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Haplostomides gottoi, new species (Crustacea: Copepoda: Cyclopoida: Ascidicolidae), living in a compound ascidian from Madagascar

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Abstract.—*Haplostomides gottoi*, new species, is described on the basis of females living in the compound ascidian *Polyclinum ?insulsum* Sluiter collected in Madagascar (Nossi Mitsio). Among nine known species of the genus (Haplostomatinae), the new species closely resembles *H. hibernicus* (Scott & Scott, 1895); both species have the same armature formula for legs 1–4. However, *H. gottoi* is distinguishable from *H. hibernicus* (*H. h.*) primarily by the following characters: body much more elongated; antenna with 4 spines (2, in *H. h.*); maxillule with 3 setae on precoxa and 6 setae on palp (2 and 4, in *H. h.*); in legs 1–4, terminal and subterminal spines on exopod not fused at base (fused, in *H. h.*).

The copepod associates of ascidians that the late Professor Arthur G. Humes collected in Madagascar (Nossi Bé, other small islands) in 1960, 1963–1964, and 1967, included representatives of at least three subfamilies of the family Ascidicolidae (see Ooishi 1995). The subfamily Haplostomatinae was one of these subfamilies and included mostly members of *Haplostoma* (Canu, 1886) and *Haplostomides* Chatton & Harant, 1924. The new copepod described in this paper is the only species of *Haplostomides* in the Humes collection, and it is the second to be described; the first was *Haplostoma humesi* Ooishi, 1995.

The nine known species *of Haplostomides* are as follows: 1) *H. hibernicus* (Scott & Scott, 1895); 2) *H. scotti* Chatton & Harant, 1924; 3) *H. brementi* Chatton & Harant, 1924; 4) *H. amaroucii* (Blake, 1929); 5) *H. bellus* Ooishi & Illg, 1977; 6) *H. luteolus* Ooishi & Illg, 1977; 7) *H. hawaiiensis* Ooishi, 1994; 8) *H. otagoensis* Ooishi, 2001; and 9) *H. sanamyani* Marchenkov & Boxshall, 2003. These species were described from various regions: North Atlantic Ocean (numbers 1 & 4); English Channel (number 2); Mediterranean Sea (number 3); North Pacific Ocean (number 5–7, 9); and South Pacific Ocean (number 8). The new species is the first recorded from the Indian Ocean. All ten species are associates of compound ascidians.

Three of the nine known species have been redescribed: *H. amaroucii*, by Dudley & Illg (1991); *H. scotti*, by Ooishi (2002); and *H. hibernicus*, by Ooishi (2005). In the redescription of *H. hibernicus*, the following facts were confirmed: 1) both *H. hibernicus* and *H. scotti* inhabit *Polyclinum aurantium* Milne Edwards, 1841, although Gotto (1952) was the first to report this from the Irish Sea; 2) (?)*Enterocola beaumonti* Scott & Scott, 1895 is synonymous with *H. scotti*, although Gotto (1954) was the first to predict this.

The males of two species are known: 1) *H. luteolus* (partly described by Ooishi & Illg 1986, when its relationship to the female was not yet known; the same male was designated as being of *H. luteolus* by Ooishi 2002); and 2) *H. scotti* (fully described by Ooishi 2002).

Haplostomides brementi was inadequately described in the original paper. The type specimen (MNHN Cp-129, on loan from the Muséum National d'Histoire Naturelle, Paris) has been reexamined by me, although it had previously been dissected (now lacking body anterior to second metasomal segment; posterior portion of body also damaged). The results (unpublished) of my study of the specimen are used in this paper for comparing the ten species of *Haplostomides*.

Materials and Methods

Data concerning the source of specimens of the new species are based on field notes (copies) made by Prof. Humes; these data are included in "*Material examined*" of this paper. According to Prof. Humes' field notes, the ascidian host *Polyclinum* ?*insulsum* Sluiter (= *P. insulsum* Sluiter?), which was identified by Dr. R. H. Miller, was listed on seven of his 52 collection numbers. I have confirmed that in each collection several different species and genera of copepod associates were present. The ascidian that harbored specimens of the new species was found in only one (no. 1109) of the seven collections; other copepod associates in this collection were mostly species of *Haplostoma* and *Botryllophilus*.

