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A new genus and species of the family Mantridae (Copepoda: Cyclopoida) infesting the bivalve *Pseudochama retroversa* from the Seto Inland Sea, western Japan

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Chamicola nagasawai n. gen., n. sp., belonging to the bivalve-infesting cyclopoid family Mantridae, is described from the Seto Inland Sea, western Japan. This is the first recorded occurrence in the Pacific Ocean of the family, which previously accommodated only two genera, *Mantra* and *Nearchinotodelphys*. The parasite was found in the mantle cavity of *Pseudochama retroversa* (Lischke) (Family Chamidae), but did not infect *Chama japonica* (Lamarck). The prevalence and intensity of *C. nagasawai* in *P. retroversa* ranged from 11.3 to 25.0%, and from 1.0 to 2.6, respectively. Considering the host affinity and distribution of ancestral and derived character states, the new genus seems to be more closely related to *Mantra* than to *Nearchinotodelphys*.

KEYWORDS: Copepoda, Cyclopoida, Mantridae, *Chamicola*, bivalve.

Introduction

During our investigation of the parasites of marine invertebrates in Japan, a new genus of the family Mantridae (Copepoda: Cyclopoida) was discovered from the mantle cavity of the bivalve *Pseudochama retroversa* (Lischke) (Family Chamidae). The family Mantridae was previously unknown from the Pacific Ocean. The Mantridae currently consists of two monotypic genera, *Mantra* Leigh-Sharpe (*M. speciosa* Leigh-Sharpe) and *Nearchinotodelphys* Ummerkutty (*N. indicus* Ummerkutty). These were found from the mantle cavities of *Chama* sp. (Family Chamidae) in Indonesia, and *Lithophaga straminea* (Reeve) (Family Mytilidae) in the Indian Ocean, respectively. The phylogenetic relationships of the Mantridae within the Cyclopoida are discussed by Huys (1990), Ho (1994) and Ho *et al.* (1998).

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This paper provides a description of a new genus of the Mantridae together with notes on its ecology and phylogenetic affinities.

Material and methods

The host bivalve *Pseudochama retroversa* (Lischke) was collected in the intertidal zone of the Seto Inland Sea, western Japan (figure 1). Parasitic copepods were removed from the host's mantle cavity under a dissecting microscope. All drawings were made with a differential interference microscope (Nikon Optiphoto). Terminology follows Huys and Boxshall (1991).

Type specimens are deposited at The Natural History Museum and Institution, Chiba (CBM-ZC) and the Natural History Museum, London (BM(NH)).

Taxonomy

Family MANTRIDAE Leigh-Sharpe, 1934

Diagnosis (emend.). The diagnosis proposed for the family by Huys (1990) is partly emended as follows: Rostrum fused or separate at base. Antenna endopod with or without seta on first segment; second segment with four or five setae. Labrum bearing pair of processes laterally. Maxillule with four or five setae on distal basal endite. Maxilliped with two or three setae on second syncoxal endite. Leg 1 with single inner seta on second endopodal segment. Male leg 6 with two or three setae.

Remarks. Although Huys (1990) carefully revised the familial diagnosis, the discovery of the new genus described below has necessitated partial emendation. The number of inner setae on the second endopodal segment of leg 1 was given as

