ISSN 1345-0662

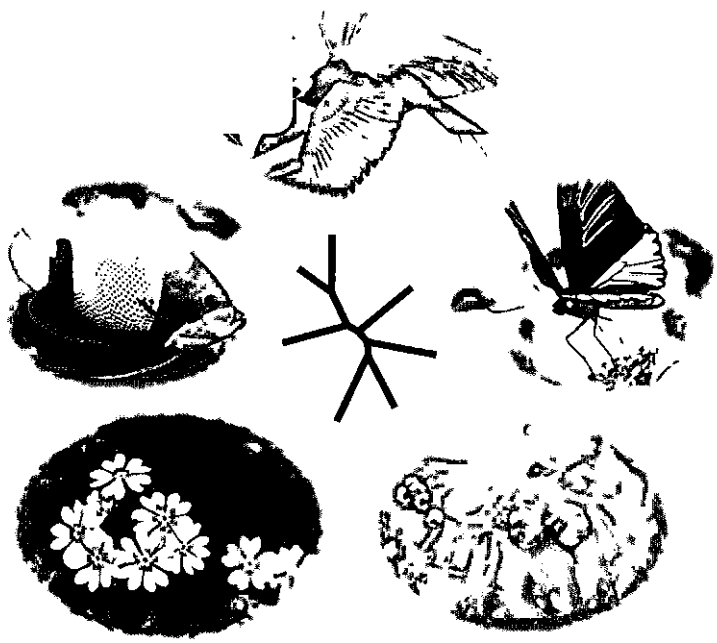
Biogeography

International Journal of Biogeography,
Phylogeny, Taxonomy, Morphology, Ecology,
Philosophy, Evolution, Biodiversity and Environmental Biology

Vol.17
pp.1–131
September 20, 2015

QH
84
.B54
v.17
2015

Biogeography.
UH Manoa: Hamilton
QH84 .B54
v.17
2015



The Biogeographical Society of Japan

University of Hawai'i at Mānoa LIBRARIES

External Services Program

Hamilton Library Room 101 • 2550 McCarthy Mail • Honolulu, HI 96822

Phone/Voicemail: 808-956-5956

Fax: 808-956-7109

Email: esp@hawaii.edu

NOTICE: The copyright law of the United Sates (Title 17, U.S.C.) governs the making of photocopies or other reproductions of copyrighted materials. Under certain conditions specified in the law, libraries and archives are authorized to furnish a photocopy or reproduction. One of these specified conditions is that the photocopy or reproduction is not to be "used for any purpose other than in private study, scholarship, or research." If a user makes a request for, or later uses, a photocopy or reproduction for purposes in excess of "fair use," that user may be liable for copyright infringement. This institution reserves the right to refuse to accept a copying order, if, in its judgment, fulfillment of the order would involve violation of copyright law.

BEST AVAILABLE COPY

MAIL REQUESTS &

Biogeography 17.
27–36. Sep. 20, 2015

First record of gall-forming copepods on hydrocorals from the Pacific coast of Japan, with descriptions of one new genus and two new species[1]

Kazunari Ogawa[2*] and Kanae Matsuzaki[3]

[2] Z. Nakai Laboratory, Minami 2-53-11, Koenji, Suginami-ku, Tokyo, 166-0003 Japan
[3] National Institute for Environmental Studies, 16-2 Onogawa, Tsukuba, Ibaraki, 305-8506 Japan

Abstract. *Darumamyzon japonicum* gen. et sp. nov. (Siphonostomatoida, Asterocheridae) and *Hammatimyzon stockii* sp. nov. (Siphonostomatoida, Asterocheridae) the first Japanese species of gall-forming copepods are described from stylasterine corals along the Pacific coast of Japan. Their respective hosts are *Stylaster profundiporus typica* (Broch, 1936) and *S. gracilis* Milne Edwards & Haime, 1850. Revised keys to the gall-forming copepod genera from stylasterines and to the females of the species of *Hammatimyzon* are given.

Key words: gall-forming copepods, *Darumamyzon japonicum* gen. et sp. nov., *Hammatimyzon stockii* sp. nov., key, hydrocorals, NW Pacific Ocean, Japan

Faunal researches on hydrocorals were made by the National Museum of Nature and Science, Tokyo in Japan in the years 2001-2005 in the Sagami Sea and adjacent coastal areas. Based on 73 specimens, Ogawa (2006) reported nine species of four genera. Among these were some gall-bearing specimens, and this report introduces the first record of gall-inhabiting copepods from hydrocorals along the Pacific coast of Japan.