For dissection, measurements, and drawings, selected specimens of the new species were immersed in lactic acid (with a small amount of methylene blue). Drawings were made with the aid of a camera lucida. The previously dissected specimen of *H. brementi* was also immersed in lactic acid and further dissected by me. Dissected parts (after making drawings) were individually mounted in polyvinyl lactophenol on six slides: right leg 2, left leg 2, left leg 3, right leg 4, left leg 4, and posterior body portion. These slides were sent back to the Muséum National d'Histoire Naturelle, Paris, in 2004.

The genus *Haplostomides* is placed in the family Ascidicolidae Thorell, 1859, sensu Illg & Dudley (1980). In the armature formula for legs 1–4, the total number of spines (Roman numerals) is given first and connected by a dash with the number of setae (Arabic numerals) on each leg. The total number (T) of these elements is given in parentheses for the basis and exopod. The total number for the exopod, which is denoted by an asterisk (*), means that one mediodistal spine is counted in addition to the number of spines and one seta on the lateral margin.

Systematics

Family Ascidicolidae Thorell, 1859
Subfamily Haplostomatinae Chatton & Harant, 1924
Genus *Haplostomides* Chatton & Harant, 1924
Haplostomides gottoi, new species
Figs. 1–3

Material examined.—6 ♀♀ (Humes collection no. 1109) from a compound ascidian (smooth, reddish orange, dark), *Polyclinum* ?*insulsum* Sluiter, 1897, taken southwest of Nossi Mitsio, Madagascar, in depth 59–38 m, on 19 June 1967. Holotype ♀ (USNM 1102745) and 2 paratypes ♀♀ (USNM 1102746) deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C. The remaining specimens (dissected) remain in the author's collection.

Description of female.—Body (Fig. 1a–c) cylindrical, remarkably elongated, slender, with slight dorsal curvature. Body length, measured along body axis (lateral view) 2.50 mm. Body divided into small cephalosome, elongated metasome, and short, narrow urosome; proportional lengths 1:12:0.76 for 3 regions. Egg sacs (Fig. 1d) relatively short, 0.1 mm long (right egg sac) in this specimen, and carried on gonoporal areas located