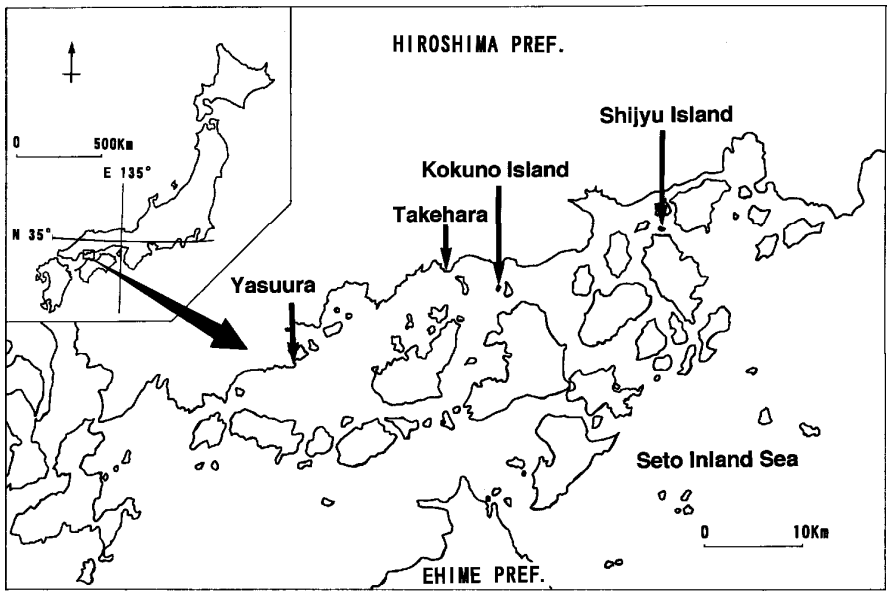

FIG. 1. Collection sites of *Chamicola nagasawai* n. gen., n. sp. in the Seto Inland Sea, western Japan.

two in the new diagnosis of Huys (1990), but there is only one seta illustrated in figure 3A (Huys, 1990, p. 288).

Chamicola new genus

Diagnosis. First pedigerous somite separate from cephalosome. Rostrum defined at base. Antenna with basis and endopod separate; endopod two-segmented, first segment with single vestigial seta, second segment bearing robust claw, two strong curved spiniform setae, two long and two short setae terminally. Labrum with pair of pointed processes laterally. Maxillule with two setae on coxal epipodite and five setae on distal basal endite. Maxilliped bearing 1, 2, 2 setae on syncoxal endites, and six setae on endopod. Legs 1–4 each with outer seta on basis. Leg 5 with outer seta on basis. Female leg 6 represented by one spine and one seta. Male leg 6 with two setae. Caudal rami with long terminal setae.

Host. *Pseudochama retroversa*.

Type species. *Chamicola nagasawai* n. sp. (by monotypy).

Remarks. The new genus is readily distinguishable from *Mantra* and *Nearchinotodelphys* as follows: (1) the rostrum separated at base; (2) the endopod of antenna distinctly two-segmented, the second to fourth ancestral endopodal segments being completely fused; (3) the antenna with one vestigial seta on the first endopodal segment; (4) the labrum with a pair of large processes laterally; (5) the maxillule with five setae on the distal basal endite; (6) the maxilliped syncoxa bearing 1, 2, 2 setae on the first to the third endites, respectively; (7) the male leg 6 with only two setae.

The new genus also exhibits a mixture of features of both other genera: (1) the cephalosome is separate from the first pedigerous somite (as in *Mantra*); (2) the antenna has the basis and endopod separated (as in *Nearchinotodelphys*); (3) the antenna bears three terminal claws (as in *Mantra*); (4) the mandible carries four setae on the first endopodal segment in the female (as in *Nearchinotodelphys*); (5) the maxillule has two setae on the coxal epipodite (as in *Mantra*); (6) the maxilliped bears six setae on the endopod (as in *Nearchinotodelphys*); (7) legs 1–4 each have an outer seta on the basis (as in *Nearchinotodelphys*); (8) the proximal segment of leg 5 has a single outer seta (as in *Nearchinotodelphys*); (9) the caudal rami carries long terminal setae (as in *Mantra*). Differences between the armature of the antennules of all three genera are summarized in table 1. However, since the antennules of both sexes of *Nearchinotodelphys* were more or less inadequately described, this is only a tentative comparison and is not robust enough to permit a

Table 1. Comparison of setal elements of genera of the Mantridae.

Segment	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Female															
Mantra	3	4	8	2	2	6	5	2	2	1	2	2	2	2	?
Chamicola	3	5	8	2	2	6	5	2	2	1	2	2+ae	2	2+ae	7+ae
Nearchinotodelphys	3	5	8	2	3	6	5	2	1	1	2	2	3	2	7
Male															
Chamicola	3	5	8	2	2	2	2	2	4+ae	1	2	1+p	1+p	10	
Nearchinotodelphys	5	3	8	2	1	1	1	1	5	1	2	2+p	2	9	

ae = aesthetasc; p = process.

cladistic analysis. Differences are found in the 2nd (III–V), 5th (XI), 8th (XVIII), 9th (XIX), 12th (XXII–XXIII), 13th (XXIV), 14th (XXV) and 15th segments (XXVI–XXVIII) of the female, and in all segments except for the 3rd (VI–IX), 4th (X) and 9th to 11th (XV–XIX) in the male.