Copepod galls on hydrocorals were first described by Stock (1981) using materials including some specimens from the Challenger Expedition, and the host hydrocorals and gall morphology were studied by Zibrowius (1981). Stock (1981) described six copepod species in four genera, all new, belonging to the family Asterocheridae, order Siphonostomatoida (Boxshall & Halsey, 2004). One station record of the host coral *Stylaster sanguineus* Milne Edwards & Haime, 1850 was Challenger stat. 232, recorded as Japan, off Bay of Yokohama, 35°11'N, 139°28'E, 345 fathoms (=632 m), 12. v. 1875. Zibrowius (1981) found two lots with specimens purportedly from stat. 232 and commented that this material must have been confused, because *S. sanguineus* has never again been reported from Japan. The geographical coordinates fit Sagami Bay (attached to the Sagami Sea), but the depth is most unlikely, so the precise provenance of this station record remains uncertain (Zibrowius, 1981).

Materials and methods

Two females (holotype and paratype) of *Darumamyzon japonicum* gen. et sp. nov. were found in the same gall (Fig. 1a, b) of *Stylaster profundiporus typica* (Broch, 1936) which was collected from St. 28 (33°31'N, 140°16'E, off Izu Hachijou-jima Is.), 327-333 m depth, on 23 September 2003. Preserved in dry condition, after ethanol had evaporated. One female (holotype) of *Hammatimyzon stockii* sp. nov. from the gall (Fig. 5a) of *Stylaster gracilis* Milne

[1] Z. Nakai Laboratory contribution No. 61.
*Corresponding author: K. Ogawa

Edwards & Haime, 1850 which was collected from St. 31 (33°32'N, 140°16'E, off Izu Hachijou-jima Is.), 135-172 m depth, on 26 September 2003. Preserved in 70% ethanol. One female (non-type specimen of the same species of copepod) was found in the different gall of *Stylaster gracilis*, collection data unknown, preserved in 70% ethanol.

All specimens were separately transferred to 75% ethanol for conservation and storage. Cleared by lactic acid and dissect under a stereomicroscope using a needle; drawings made by camera lucida, with photographs taken at need. Terminology adopted from Huys and Boxshall (1991). Fully dissected appendages mounted on glass slides and finally sealed with Canada balsam. These materials are deposited in the National Museum of Nature and Science, Tsukuba, Ibaraki, Japan (NSMT-Cr 24229 for *Darumamyzon japonicum*; NSMT-Cr 24230 for *Hammatimyzon stockii*).

Systematic part

Darumamyzon gen. nov.
Family: Asterocheridae.

