarella*
-	Trunk without lateral processes	*Philoblenna*

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