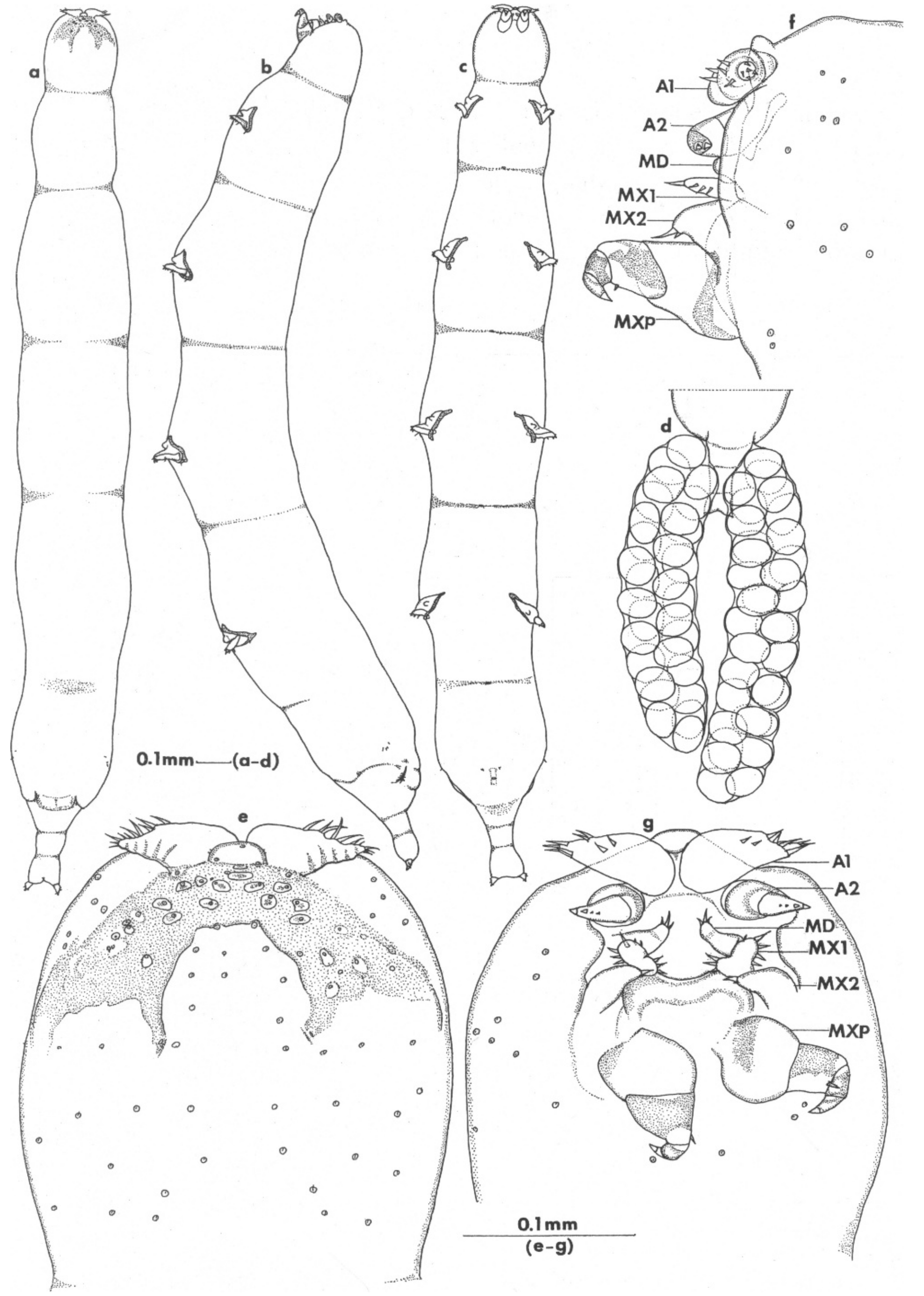

Fig. 1. *Haplostomides gottoi*, female. a, body form, dorsal; b, body form, left side; c, body form, ventral; d, 2 egg sacs attached to gonoporal areas, dorsal; e, cephalosome, dorsal; f, cephalosome, left side; g, cephalosome, ventral. A1 = antennule, A2 = antenna, MD = mandible, MX1 = maxillule, MX2 = maxilla, MXP = maxilliped.