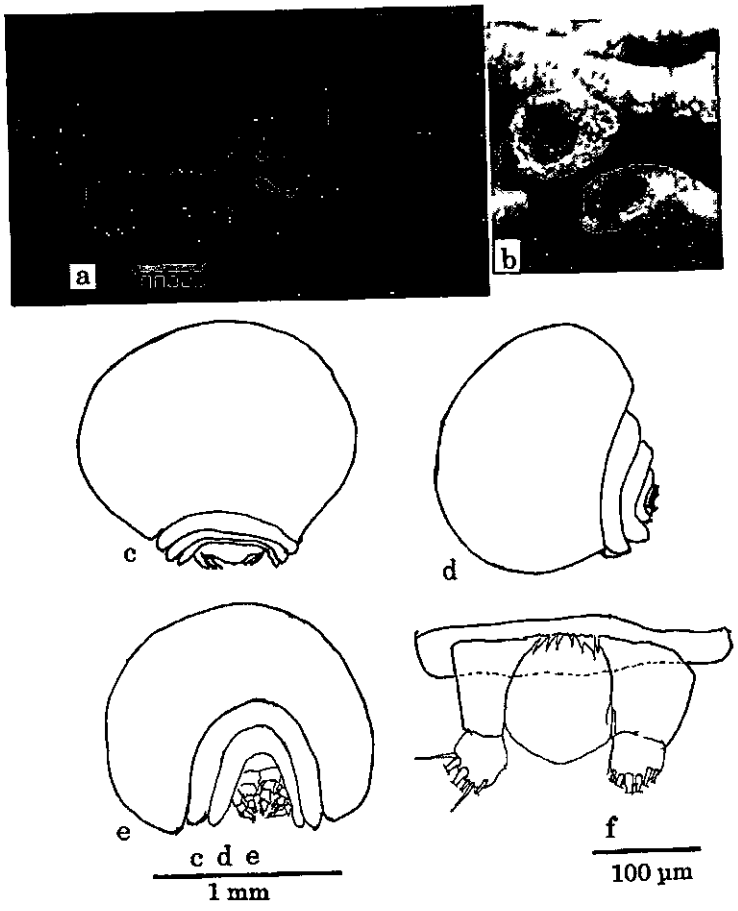


Fig. 1. a. Copepod gall caused by *Darumamyzon japonicum* gen. et sp. nov., with insert showing pore with slit in gall; b. same gall broken open. Scale bar divisions in mm; c. *Darumamyzon japonicum* gen. et sp. nov., holotype, dorsal view; d. lateral view; e. ventral view; f. anal somite and caudal ramus, ventral view.

Diagnosis: Female transformed. Epimerae of metasomites small. Antennule nine-segmented with the usual aethete I, situated on the penultimate eighth segment. Exopodite of antenna well developed, although shorter than first endopodal segment. Outer ramus of maxillule with fully developed armature (four setae) with an accessory lobe. Three pairs of biramous legs, with all rami three-segmented; third exopodal segment of leg one to leg three with two, four, and four spines respectively. Fourth leg with free segment. Fifth leg absent.

Type-species: *Darumamyzon japonicum* sp. nov.
Other species: So far, the genus is monospecific.
Etymology: From Daruma, the founder of Zen known for its rotund figure in Japan, and from the Greek μυζειν (= to suck); alluding to the copepod's peculiar swollen body shape and suctorial mouthparts.

Darumamyzon japonicum gen. et sp. nov. (Figs. 1-4)
New Japanese name: Daruma kobu-yadori.
Material examined. One female (holotype), one female (paratype). In the same gall of *Stylaster profundiporus typica* (Broch, 1936).

Description of female holotype. Body round, onion-shaped, very difficult to orient stably for observation; cephalosome forming most of body. Lateral and frontal margins of cephalosome bent beneath body, with only small medioventral area remaining exposed. Cephalosome wider than long. Greatest width of cephalosome 1,460 μm, body length 1,300 μm, body depth 1,340 μm (Fig. 1c-e). Nauplius eye not ascertained.

Epimerae of first to third metasomites small, pointing backwards, rounded distally (Fig. 1c, d), third epimera not visible in ventral view (Fig. 1e). Genital double somite much wider than long, rough-

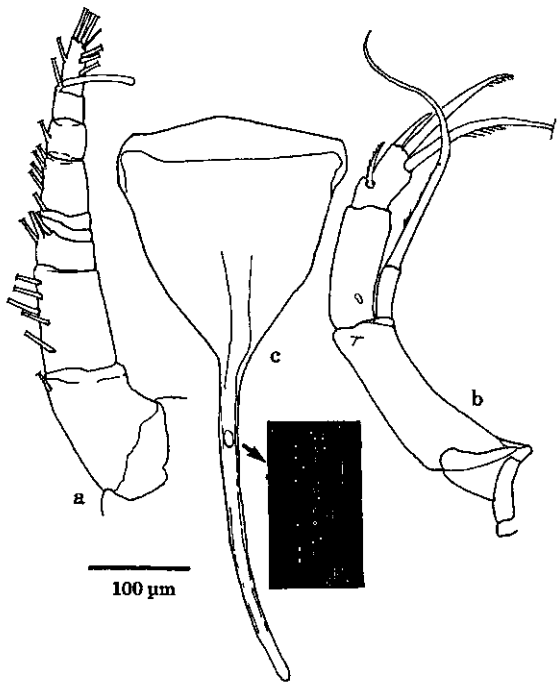


Fig. 2. *Darumamyzon japonicum* gen. et sp. nov., holotype.
a. antennule; b. antenna; c. oral cone, with magnified insert showing ingested particulate matter within siphon.

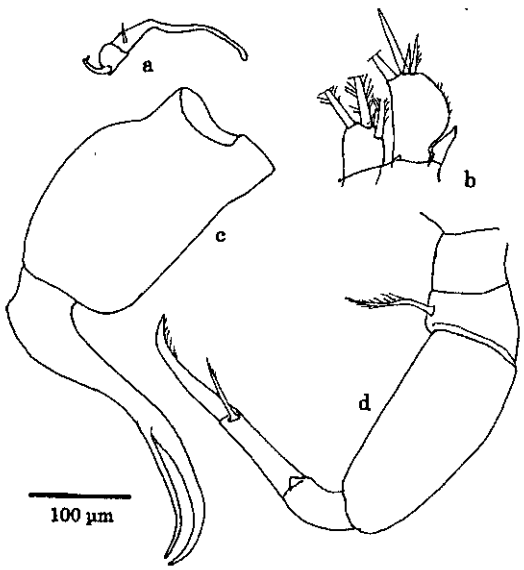


Fig. 3. *Darumamyzon japonicum* gen. et sp. nov., holotype.
a. mandible; b. maxillule; c. maxilla; d. maxilliped.

ly rectangular in outline. Anal somite shortest (Fig. 1f).