Both *Mantra speciosa* and the new genus infest the same bivalve family, the Chamidae, whereas *Nearchinotodelphys indicus* parasitizes a rock-boring species of the Mytilidae (Ummerkutty, 1960).

Etymology. The new generic name is derived from the host bivalve *Chama*, and the Latin *colo*, meaning to inhabit. Gender feminine.

Chamicola nagasawai n. gen., n. sp.
(figures 2–5)

Material examined. Nine adult females and four adult males.

Types. HOLOTYPE: 1♀, Yasuura, 7 January 1999, dissected, CBM-ZC 4942. PARATYPES: 2♀♀, Shiju Islands, 20 August 1998, dissected, CBM-ZC 4943; 1♀ and 2♂♂, Kokuno Island, 19 August 1998, dissected, CBM-ZC 4944; 1♀, Kokuno Island, 19 August 1998, whole specimen, CBM-ZC 4945; 1♀ and 1♂, Shiju Island, 20 August 1998, whole specimens, CBM-ZC 4946; 3♀♀ and 1♂, Kokuno Island, 19 August 1998, whole specimens, BM(NH) 1999.748-751.

Body length. ♀: mean ± SD, 2.29 ± 0.25 mm ($n = 8$), range 1.99–2.76 mm. ♂: 1.52 ± 0.11 mm ($n = 4$), 1.42–1.67 mm.

Description. *Female (holotype)*. Body (figure 2A) 2.47 mm in length, more or less depressed; cephalosome separate from first pedigerous somite; cephalosome expanded laterally, with distinct naupliar eyes present; maximum width measured at its posterior end. Rostrum (figure 2B) separate at base, weakly bifurcate at tip. First pedigerous somite narrow. Urosome consisting of fifth pedigerous somite, genital double-somite and three-segmented abdomen; fifth pedigerous somite expanded laterally. Genital double-somite (figure 2A, C) wider than long; gonopores located laterally at about one-third length, covered with vestigial leg 6 (figure 2D); single copulatory pore located ventro-medially at about one-third length, connected via paired copulatory ducts to seminal receptacles; transverse rows of minute spinules posteriorly on ventral surface. Anal somite (figure 2E) with serrated posterior margin ventrally; caudal ramus approximately five times longer than wide; seta V longest.

Antennule (figure 2F, G) 15-segmented. Segmentation pattern and armature elements as follows: 1(I–II)—3, 2(III–V)—5, 3(VI–IX)—8, 4(X)—2, 5(XI)—2, 6(XII–XIV)—6, 7(XV–XVII)—5, 8(XVIII)—1, 9(XIX)—2, 10(XX)—1, 11(XXI)—2, 12(XXII–XXIII)—2 + aesthetasc, 13(XXIV)—1 + 1, 14(XXV)—1 + 1 + aesthetasc, 15(XXVI–XXVIII)—7 + aesthetasc. Antenna (figure 2H) four-segmented; basis separate from endopod; exopod represented by two setae of unequal length; first endopodal segment with vestigial seta at midlength; distal compound segment representing second to fourth ancestral segments, with three setae and one rudimentary seta at one-third length, and one robust claw, two curved spiniform setae, and two long and two short setae terminally; distal endopodal segment bearing two oblique rows of spinules along outer margin. Labrum (figure 3A, B) with strong paired processes laterally.

Mandible (figure 2I–K) with small protuberance between two ventral-most teeth; first endopodal segment bearing four setae, second segment with four lateral and two terminal setae in addition to three setae on subterminal process which is not