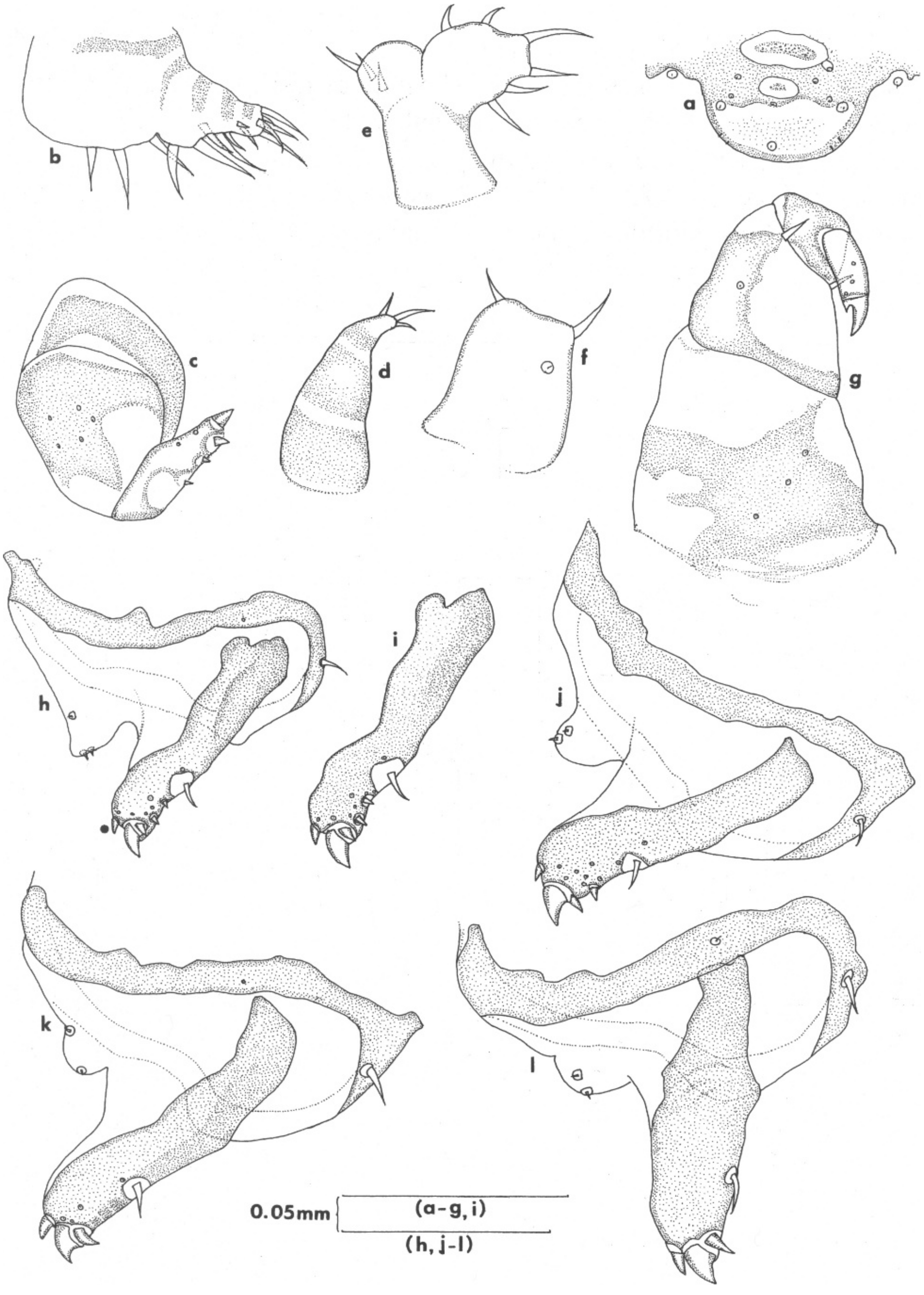

Fig. 2. *Haplostomides gottoi*, female. a, rostrum, anterior; b, left antennule, anterior; c, left antenna, anterior; d, left mandible, posterior; e, left maxillule, posterior; f, left maxilla, medial; g, left maxilliped, anterior; h, left leg 1, anterior (dot indicates mediodistal spine); i, left leg 1 exopod, anterior; j, left leg 2, anterior; k, left leg 3, anterior; l, left leg 4, anterior.