Antennule (Fig. 2a) nine-segmented, with very short fourth and fifth segments. Approximate number of setal elements on each segment one, five, three, one, one, five, one, one aethete, and nine respectively, from proximal to distal. Aesthete, on penultimate segment, narrow and thin.

Antenna (Fig. 2b) with short exopodite (half as long as first segment of endopodite), distally armed with very long seta reaching end of longest endopodal seta. Endopodite two-segmented; first segment unarmed, second segment bearing one medial seta, two terminal claw-like elements, and one lateral subterminal seta.

Oral cone (Fig. 2c) conical basally, narrowing to long, slender distal siphon. Minute ingested particle (10.5×15.8 μm) situated near base (Fig. 2 insert.).

Mandible (Fig. 3a) consisting of small stylet and slender palp armed with one seta.

Maxillule (Fig. 3b) consisting of two rami, each lobe armed with four setae. Inner lobe with three long setae and one short seta, outer lobe with one long seta and three short ones, with accessory lobe at base.

Maxilla (Fig. 3c) with armed basal portion and recurved distal claw bearing one long seta.

Maxilliped (Fig. 3d) five-segmented, segment one unarmed, segment two with long seta on inner margin, segment three unarmed, segment four with broken setal stub, segment five with one seta, and strong apical claw.

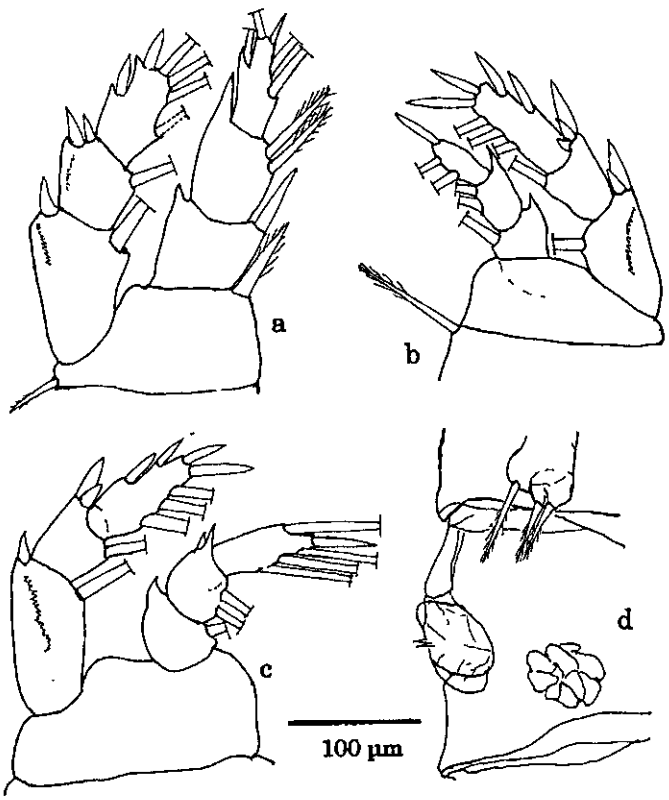


Fig. 4. *Darumamyzon japonicum* gen. et sp. nov., holotype.
a. first leg; b. second leg; c. third leg; d. fourth leg with partial ventral view of genital double somite.

Legs one to three biramous. Intercoxal plates well developed. Leg one (Fig. 4a) with well developed inner basipodal spine and outer basipodal short seta, lacking coxopodal element. Bicuspidate process found on distolateral corner of second exopodal segment, row of spinules present on exopodal segments one and two.

Leg two (Fig. 4b) with long coxopodal seta but lacking basidopodal element, and having larger lateral exopodal spines than leg one. Tricuspidate process on second segment. Bicuspidate process found on first segment on one side of body. Row of spinules present on first segment.

Leg three (Fig. 4c) lacking both coxopodal and basipodal elements. Bicuspidate process found on second exopodal segment and on endopodal segment on one side of body.