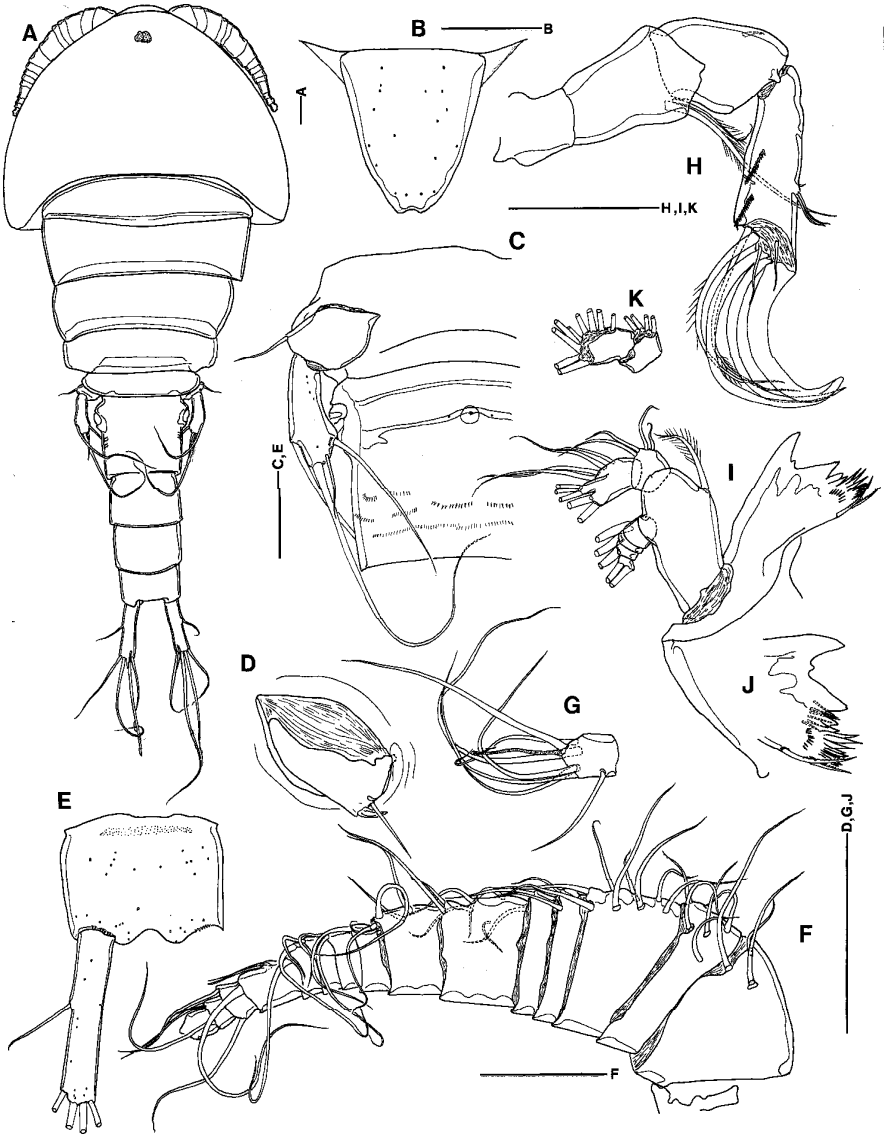

FIG. 2. *Chamicola nagasawai* n. gen., n. sp., adult female (holotype). (A) Habitus, dorsal; (B) rostrum; (C) fifth pedigerous somite and genital double-somite, ventral (right side); (D) leg 6; (E) anal somite and caudal ramus, ventral; (F) antennule, setae on terminal segment omitted; (G) terminal segment of antennule; (H) antenna; (I) mandible; (J) mandibular cutting edge; (K) mandibular endopod, opposite member of pair from that illustrated in (I). All scales = 0.1 mm.

found in opposite palp; exopod four-segmented, setal formula 1, 1, 1, 2. Maxillule (figure 3C) with stout praecoxal arthrite, bearing two spinulose setae and seven spines, distal-most of which heavily sclerotized; coxal endite with single plumose

