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A New Species of *Balaenophilus* (Copepoda: Harpacticoida), an Ectoparasite of a Sea Turtle in Japan

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ABSTRACT—*Balaenophilus umigamecolus* n. sp., the second species known at present in the aberrant harpacticoid family Balaenophilidae, has been collected from the neck skin of a juvenile loggerhead sea turtle *Caretta caretta* in the aquarium of the Kushimoto Marine Park Center, Wakayama Prefecture, Japan. This is the first record of copepods occurring on a sea turtle. This new species differs from *Balaenophilus unisetus*, which has been recorded only as an associated species on baleen plates of baleen whales, in its small size, the number of apical claws of leg 1, the setal arrangement of leg 4, and the length of the caudal rami. Gut contents indicate that the copepod scrapes the skin of the host sea turtle directly for food.

INTRODUCTION

While breeding juvenile loggerhead sea turtles *Caretta caretta* (Linnaeus) at the Kushimoto Marine Park Center (K. M. P. C), Wakayama Prefecture, Mr. I. Miyawaki found one weak individual which had discolored neck skin. After bathing the turtle in tap water, one of the authors (H. M.) obtained numerous associated copepods by filtering the bath water through bolting cloth (mesh size: 0.10 mm). The senior author tentatively identified the copepods as *Balaenophilus unisetus* Aurivillius (Harpacticoida: Balaenophilidae), hitherto known as a commensal on baleen plates of baleen whales: blue whale *Balaenoptera musculus* (L.) (Aurivillius, 1879a, b; Lillie, 1910; Mackintosh, 1942; Vervoort and Tranter, 1961), fin whale *B. physalus* (L.) (Bannister and Grindley, 1966; Raga and Sanpera, 1986), sei whale *B. borealis* Lesson (Collett, 1886; Mackintosh, 1942; Bannister and Grindley, 1966), and Bryde's whale *B. edeni* Anderson (Bannister and Grindley, 1966), landed or collected in northern Norway, the Irish west coast, western Australia, Durban and Cape Town of South Africa, and Atlantic Iberian waters. Bannister and Grindley (1966) compiled the record of occurrence on whales caught in the southern hemisphere and concluded that the sei whale is the most important host, *Balaenophilus unisetus* being found on 80% of that species, but on less than 2% of fin whales and Bryde's whales.

We requested Dr. J. A. Raga, University of Valencia, to loan us specimens of *B. unisetus* collected from the baleen plates of fin whales(Raga and Sanpera, 1986). After comparing the material, we concluded that the species from the sea turtle is new to science and describe it as the second species of *Balaenophilus* together with its nauplius and copepodid stages.

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MATERIALS AND METHODS

More than 440 specimens were obtained from the single juvenile *Caretta caretta* on March 24, 1987. These were preserved in 20% formalin, transferred to 70% ethanol, stained in aniline blue, and cleared and mounted in lactic acid. More than 20 mature specimens were dissected in order to observe variations and gut contents. Ten specimens each of females and males were used for measuring the body length, maximum width, and the length of the caudal setae. Loaned specimens of *B. unisetus* preserved in ethanol were also treated in the same manner. The terminology is adopted from Huys and Boxshall (1991).

DESCRIPTION

Order HARPACTICOIDA Sars, 1903
Family Balaenophilidae Sars, 1910
Genus *Balaenophilus* Aurivillius, 1879
Balaenophilus umigamecolus n. sp.
(Figs. 1–10)

[Japanese name: umigame-kagitsume-harupa, new]

Type series. The holotype (NSMT-Cr12022, female), the allotypic paratype (NSMT-Cr12023, male), 10 other paratypes (NSMT-Cr12024, 5 ♀♀, 5 ♂♂) are deposited in the National Science Museum, Tokyo. Ten paratypes (IORD IN 97001, 5 ♀♀, 5 ♂♂) are deposited in the Institute of Oceanic Research and Development, Tokai University, Shizuoka Prefecture.

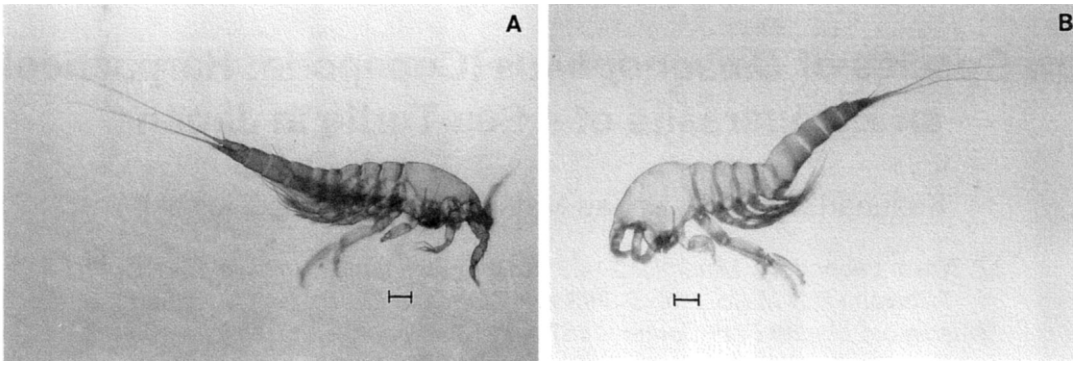

Fig. 1. *Balaenophilus umigamecolus* n. sp., **A**, male (paratype); **B**, female (holotype). Scale bars = 0.1 mm.

Additional materials. 2 copepodids, 5 nauplii, and all slides of dissected paratypes and gut contents are deposited in the National Science Museum, Tokyo. The remaining specimens are deposited in the collections of the K. M. P. C. and the Z. Nakai Laboratory.