Spine and seta formula as follows, with variation observed on endopodal segments:

	coxa	basis	exopodal segments	endopodal segments
leg 1	0-0	1-I	I-1; I-1; II, 1, 3	0-I; 0-2; 2, I, 3 (or 2, I, 2)
leg 2	0-1	0-0	I-1; I-1; III,I, 3	0-1; 0-2; 0, I, 2 (or I, I, 2)
leg 3	0-0	0-0	I-1; I-1; III, I, 3	0-1; 0-2; 1, 1, 3

Fourth leg reduced to two small lobes, these bearing one and two setae respectively (Fig. 4d). Fifth leg absent.

Caudal rami (Fig. 1f) round and widely separated,

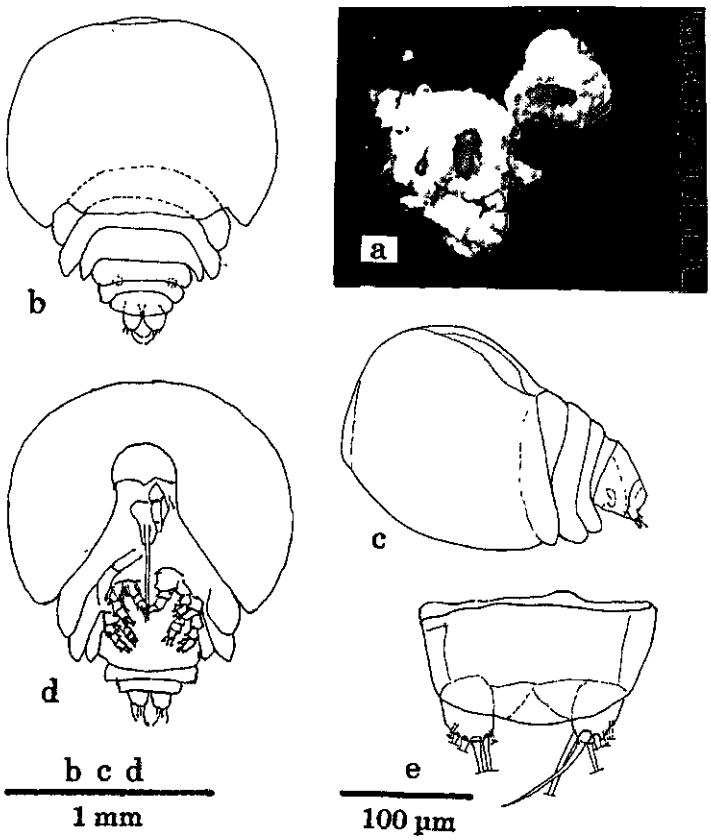


Fig. 5. a. Broken open gall caused by *Hammatimyzon stockii* sp. nov., scale bar divisions in mm.; b. *Hammatimyzon stockii* sp. nov., holotype, dorsal view; c. lateral view; d. ventral view; e, anal somite and caudal rami, dorsal view.

terminal setae broken. Anal operculum rounded, not prominent.

Remarks: Stock (1981) reported *Oedomyzon* and *Cystomyzon* as having three pairs of biramous legs. The present new genus can easily be distinguished from them by its strongly inflated and peculiar body features. In addition, the spine arrangements of the exopodal segments of leg one to leg three differ from those of known genera (see Revised key to genera, herein below). Numerous loose eggs were found in the gall together with the female, their diameter ranging from 230 to 250 μm. The tiny object inside the oral cone indicates that the new species can suck up not only dissolved matter but also minute particulate matter.

Hammatimyzon stockii sp. nov. (Figs. 5 – 8)

New Japanese name: Kobu-yadori.

Material examined. One female (holotype). In gall of *Stylaster gracilis* Milne Edwards & Haime, 1850.