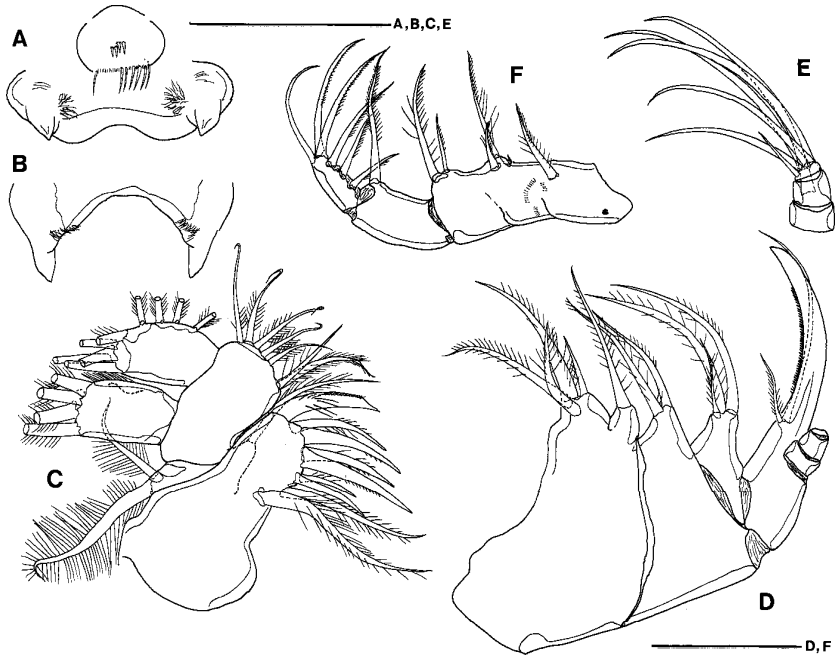

FIG. 3. *Chamicola nagasawai* n. gen., n. sp., adult female (holotype). (A) Labrum, ventral surface; (B) labrum, dorsal surface; (C) maxillule; (D) maxilla, setae on free endopodal segments omitted; (E) maxillary free endopodal segments; (F) maxilliped. All scales = 0.1 mm.

seta; coxal epipodite bearing two plumose setae of unequal length; proximal and distal basal endites rudimentary, two and five setae, respectively; endopod unisegmented, with four lateral and five terminal setae; exopod quadrate, with four long plumose setae terminally. Maxilla (figure 3D, E) well developed; praecoxa incompletely fused with coxa, first and second endites bearing four and one seta, respectively; coxal endites with two and three setae, respectively; basis fused with heavily sclerotized claw bearing two setae of unequal size; endopod three-segmented, first to third segments bearing 1, 1, 4 setae, respectively. Maxilliped (figure 3F) bearing 1, 2, 2 setae on syncoxal endites; syncoxa also with three rows of minute spinules; basis with subterminal spinulose seta; endopod unisegmented, with five pinnate setae and one naked seta.

Legs 1–4 (figure 4A–D) with both rami three-segmented. Spine and seta formula of these legs as in diagnosis of the family given by Huys (1990, p. 284), except for the presence of only one inner seta on the second endopodal segment of leg 1. Coxae of legs 1–4 each with inner seta; basis of leg 1 with inner spine and outer seta; outer basal seta present in legs 2–4. Terminal spines of legs 2–4 curved inwards.

Leg 5 (figure 2A, C) two-segmented; proximal segment bearing outer seta; distal segment with two terminal setae of unequal length, one outer and one inner subterminal seta; inner subterminal seta shortest, at base of which row of minute spinules present. Leg 6 (figure 2D) lamelliform, bearing short outer spine and inner setule at dorso-posterior corner.