Measurements. Female: average length of 10 specimens 1.24 mm (range: 1.14–1.32) from anterior end to end of caudal ramus, a little bit longer than male (length of ♀:♂= 1.07 : 1.00). Caudal setae adding on average 0.81 mm (0.71–0.88 mm) to length. Maximum width 0.19–0.24 mm, 0.23 mm on average. Average number of eggs 30 (range: 29–35) per egg sac. Male: average length of 10 specimens 1.16 mm (1.10–1.20 mm), with caudal setae adding on average 0.81 mm (0.71–0.90 mm). Maximum width averaging 0.20 mm (0.19–0.23 mm).

The sex ratio is 1 : 3.6 (♂:♀).

Female (holotype): Body length 1.18 mm including caudal rami, caudal setae adding 0.74 mm. Maximum body width 0.20 mm measured at posterior margin of cephalothorax. Body shape slender and elongated (maximum width : body length =0.17 : 1.0). No distinction between prosome and urosome but slightly constricted at midlength, with anterior part scarcely wider than posterior (Fig. 2A). First legs remarkably strongly developed (Fig. 1B). Head and first pedigerous somite fused to form cephalothorax, with no line of fusion visible (Fig. 2A). Cephalothorax longer, than combined length of pedigerous somites 2 to 5. Pedigerous somites 2 to 4 all of about same length, 5th somite shorter. Genital double-somite with no line of fusion visible, longer than combined lengths of abdominal somites 2 and 3. Anal somite shorter than abdominal somite 2 or 3. Caudal setae more than half as long as body (proportions 0.60 : 1.0). Integumental sensilla scarce on whole body, with exception of abdominal and anal somites. Rows of spinules arranged laterally on trunk as shown in Fig. 2B. Rostrum (Fig. 3A) linguiform, its length equaling the combined length of first two antennular segments, a pair of sensilla visible on median dorsal surface.

Caudal rami (Fig. 2A) short, slightly longer than anal somite, and provided with 4 well developed and 2 small setae plus numerous short setules, only one of former appreciably longer than the others. Egg sac (Fig. 2C) elongated, 0.45 × 0.13 mm, containing eggs of about 0.05 mm diameter. No spermatophore observed.

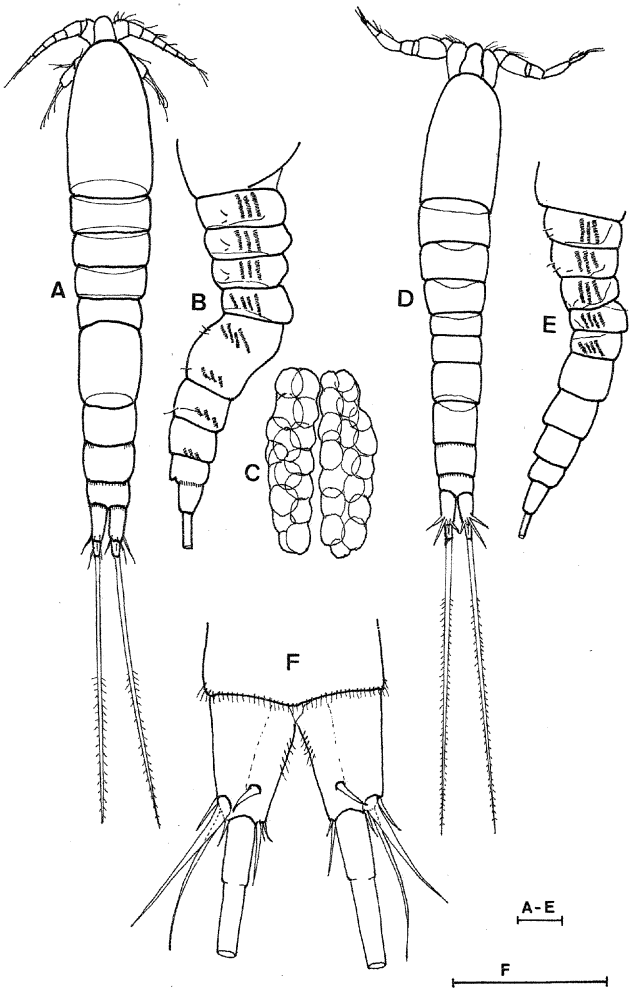

Fig. 2. *Balaenophilus umigamecolus* n. sp., **A**, dorsal view of female (holotype); **B**, lateral view of female; **C**, pair of egg sacs; **D**, dorsal view of male (paratype); **E**, lateral view of male; **F**, anal segment and furca of male, dorsal view. Scale bars = 0.1 mm.