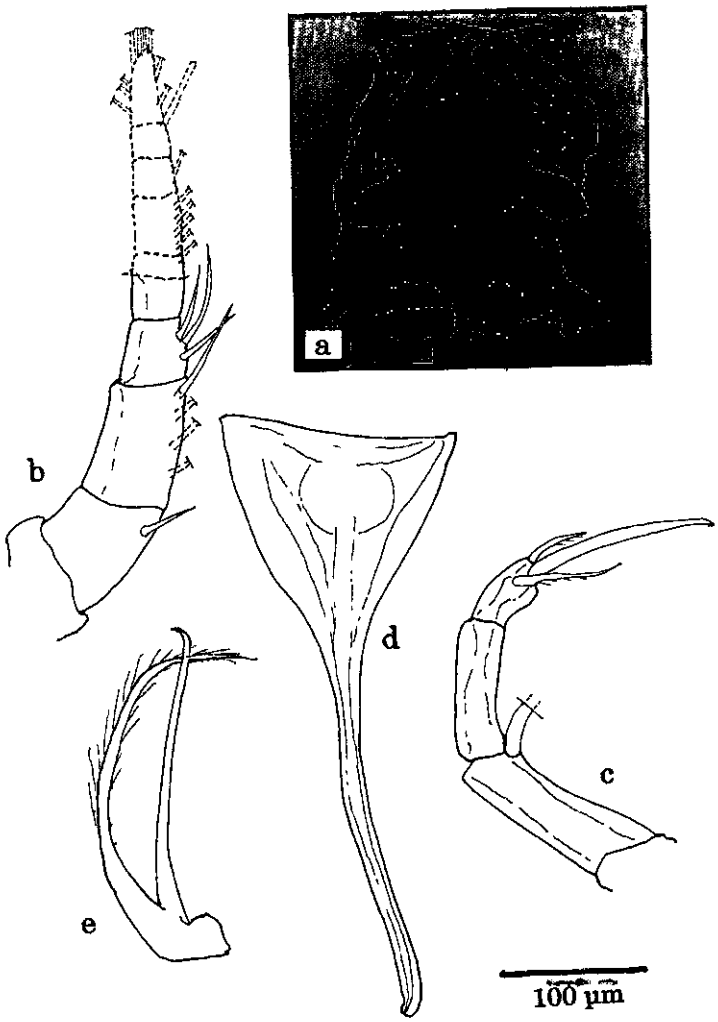


Fig. 6. *Hammatimyzon stockii* sp. nov., holotype.
a. ventral view of anterior part and mouth parts, scale 200 μm;
b, antennule; c. antenna; d. oral cone; e. mandible.

One female (reference specimen, severely damaged). In gall of the same species of hydrocoral.

Etymology. Species name *stockii* dedicated to Jan H. Stock, who reported new genera and species of copepods forming galls on hydrocorals for the first time in 1981.

Description of female holotype. Greatest width of cephalosome 1,050 μm, length of body (excluding furcal setae) 1,220 μm, body depth 850 μm. Body swollen, shaped like fan in dorsal view and oval in lateral view (Fig. 5b, c). Nauplius eye not ascertained.

Cephalosome much wider than long, its lateral and frontal margins folded beneath half of body (Fig. 5d). Epimerae of three metasomites strongly developed, pointing backwards. Epimera of metasomite one rounded distally, and that of metasomite three somewhat narrower and shorter than others (Fig. 5b-d). Genital somite much wider than long, roughly rectangular in outline. Postgenital somite narrower than genital somite. Anal somite well developed, with large anal lobe covering insertions of caudal rami (Fig. 5e).

Antennule broken (Fig. 6b), so the number of original segments unknown, but judging from pre-dissecion photograph probably nine (Fig. 6a).

Antenna (Fig. 6c) with short exopodite (less than half as long as first endopodal segment), its long seta