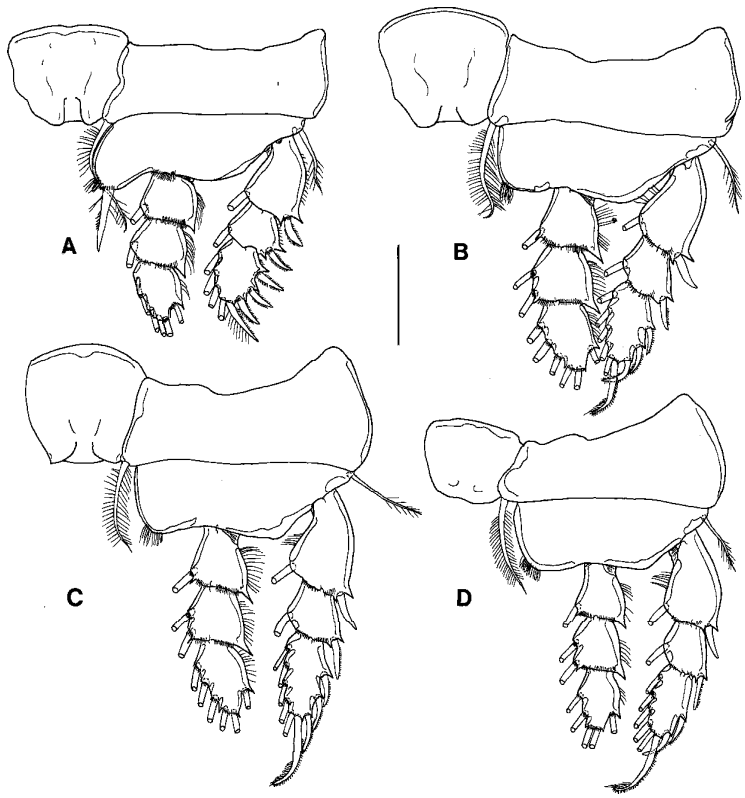

FIG. 4. *Chamicola nagasawai* n. gen., n. sp., adult female (holotype). (A) Leg 1, anterior surface; (B) leg 2, anterior surface; (C) leg 3, anterior surface; (D) leg 4, anterior surface. Scale = 0.1 mm.

Male (paratypes). Body (figure 5A) similar to that of female, but more slender. Rostrum (figure 5B) separate at base as in female. Urosome consisting of fifth pedigerous somite, genital somite, and four-segmented abdomen. Antennule (figure 5B) 14-segmented, unigeniculate between 12 (XX) and 13 (XXI–XXIII). Segmentation pattern and armature elements as follows: 1(I–II)—3, 2(III–V)—5, 3(VI–IX)—8, 4(X)—2, 5(XI)—2, 6(XII)—2, 7(XIII)—2, 8(XIV)—2, 9(XV–XVII)—4 + aesthetasc, 10(XVIII)—1, 11(XIX)—2, 12(XX)—1 modified spine-like fused element + 1, 13(XXI–XXIII)—1 modified spine-like fused element + 1, 14(XXIV–XXVIII)—10 (elements indisguishable). Antenna as in female. Mandible (figure 5E) as in female; first endopodal segment bearing four or five setae; subterminal protuberance absent on second endopodal segments on either side. Maxilla as in female. Maxilliped (figure 5F) without distinct sexual dimorphism.

Legs 1–4 as in female, but outer spines on third exopodal segment not as strongly curved inward as in female. Leg 5 (figure 5C) as in female. Leg 6 (figure 5D) lamelliform, with two setae at outer posterior corner.

Variation. The terminal prominence on the second endopodal segment of the mandibular palp on one side only of the holotype (figure 2I) was not found in other