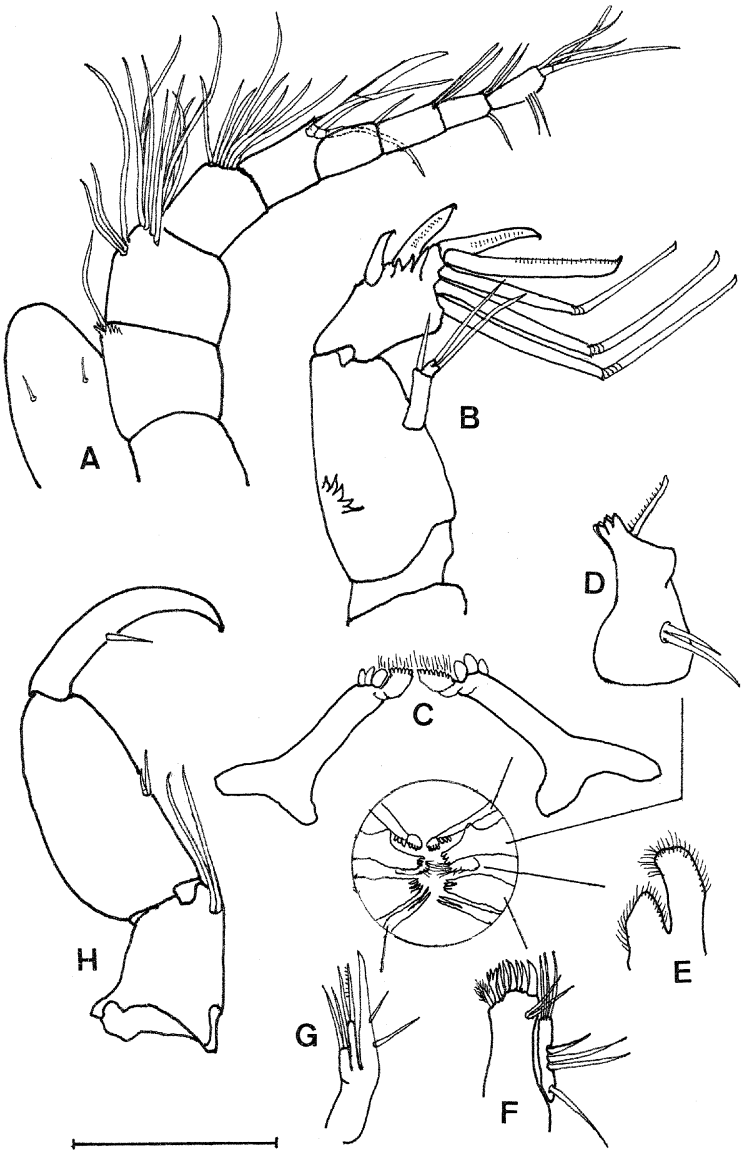

Fig. 3. *Balaenophilus umigamecolus* n. sp., female (paratype). **A**, antennule; **B**, antenna; **C**, labrum; **D**, mandible; **E**, paragnath; **F**, maxillule; **G**, maxilla; **H**, maxilliped. Scale bar = 0.1 mm. The inserted schematic figure shows the mouthpart arrangement viewed from the ventral side.

Antennule (Fig. 3A) 9-segmented. Number of setae on segments: 0 on first, 1 on second with spinules, 11 on third, 8 on fourth, 3 on fifth with distinct apical cone, including 1 aesthetasc, 1 on sixth, 2 on seventh, 3 on eighth, 6 on ninth including 1 aesthetasc.

Antenna (Fig. 3B) Coxa extremely short. Cylindrical allobasis carrying coronula of spinules near inner margin and small, styliform exopod halfway along outer margin. Exopod 2-segmented, with 2 setae on minute, free apical segment and 1 seta located near insertion of this segment on proximal one. Well developed, powerful, free portion of endopod composed of single segment articulated at right angle to allobasis, bearing 3 strongly curved and hooked and 4 straight but hooked claws, and row of coarse teeth along outer margin.

Labrum (Fig. 3C) with masticatory process backed by strongly haired integument, long and bearing 3 chitinized plates at tip.

Mandible (Fig. 3D) with crown of strong teeth and pectinate distal seta. Palp reduced, represented by 2 long setae.

Paragnath (Fig. 3E) consisting of two haired lobes placed between mandible and maxillule.

Maxillule (Fig. 3F) with well developed praecoxal arthrite, carrying 6 strong spines, 1 trifurcate spine, and 1 plumose seta on its margin, preceded by 2 long setae. Protopod and both rami reduced to unsegmented rod with 3 distal, 3 outer middle, and 1 basal setae.

Maxilla (Fig. 3G) with 3 endites, first endite with 2 simple setae, second endite with 1 simple and 1 spinulose seta, third endite with strong apical spine and 1 seta on basis of this spine. Endopod reduced to a seta located near base of third