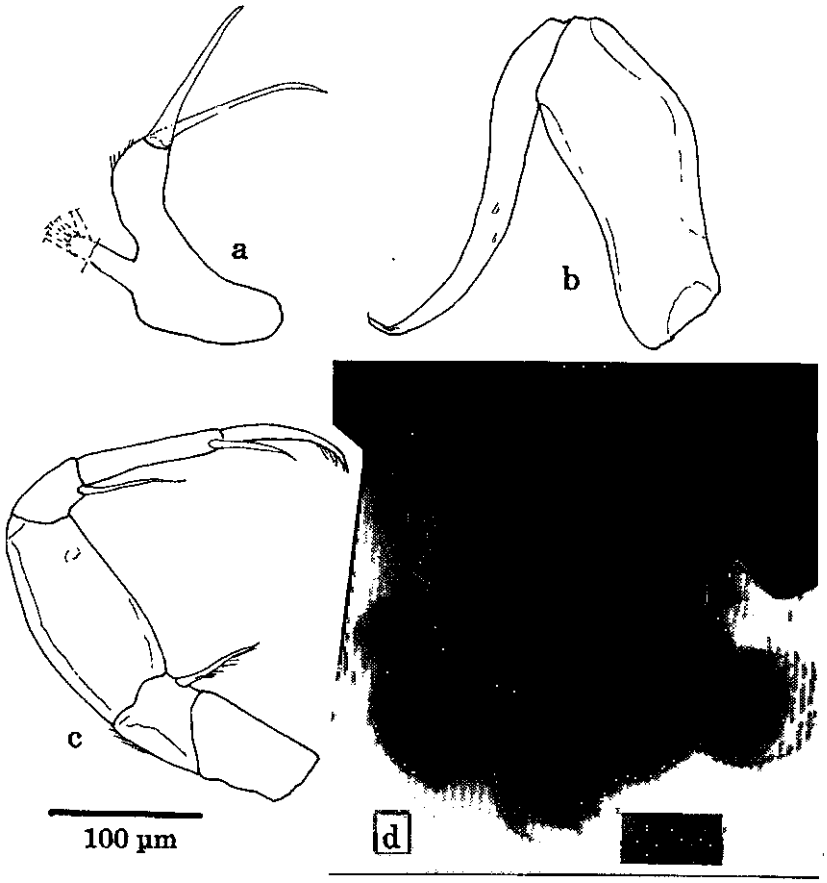


Fig. 7. *Hammatimyzon stockii* sp. nov., holotype.
a. maxillule; b. maxilla; c. maxilliped; d. eggs and first-stage nauplii. Scale 200 μm.

broken off. Endopodite two-segmented; first segment unarmed, second segment bearing two medial setae, and one terminal claw-like element.

Oral cone (Fig. 6d) conical basally, narrowing to long, slender siphon distally.

Mandible (Fig. 6e) with long, slightly curved stylet and long, plumose distal seta.

Maxillule (Fig. 7a) badly preserved; outer lobe bearing two long setae, tip with all setae of inner lobe broken off (normally four setae present).

Maxilla (Fig. 7b) consisting of unarmed, robust basal segment and recurved distal claw.

Maxilliped (Fig.7c) five-segmented, first segment unarmed, second segment with one seta, third segment unarmed, fourth and fifth segments each with one seta, and latter also bearing strong terminal denticulated claw.

Legs one to four are biramous. Leg one (Fig. 8a) lacking both inner basidopodal spine and coxopodal seta. Distolateral corners of first exopodal segment and second endopodal segment each with bicuspidate process.

Leg two (Fig. 8b) with coxopodal seta and outer basipodal seta. First exopodal segment with bicuspidate process, second segment with tricuspidate process, both segments with laterodistal row of spinules.

Leg three (Fig. 8c) with coxopodal seta and outer

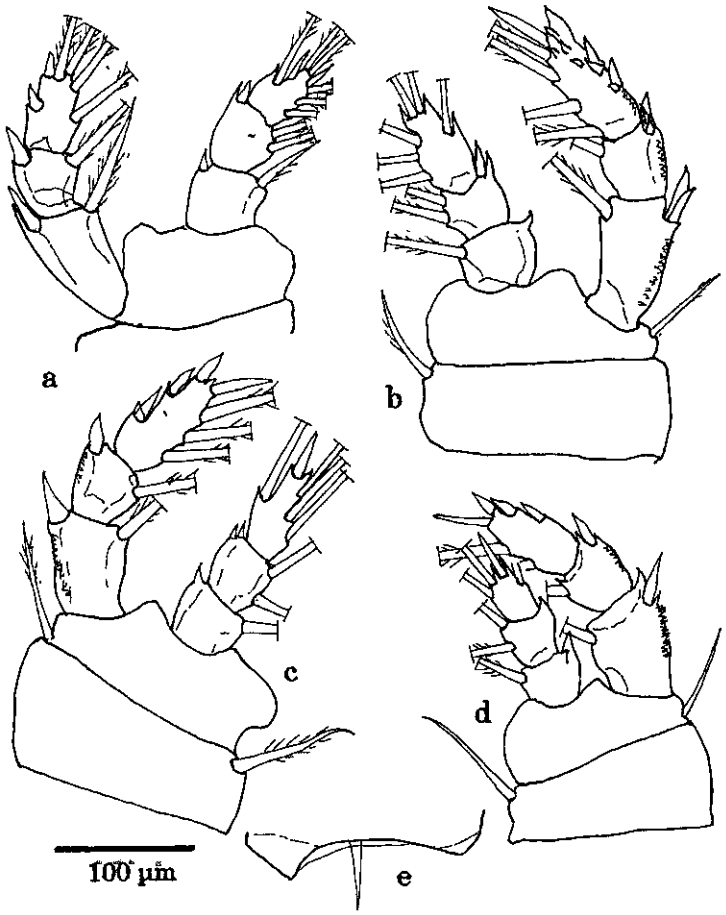


Fig. 8. *Hammatimyzon stockii* sp. nov., holotype.
a. first leg; b. second leg; c. third leg; d. fourth leg; e. fifth leg.

basipodal seta. First and second exopodal segments with laterodistal row of spinules.