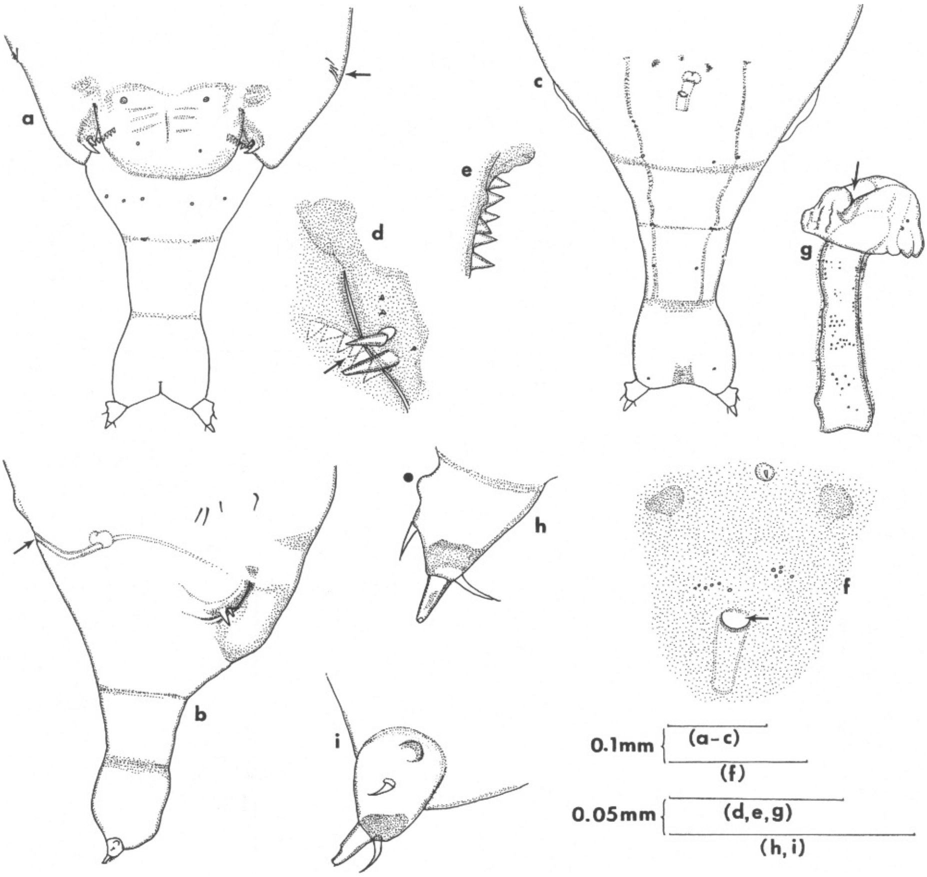

Fig. 3. *Haplostomides gottoi*, female. a, posterior portion of metasome (fifth metasomal section) and urosome with caudal rami, dorsal, showing fifth legs represented by 4 setae (indicated by arrow) and genital area with 2 gonopores and 2 pairs of hairlike sensilla; b, same specimen, left side, showing 4 setae for fifth leg, copulatory organs (arrow indicates position for copulatory pore), and gonoporal area; c, same specimen, ventral, showing midventral copulatory organs; d, right gonoporal area, dorsal, showing 2 rows (external, internal) of spines (arrow indicates internal row) on medial margin of gonopore; e, same specimen, viewed from ventral side, showing internal row of 6 conical spines; f, circular copulatory pore (indicated by arrow) and adjacent integument of posterior metasome, ventral; g, long copulatory duct and cap-shaped seminal receptacle with apical slit (indicated by arrow), ventral; h, left caudal ramus, dorsal (dot indicates mammiform projection); i, left caudal ramus, lateral.

dorsolaterally on posterior metasome. Round eggs (embryos) arranged multiserially.

Cephalosome (Fig. 1a–c) as long as wide (at mid-dorsal area), anterior margin rounded and slightly constricted proximally. Dorsal cephalic sclerite (Fig. 1e) butterfly-shaped, with small unsclerotized areas (each with 1 hairlike sensillum) scattered: 1 anterodistal and 9 or 10 on each side. Rostrum (Figs. 1e, 2a) wider than long, with broadly rounded distal margin. Distal half unsclerotized, with 3 hairlike sensilla (1 centrodistal, 2 lateroproximal); proximal half sclerotized and connected with sclerotized anterior cephalosome. Appendages (Fig. 1f, g) consisting of 6 pairs (antennules to maxillipeds). Paragnaths not present.

Metasome (Fig. 1a–c) comprising first to fourth thoracic segments and fifth metasomal section (fusion of fifth thoracic, genital, and abdominal segments). Proportional lengths 1:1.3:1.4:1.5:1.2 for

5 portions (4 thoracic segments, fifth section). Right and left legs widely separated, lacking intercoxal sclerite. Greatest width 0.3 mm on second to fourth thoracic segments. Posterior half of fifth section gradually tapered; setiferous fifth legs dorsolateral, gonoporal areas posterior to them, and copulatory organs midventral.

Urosome (Figs. 1a–c, 3a–c) much narrower and shorter than fifth metasomal section, consisting of 2 segments (abdominal, anal). Anal segment wider and longer than abdominal segment; distal margin slightly branched, each side with small caudal ramus.

Antennule (Fig. 2b) lobate, indistinctly divisible into 4 segments; each segment partially sclerotized. First segment large, and second to fourth segments gradually tapered. Armature consisting of 15 simple setae (long, short); 3,2,3,7 on first to fourth segments.

Antenna (Fig. 2c) 3-segmented; proportional lengths, measured on central axis (lateral view), 1:2.5:2. Third segment narrower than first and second segments, bearing 4 graduated conical spines on distal half of medial margin; 2 small medial, 1 larger subterminal, and 1 largest terminal. Several small hairlike sensilla on second and third segments.

Labrum (Fig. 1g) with distal margin broadly rounded, without armature.

Mandible (Fig. 2d) elongate lobe, directed medially, and indistinctly divided into 3 segments; each segment slightly sclerotized. Large proximal segment 4 times as wide as small distal segment. Rounded apical margin of third segment bearing 3 simple setae (1 long, 2 short).