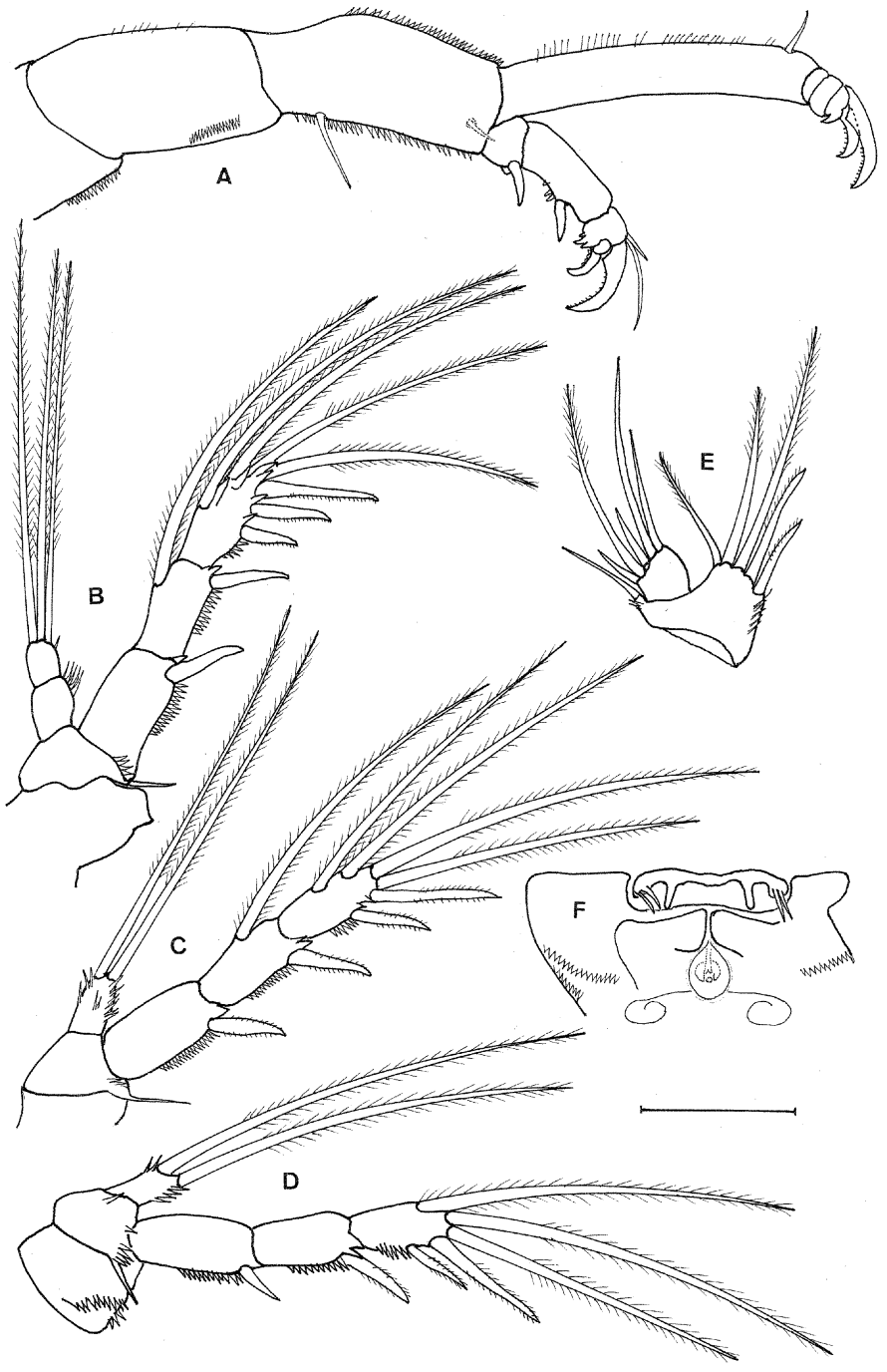

Fig. 4. *Balaenophilus umigamecolus* n. sp., female (paratype). **A**, leg 1; **B**, leg 2; **C**, leg 3; **D**, leg 4; **E**, leg 5; **F**, leg 6. Scale bar = 0.1 mm.

endite.

Maxilliped (Fig. 3H) 3-segmented and developed as powerful clasping organ. Syncoxa with 2 long setae at distal end of inner margin. Basis elongated and swollen with 2 short setae at midlength of inner margin. Endopod represented by very strong claw with fine seta on inner margin at midlength.

Leg 1 (Fig. 4A) bearing strongly developed, unequal rami as clasping organs, with rather long coxa and basis, short, 3-segmented exopod, and long, 3-segmented endopod. Coxa with sparse short spinules; outer border of praecoxa spinulose. Basis about as long as coxa, inner and outer margins spinulose, with proximal and distal seta. First exopod segment short, with strong outer spine distally; second segment longest, with row of spinules and spine along outer margin;

third segment shortest, with 2 strong but unequal, curved apical claws, serrated along outer margin, with accessory claws basally and 2 unequal simple setae apically. First endopod segment greatly elongated, curved a little inwards, inner margin hairy with single subapical seta; second segment short, unarmed; third segment as long as second, with 3 unequal claws, two larger ones serrated along outer margin.

Legs 2 to 4 each with 3-segmented exopod; leg 2 (Fig. 4B) with 2-segmented endopod, leg 3 (Fig. 4C) and leg 4 (Fig. 4D) with 1-segmented endopod. Spine and setal formulae as follows, with Roman and Arabic numerals indicating spines and setae, respectively:

Leg 2	coxa 0-0	basis 1-0	exp.	I-0; I-1; III,2,2
			end.	0-0; 0,3,0
Leg 3	coxa 0-0	basis 1-0	exp.	I-0; I-1; II,2,2
			end.	0,2,0
Leg 4	coxa 0-0	basis 1-0	exp.	I-0; I-0; II,2,1
			end.	0,2,0

Bases and outer margins of all exopods armed with short spinules. One acute process present near insertion of each exopodal spine. Outer margins of all endopods bearing spinules. All distal setae of exopods and all endopodal setae naked near their base.

Leg 5 (Fig. 4E) small, exopod articulating distinctly with baseoendopod. Exopod with 1 long, plumose seta, 2 long, naked setae, and 2 spines. Baseoendopod of left and right sides well separated, each with 1 simple outer seta, 3 long apical setae, and 2 pectinate spines. Leg 6 (Fig. 4F) very small but distinct, bearing 2 minute setae and genital flaps. Copulatory pore circular, minute, and covered by bulb-shaped protuberance.

Male (paratype): Body length 1.14 mm including caudal rami, caudal setae adding 0.82 mm. Maximum width 0.20 mm measured at the posterior margin of cephalotharax. General body form resembling that of female except for robust, geniculate antennules (Figs. 1A, 2D). Genital somite short and first abdominal somite longest, abdominal somites 2 and 3 of about the same length. Anal somite shortest, with caudal rami developed as in females. Except for being absent on abdominal somites, rows of lateral spinules arranged similarly to those of female (Fig. 2E).

Caudal rami (Fig. 2D, F) almost as in female, but caudal setae slightly longer in proportion to body length (0.7 : 1.0).

Antennule (Fig. 5A) 9-segmented, geniculate, robust, and longer than in female. Number of setae on segments: 0 on first, 1 on second with coronula of spinules, 11 on third, 8 on fourth including 1 aesthetasc, 8 on fifth including 1 aesthetasc, 1 on sixth, 2 on seventh, 1 on eighth, 9 on ninth including 1 aesthetasc.