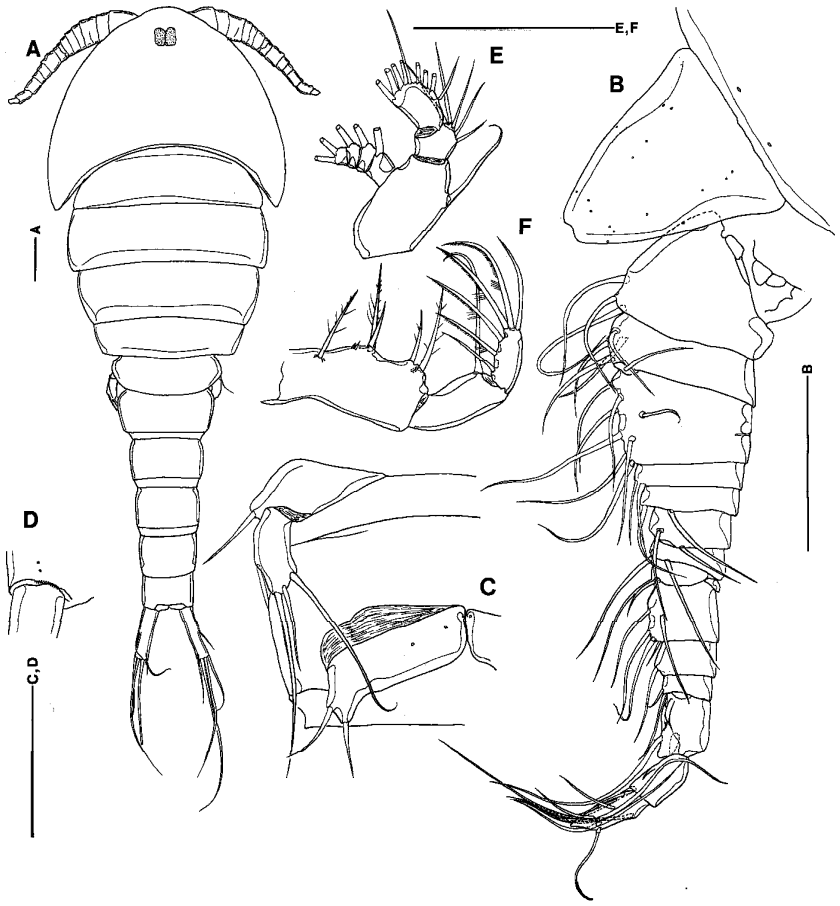

FIG. 5. *Chamicola nagasawai* n. gen., n. sp., adult male (paratype). (A) Habitus, dorsal; (B) rostrum; (C) leg 5 and genital somite, ventral (right side); (D) junction between anal somite and caudal ramus, ventral; (E) mandibular palp; (F) maxilliped. All scales = 0.1 mm.

type specimens. It is therefore interpreted as an abnormal condition. The dissected paratypes (4♀♀, 2♂♂) bear four setae on the first endopodal segment in the female and either four or five in the male. The presence of five setae in one male paratype is interpreted here as abnormal.

The degree of inward curvature of outer spines on the second and third exopodal segments of legs 1–4 varies between the dissected types. In one paratype female an inner seta is present on the right basis of leg 1 instead of a spine.

Etymology. The new specific name is named in honour of Dr Kazuya Nagasawa (National Institute of Far Seas Fisheries Research).

Ecological notes

The prevalence and intensity of *Chamicola nagasawai* in *Pseudochama retroversa* collected in the Seto Inland Sea, western Japan ranged from 11.3 to 25.0%, and

from 1.0 to 2.6, respectively. No other parasitic copepods were found in *P. retroversa*. This copepod appears to be relatively host-specific since it was not found in the sympatric bivalve *Chama japonica* (Lamarck), belonging to the same family, Chamidae, although only small samples were available for examination (table 2).

Ovigerous females were found on 19–20 August 1998 in Shiju and Kukuno Islands, and 7 January 1999 in Yasuura. Surface water temperature in the central part of the Seto Inland Sea, where the new species was collected, widely ranged from 9–12°C (January) to 27–29°C (August) (Hirota, 1961, 1979; present study). The species seems to be in reproductive condition throughout the year. The holotype female of *C. nagasawai* carries a pair of egg-sacs on the genital double-somite, each of which contains 17 or 18 eggs.

Discussion

Relationships and phylogeny

Huys (1990) suggested that the Mantridae is related to the Notodelphyidae and the Ascidicolidae but Ho (1994) and Ho *et al*. (1998), using cladistic analyses, proposed that the Mantridae forms a clade together with the Notodelphyidae and the Archinotodelphyidae, and has only a remote relationship to the Ascidicolidae. The Mantridae is more closely related to the Notodelphyidae than to the Archinotodelphyidae on the basis of the following synapomorphies (Ho, 1994; Ho *et al*., 1998): (1) the antennary basis lacking an inner seta; (2) the basis of maxilliped with an inner seta; and (3) having a one-segmented endopod on the maxilliped. All of these synapomorphies are also shared by the new genus *Chamicola* within the Mantridae.

The new genus *Chamicola* shares several synapomorphies with both *Mantra* and *Nearchinodelphys*. Since the male of *Mantra* is unknown and the antennules of both sexes of *Nearchinodelphys* are inadequately described, a cladistic analysis was not undertaken in the present study. However, *Chamicola* seems to be more closely related to *Mantra* on the basis of their more closely related hosts and the following synapomorphies: (1) the antenna bears three terminal claws and (2) the female leg 6 has only two elements.

Table 2. Prevalence and intensity of infection with *Chamicola nagasawai* in *Pseudochama retroversa* (upper) and *Chama japonica* (lower) collected from the Seto Inland Sea, western Japan.

Locality	Date	Number of bivalves examined	Number of bivalves infested	Prevalence (%)	Number of copepods	Mean intensity
Kokuno Island	19 August 1998	20	5	25.0	13	2.9
Sijyu Island	20 August 1998	44	5	11.3	7	1.6
Yasuura	7 January 1999	8	1	12.5	1	1.0
Takehara	27 April 1998	1	0			
Kokuno Island	24 July 1998	1	0			
Sijyu Island	20 August 1998	5	0			
Yasuura	7 January 1999	1	0			

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