Leg four (Fig. 8d) with coxopodal seta and outer basipodal seta. First and second exopodal segments with laterodistal row of spinules as leg three.

Spine and seta formula as follows:

	coxa	basis	exopodal segments	endopodal segments
leg 1	0-0	0-0	I-1; I-1; II, I, 3	0-1; 1-2; 1, 2, 3
leg 2	0-1	1-0	I-1; I-1; III, I, 3	0-1; 1-2; 1, 2, 3
leg 3	0-1	1-0	I-1; I-1; III, I, 3	0-1; 1-2; 1, I, 3
leg 4	0-1	1-0	I-1; I-1; III, I, 2 (or 3)	0-1; 0-2; 1, I, 3

Leg five represented by isolated free seta at posterior margin of first urosomite (Fig. 8e). Sixth legs absent.

Caudal rami (Fig. 5e) slightly oblong. Rami inserted far apart, terminal setae broken. Anal operculum well developed as large anal lobe, covering implantation sites of caudal rami.

Remarks: The antennule was broken but the photograph taken before dissection shows that this specimen belongs to the genus *Hammatimyzon*, in which the antennule is eight- to ten-segmented (Stock, 1981). This new species is similar to *H. dimorphum* Stock, 1981 but is easily distinguishable from it by the short genital somite and very prominent anal operculum (see Key to Species). Numerous loose eggs were found in the gall together with a few first-stage nauplius (Fig. 7d). The diameter of these eggs ranged from 260 to 330 μm, and the nauplii were 220×320 μm.

Revised key to the genera of copepods (female) producing galls in stylasterine corals.

1a. Four pairs of biramous legs presen----------2
b. Three pairs of biramous legs present ---------- 3
2a. Outer ramus of maxillule with 2-3 setae. Exopod of antenna shorter than first endopodal segment ---------- *Hammatimyzon*
b. Outer ramus of maxillule with 4 setae. Exopod of antenna very elongate ---------- *Cecidomyzon*
3a. Rami of leg1-leg3 all 3-segmented ----------4
b. Both rami of leg1 and endopod of leg2-leg3 2-segmented ---------- *Cystomyzon*
4a. Antennule 7-segmented. Third exopodal segments of leg1-leg3 with 2, 3, and 3 spines respectively ---------- *Oedomyzon*
b. Antennule 9-segmented. Third exopodal segments of leg1-leg3 with 2, 4, and 4 spines respectively ---------- *Darumamyzon gen.* nov.

Revised key to the species of *Hammatimyzon* (female)

1a. Pleurae of metasomites well developed. Second maxilla and maxilliped robust.
Anal operculum very prominent ---------- *H. stocksii* sp. nov.
Anal operculum not prominent ---------- *H. dimorphum*
b. No pleura on metasomite 1. Second maxilla and maxilliped slender ---------- *H. zibrowii*

Acknowledgements

We are grateful to Dr. M. J. Grygier of the Lake Biwa Museum for critically reading the manuscript with useful comments, and K.O. thanks Dr. H. Namikawa of the National Museum of Nature and Science, Tokyo, for invitation to participate in that museum's Sagami Sea Survey. We also extend our gratitude to an anonymous reviewer for useful comments to improve the manuscript.

References

Boxshall, G. A. & S. H. Halsey, 2004. Family Asterocheridae (Giesbrecht, 1899) *in* An Introduction

to Copepod Diversity. Part II. The Ray Society, London, pp. 714-722.

Huys, R. & G. A. Boxshall, 1991. Copepod Evolution. The Ray Society, London, 468 pp.

Ogawa, K., 2006. Hydrocorals of the Sagami Sea. *Mem. Natn. Sci. Mus., Tokyo*, **40** : 75-78. (in Japanese with English summary)

Stock, J. H. 1981. Associations of hydrocorallia stylasterina with gall- inhabiting Copepoda Siphonostomatoidea from the south-west Pacific Part II. On six species belonging to four new genera of the copepod family Asterocheridae. *Bijdragen tot de Dierkunde*, **51** (2), 287-312.

Zibrowius, H. 1981. *Ditto*. Part I. On the Stylasterine hosts, including two new species, *Stylaster papuensis* and *Crypthelia cryptotrema*. *Ibid.*, **51** (2), 268-286.

(Received May 18, 2015; Accepted August 10, 2015)