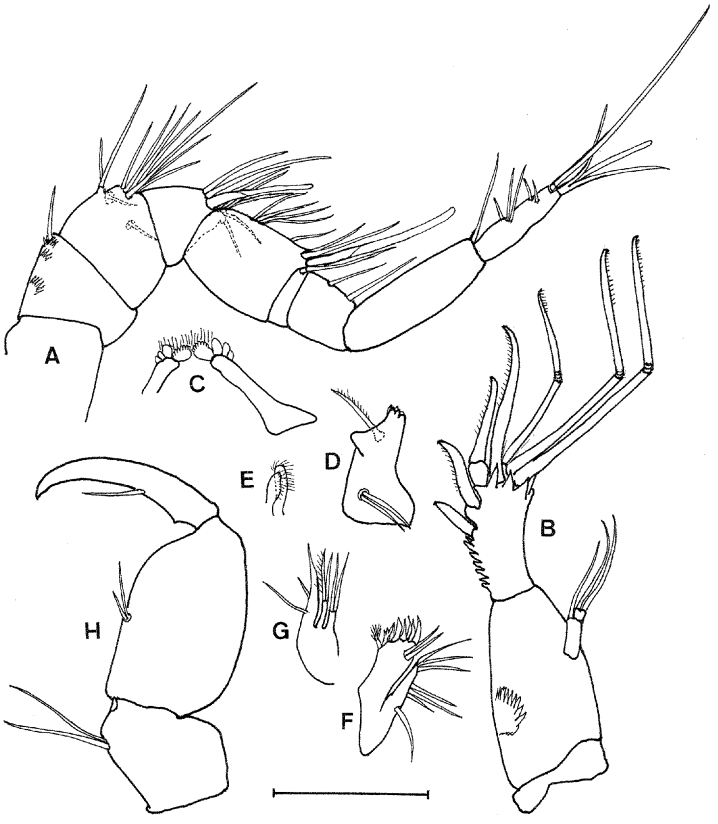

Fig. 5. *Balaenophilus umigamecolus* n. sp., male (paratype). **A**, antennule; **B**, antenna; **C**, labrum; **D**, mandible; **E**, paragnath; **F**, maxillule; **G**, maxilla; **H**, maxilliped. Scale bar = 0.1 mm.

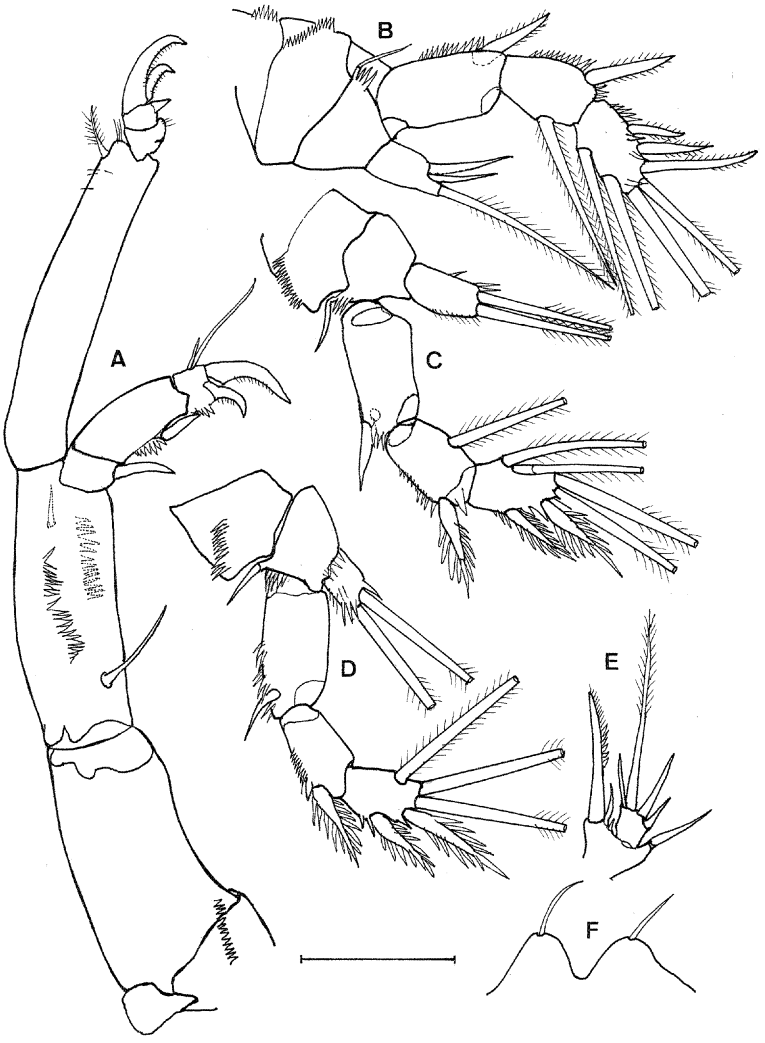

Fig. 6. *Balaenophilus umigamecolus* n. sp., male (paratype). **A**, leg 1; **B**, leg 2; **C**, leg 3; **D**, leg 4; **E**, leg 5; **F**, leg 6. Scale bar = 0.1 mm.

Antenna (Fig. 5B) almost the same as in female, but more robust and apical endopod segment with stronger spinules along inner margin and at bases of spiniform hooked setae.

No differences between sexes in structure of mouthparts (Fig. 5C-G), but smaller in male than in female. Armature also the same in maxilliped as in female, except that of male slightly stronger and larger than in female(Fig. 5H).

Leg 1 (Fig. 6A) as in female, except more strongly developed and longer. Spine and setal formula of legs 2 to 4 as in female, except endopod of leg 2 with only 1 segment, and exopod with more strongly developed outer spines (Fig. 6B-D). Setal formula for leg 2 as follows:

Leg 2	coxa 0-0	basis 1-0	exp.	I-0; I-1; III,2,2
			end.	II,1,0

Leg 5 (Fig. 6E) smaller than in female, exopod articulating distinctly with baseoendopod as in female. Exopod with 1 short simple seta, 1 long seta, and 2 spines. Baseoendopod of left and right sides well separated, each with 1 simple outer seta; long inner spine pectinate, but with denticles replaced by setules distally. Leg 6 (Fig. 6F) very small, represented by 1 simple seta on prominence.

First nauplius stage (Fig. 7A, B): 10 specimens obtained clinging to egg sacs just after hatching. Body convex and oval, 127 μm wide and 89 μm long, bearing 3 pairs of appendages and caudal rami represented by small protuberances, each with a plumose seta. Antennule (Fig. 7A1) bearing 3 long setae, short plumose seta, and small spine. Antenna (Fig. 7A2) with dentate coxa, endopod bearing strong claw, 2 small spines, and 4 long setae, exopod terminating with 4 bristly, hooked spines. Mandible (Fig. 7Md) 1-segmented, bearing strong claw, a small spine, and 2 setae.