Maxillule (Fig. 2e) consisting of 2 portions (precoxa, palp). Precoxa protruded mediodistally as rounded projection and armed with 3 simple subequal setae on margin. Palp longer than wide, indistinctly articulated with laterodistal margin of precoxa, bearing 6 simple setae along margin.

Maxilla (Fig. 2f) unsegmented lobe, slightly longer than wide, and directed medially, bearing 2 simple unequal setae (long terminal, short subterminal) on medial margin and 1 hairlike sensillum on surface.

Maxilliped (Fig. 2g) consisting of large coxa, smaller basis, and small endopod. Coxa without armature. Basis with 2 simple, subequal short setae (anterior, posterior) on medial margin near endopod. Endopod 3-segmented; third segment claw-shaped.

Legs 1–4 (Fig. 2h–l) alike in shape; leg 1 smallest. Sclerotized basis belt-like, with 1 simple seta on lateral margin. Width of basis approximately 1.3 to 1.4 times as long as exopod. Endopod distinctly shorter than exopod; these rami fused proximally. Distal portion of endopod represented by low subconical or mammiform protrusion with slight constriction at base; 2 or 3 hairlike sensilla on surface. Exopods sclerotized; distal one-third of sclerotized lateral margin armed with 2–4 graduated conical spines plus 1 small simple seta proximal to spines. Terminal and subterminal spines closely set, but not fused at base. In legs 1–4 exopods, terminal spine largest; in legs 1 and 2, subterminal and lateral spines obviously smaller than terminal spine. In addition, legs 1–4 exopods with 1 conical spine mediodistally, close to medial base of terminal spine. Armature formula for legs 1–4 as follows:

	Basis (T)	Exopod (T)
P1	0–1.......(1)	V–1.......(6*)
P2	0–1.......(1)	IV–1.......(5*)
P3	0–1.......(1)	III–1.......(4*)
P4	0–1.......(1)	III–1.......(4*)

Leg 5 (Fig. 3a, b) represented by 4 small simple setae (1 proximal, 3 distal) inserted directly on dorsolateral side (anterior to genital area) of fifth metasomal section.

In genital area (Fig. 3a), dorsal cuticle between gonopores slightly sclerotized, twice as wide as long, with 2 pairs (anterior, posterior) of hairlike sensilla. Medial margin of slitlike gonopore (Fig. 3a, d) armed with 2 rows (external, internal) of spines. External row consisting of 2 unequal sharp conical spines (1 shorter proximal, articulated; 1 longer distal, unarticulated). Internal row with 6 merely conical spines (Fig. 3e).

Copulatory organs (Fig. 3b, c, f, g) consisting of circular copulatory pore, long cylindrical copulatory duct ornamented with minute elements, cap-shaped seminal receptacle (ventral view), and 2 slender receptacle ducts extending from it toward gonoporal areas. Apical surface of seminal receptacle unequally divided by slit into 2 portions. When viewed from ventral side, seminal receptacle connected with copulatory duct mushroom-shaped. Cuticle, anterolateral to copulatory pore, with 2 small sclerotized areas (right, left).

Caudal ramus (Fig. 3h, i) subconical; lateral margin with small mammiform projection near anal segment. Armature consisting of 2 simple setae (midway on lateral margin; dorsoproximal) and 1 terminal spine with small indentation ventrally.

Male.—Unknown.

Etymology.—The species name *gottoi* honors the late Dr. Vivian Gotto, who contributed to the resolution of a problem with respect to the relationship of *H. hibernicus* and *H. scotti* to their ascidian host. Dr. Gotto gave me a valuable opportunity to study *H. hibernicus* from Strangford Lough (see Ooishi 2005), making it possible to describe the present new species.

Discussion

The armature formula for legs 1–4 can be obtained for the ten species of *Haplostomides* based on the following studies (see the introduction for the authors and years): original descriptions of *H. bellus*, *H. luteolus*, *H. hawaiiensis*, *H. otagoensis*, *H. sanamyani*, and *H. gottoi*; redescriptions of *H. amaroucii*, *H. scotti*, and *H. hibernicus*; my reexamination of *H. brementi*. In the ten leg armature formulas obtained, it is possible to distinguish their patterns and related features, as given below.