Copepodid stages (Figs. 7C-E, 8, 9): Five copepodids obtained among all available specimens, including third (1 specimen), fourth (2 specimens), and fifth (2 specimens)

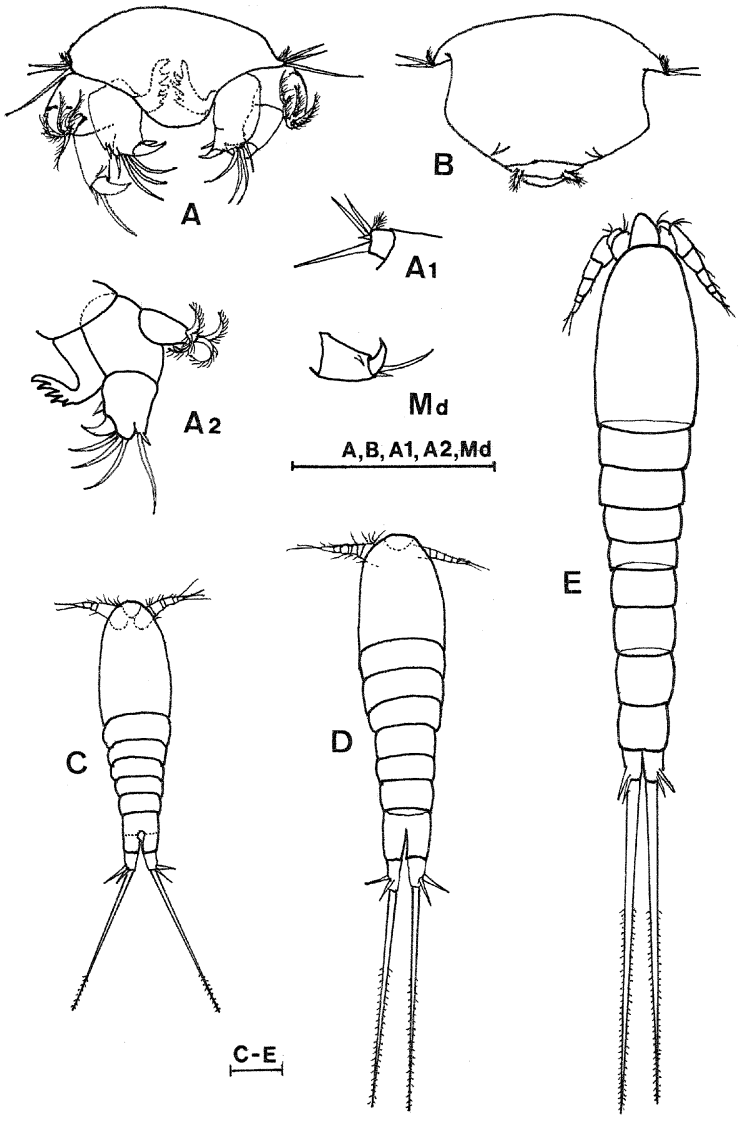

Fig. 7. *Balaenophilus umigamecolus* n. sp., first nauplius and copepodids. **A**, frontal view of nauplius; **B**, dorsal view of nauplius; **A1**, antennule; **A2**, antenna; **Md**, mandible; **C**, third copepodid; **D**, fourth copepodid; **E**, fifth copepodid. Scale bars = 0.1 mm.

stages.

Third stage. Body consisting of 6 postcephalothoracic somites, 0.50 mm long from anterior end to end of caudal ramus (Fig. 7C). Antennule 6-segmented with an aethetasc on second segment (Fig. 8A-CIII). Antenna consisting of coxa, allobasis, and 1-segmented, free endopod segment; apex of endopod bearing 3 geniculate spines and 2 claw-like spines with fine setule; exopod 1-segmented with 2 setae (Fig. 8B-CIII). Leg 1 consisting of coxa, basis, and 2-segmented endopod and exopod. First segment of endopod elongated, second segment short with 2 terminal claws and a small fixed claw. First segment of exopod with a small spine and second segment with 2 claws with 2 long setae (Fig. 8C-CIII). Legs 2 (Fig. 8D-CIII) and 3 (Fig. 8E-CIII) with 2-segmented exopod and 1-segmented endopod; leg 4 (Fig. 8F-CIII) with 1-segmented exopod and no endopod.

Fourth stage ♀. Body consisting of 7 postcephalothoracic somites, 0.65 mm long (Fig. 7D). Antennule 9-segmented with an aethetasc on fifth and ninth segments (Fig. 8A-CIV). Antenna with short coxa, apical endopod with 3 geniculate spines and 3 claw-like spines; exopod with 3 setae (Fig. 8B-CIV). Leg 1 consisting of coxa, basis, and 2-segmented endopod and exopod. First segment of endopod elongated, second segment short with 3 unequal terminal claws. First segment of exopod with 1 spine and second segment with 2 terminal claws accompanied by 2 setae, and 1 subapical spine (Fig. 8C-CIV). Legs 2 to 4 with 2-segmented exopod and 1-segmented endopod (Fig. 8D-CIV ~ F-CIV).

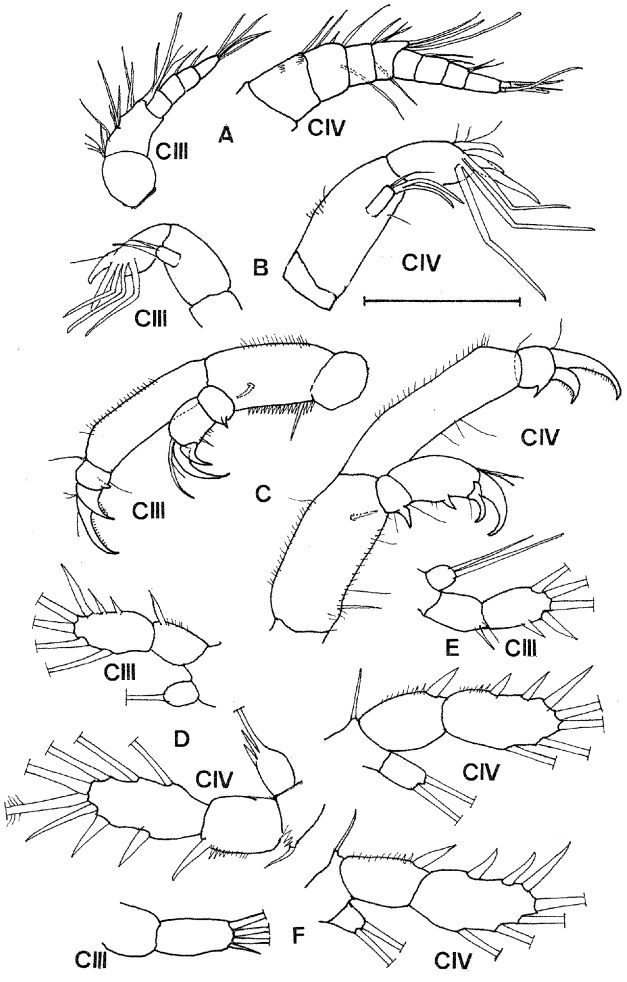

Fig. 8. *Balaenophilus umigamecolus* n. sp., third (CIII) and fourth (CIV ♀) copepodids. **A**, antennule; **B**, antenna; **C**, leg 1; **D**, leg 2; **E**, leg 3; **F**, leg 4. Scale bar = 0.1 mm.

Fifth stage ♀. Body consisting of 8 postcephalothoracic somites, 0.97 mm long (Fig. 7E). Antennule 9-segmented with an aethetasc on fifth and ninth segments (Fig. 9A). Antenna with extremely short coxa, apical endopod bearing 3 geniculate spines, 2 apical claw-like spines, and 1 subapical spine, and rod-shaped, unsegmented exopod with 3 setae (Fig. 9B). Leg 1 consisting of coxa, basis, and 2-segmented endopod and exopod. First segment of endopod elongated and unarmed, second segment short with 3 unequal terminal claws. First segment of exopod with 1 spine and second segment 3 unequal terminal claws accompanied by 2 long setae, and 1 subapical spine (Fig. 9C). Legs 2 to 4 with 3-segmented exopod and 1-segmented endopod (Fig. 9D-F); setal formulae of copepodid stages III-V as follows:

Copepodid stage		Third	Fourth	Fifth
Leg 2	exp.	I-0; III,2,2	I-0; III,2,2	I-0; I-1; III,2,2
	end.	0,1,0	0,3,0	0,3,0
Leg 3	exp.	I-0; II,2,1	I-0; III,2,2	I-0; I-1; II,2,2
	end.	0,2,0	0,2,0	0,2,0
Leg 4	exp.	I,2,1	I-0; III-2,2,	I-0; I-0; II,2,1
	end.	–	0,2,0	0,2,0

Etymology. The specific name, *umigamecolus*, is a combination of Japanese *umigame*, meaning sea turtle, and the suffix *-colus*, denoting 'inhabiting' in Latin. Gender masculine.

Variation. Noticed in: (1) the setation of the second antennulary segment (10–11 in ♀, 11–13 in ♂) and the third segment (7–9 in both sexes); (2) the number of smallest claws on the third exopod segment of the first leg (0–3 in ♀, 2–3 in ♂); (3) one female specimen with abnormal exopod setal arrangement of 2nd leg (Fig. 10); (4) the number of small setae on the furcal rami (2–3).

Remarks. This is the second species of *Balaenophilus*. It can be clearly distingushed from *B. unisetus* by : (1) its small size, the length ratio of *B. umigamecolus* and *B. unisetus* being 1.0 : 1.8 in both sexes; (2) the 3 strong apical claws on the third segment of both the exopod and endopod of the 1st leg (*B. unisetus* has 2 claws); (3) the lack of an inner seta on the second exopod segment of leg 4 (*B. unisetus* has 1 seta); (4) the short length of caudal rami (*B. unisetus* has long rami).

In the description of this genus's type species *B. unisetus*, there are some confusion and errors. Regarding the antennule, Aurivillius (1879a, b) described it as 8-segmented, Sars (1910) described it as 9-segmented, and Lang (1948) described it as 8- or 9-segmented. Vervoort and Tranter (1961) described it as 8-segmented excluding the first segment, which they called socle. Aurivillius (1879a, b) correctly described the labrum as the upper lip, and the paragnaths as the under lip. Vervoort and Tranter (1961) described the paragnaths as the labrum and the labrum as the labium. Aurivillius (1879a, b) and Sars (1910) described the caudal ramus armed with 4 setae and some small spines, but Vervoort and Tranter (1961) described 6 setae.

The aberrant nauplius has very strongly developed claws, almost the same as illustrated in *B. unisetus* by Aurivillius (1879a, b), although some errors are found in the figure by Bannister and Grindley (1966). In addition, this nauplius has clasping appendages rather than ones typical of a free-living, planktonic nauplius. Some copepodids of stages III-V were also found on the host sea turtle. These facts indicate that this new species may spend its whole life on the skin of a host sea turtle, just as *B. unisetus* lives on the baleen plates of a host baleen whale.