Patterns of leg armature formulas.—In a given leg armature formula, four total numbers (Arabic numerals) are compared; each total number represents the number of spines plus one seta on the exopods of legs 1–4. The four total numbers are available for the ten species of *Haplostomides*, although in *H. brementi* one of the four numbers was obtained by prediction, as explained below.

In the specimen of *H. brementi* reexamined, leg 1 pair had already been lost, but it was possible to obtain the formula (4,3,3) for left legs 2–4. In five other known species of this genus, the formula for legs 1–4 (right, left) is 5,4,3,3. As the last three numbers for *H. brementi* are identical to those for the five species, it is easy to predict the armature number (5) of leg 1 for *H. brementi*. However, it was found that right leg 3 of the specimen has one small spine between two elements (subterminal spine, lateral seta), thus the formula for right legs 2–4 is 4,4,3. It is considered that this specimen shows a variation with respect to the armature on right leg 3.

The armature formulas (with 4 total numbers) for the ten species can be divided into four patterns (I–IV); these species are assigned to their respective patterns as follows:

Pattern I (5,4,3,3)—*H. brementi*, *H. amaroucii*, *H. bellus*, *H. luteolus*, *H. otagoensis*, *H. sanamyani*.

Pattern II (5,4,4,4)—*H. scotti*.

Pattern III (3,3,3,3)—*H. hawaiiensis*.

Pattern IV (6*,5*,4*,4*)—*H. hibernicus*, *H. gottoi*.

Armature formula patterns and related features.—The ten species of *Haplostomides* occur mainly in two genera of ascidians (Aplousobranchia: Polyclinidae). Five of the six species which have formula pattern I, as listed above, are associated with species of *Aplidium*; one (*H. bellus*) is associated with a species of *Sigillinaria*. These six copepod species are similar with respect to the body form (refer to *H. otagoensis* by Ooishi 2001, for this kind of body form): the posterior portion of the fourth metasomal section consists of a dorsally fused short fifth thoracic segment whose posterolateral corners (with setae representing fifth legs) are protruded (in various degrees); the genital segment is included in the urosome.

In the remaining four species that have formula patterns II–IV, the ascidian hosts are exclusively species of *Polyclinum*. In *H. scotti*, which has formula pattern II, the posterolateral corners of the short fifth thoracic segment are not distinctly protruded; the genital segment forms the anterior portion of the urosome. In three other species with formula patterns III (*H. hawaiiensis*) and IV (*H. hibernicus*, *H. gottoi*), the body is cylindrical, the elongated metasome includes the fifth section (fusion of the fifth thoracic, genital, and abdominal segments), and the urosome (abdominal, anal) is small.

Of the four species that are associates of *Polyclinum*, three have similarly shaped seminal receptacles (connected to a long copulatory duct). These seminal receptacles are bulb-shaped in *H. scotti* (with pattern II) and *H. hibernicus* (with pattern IV), and cap-shaped in *H. gottoi* (with pattern IV). In *H. hawaiiensis* (with pattern III), its shape is not really comparable, but it does somewhat resemble those in *H. scotti*, *H. hibernicus*, and *H. gottoi* in having an enlarged seminal receptacle connected to a long copulatory duct. These types of seminal receptacles have not been found in the six species of *Haplostomides* with pattern I or in any species of *Haplostoma*.

Characteristics of H. gottoi.—As discussed above, *H. gottoi* closely resembles *H hibernicus* in having the leg armature formula of pattern IV, metasome including the fifth metasomal section, and similar seminal receptacle. Some other characters common to both are found in the antennule (with 15 or 17 setae), mandible (with 3 setae), and maxilla (with 2 setae). The new species, however, can be distinguished from *H. hibernicus* (= *H. h.*) as follows: 1) body much more elongated; 2) rostrum with 3 hairlike sensilla centrodistally and lateroproximally (4 transversely, in *H. h.*); 3) antenna with 4 graduated spines (only subterminal and terminal, in *H. h.*); 4) in maxillule, precoxa with 3 setae and palp with 6 setae (2 and 4, in *H. h.*); 5) in maxilliped, basis with 2 subequal simple setae (anterior, posterior) on medial margin (1 stout anterior, 1 much smaller posterior, in *H. h.*); 6) in legs 1–4, terminal and subterminal spines on exopods not fused at base (fused, in *H. h.*); 7) caudal ramus with small rounded projection lateroproximally (lacking it, in *H. h.*).

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