We could not deduce where the copepod comes from. Juvenile sea turtles were being artificially incubated and reared in raw sea water from directly in front of the K. M. P. C. without passing through other tanks of the aquarium. The gut contents of *B. umigamecolus* consisted of packed brownish material which had the same appearance as material scraped from host juvenile loggerhead turtle's neck skin (Fig. 11A, B). This is positive evidence that *B. umigamecolus* eats sea turtle skin directly for food, and that this copepod is an epibiotic parasite. We also found packed brownish material in the gut

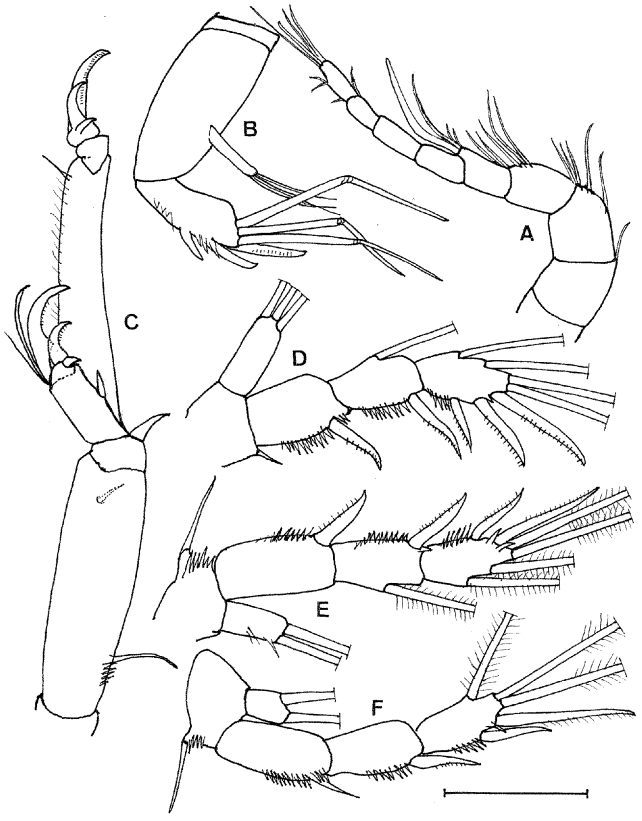

Fig. 9. *Balaenophilus umigamecolus* n. sp., fifth copepodid ♀. **A**, antennule; **B**, antenna; **C**, leg 1; **D**, leg 2; **E**, leg 3; **F**, leg 4. Scale bar = 0.1 mm.

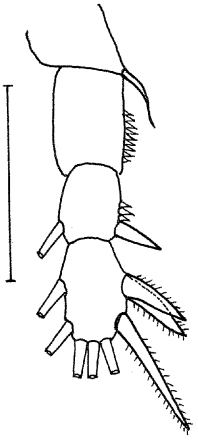

Fig. 10. *Balaenophilus umigamecolus* n. sp., Aberrant leg 2 exopod of female. Scale bar = 0.1 mm.

contents of *B. unisetus* collected from the baleen plates of fin whales without any unicellular algae or remains of diatoms (Fig. 11C). Though Vervoort and Tranter(1961) discussed the possibility that *B. unisetus* eats the sessile algae on the baleen plates, we suppose that *B. unisetus* may also scrape the epidermis, which is shown in the photograph by Bannister and Grindley (1966), directly for food and thus may be a true epibiotic parasite of baleen whales.

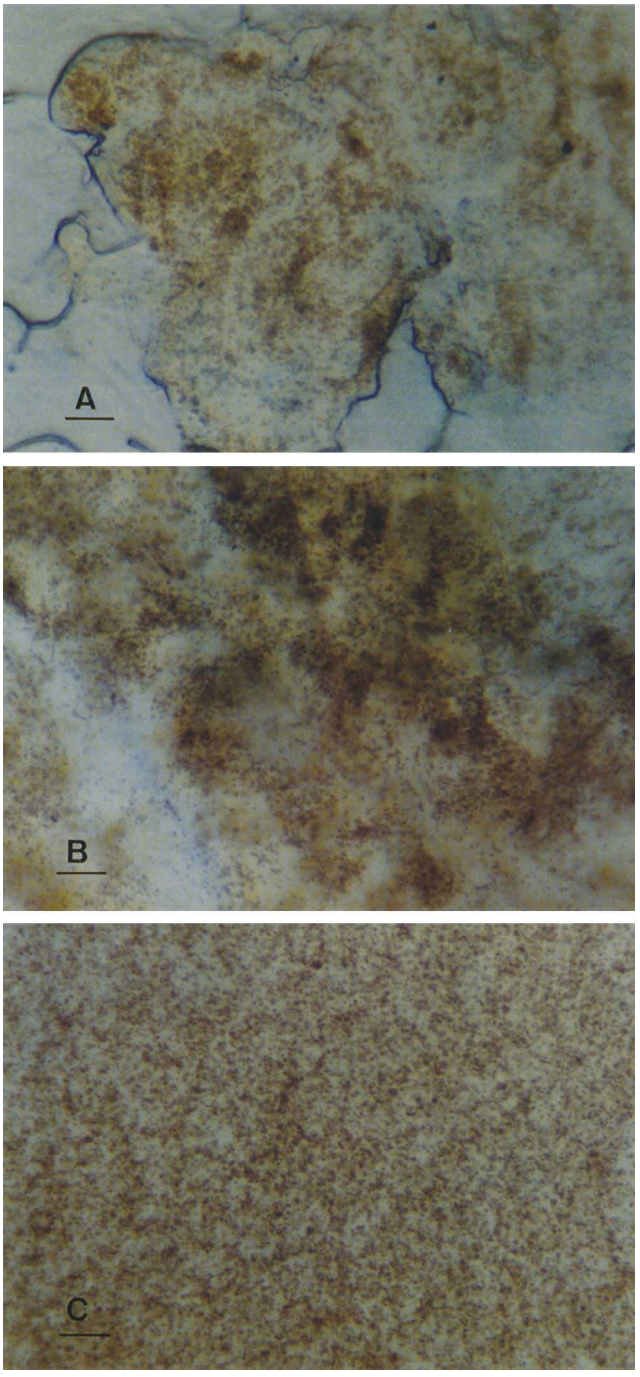

Fig. 11. Comparison of gut contents and the host sea turtle's neck skin. **A**, gut contents of *Balaenophilus umigamecolus* n. sp.; **B**, scraped neck skin of sea turtle *Caretta caretta*; **C**, gut contents of *Balaenophilus unisetus* collected from baleen plates of fin whale *Balaenoptera physalus*. Scale bars = 0.1 mm.

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