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A new species of *Alvinocaris* (Crustacea: Decapoda: Caridea: Alvinocarididae) and a new record of *A. muricola* from methane seeps on the Blake Ridge Diapir, Northwestern Atlantic

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Abstract

Two species of the alvinocaridid shrimp genus *Alvinocaris*, *A. methanophila* n. sp. and *A. muricola* Williams, are reported from a cold seep site on the Blake Ridge Diapir, northwestern Atlantic, at a depth of 2155 m. *Alvinocaris methanophila* is described and illustrated on the basis of 33 adult specimens. It is most similar to the sympatrically found *A. muricola* Williams, but differs in the comparatively stout second segment of the antennular peduncle and smaller size at maturity in females. Available data suggest that *A. muricola* is rare at this site. Brief notes on habitat and distribution of the two species are provided.

Key words: Crustacea; Decapoda; Caridea; Alvinocarididae; *Alvinocaris*; new species; cold seeps; Blake Ridge; northwestern Atlantic

Introduction

Shrimps of the genus *Alvinocaris* are almost exclusively associated with chemosynthetic communities influenced by hydrothermal vents or hydrocarbon seeps (Komai & Segonzac, 2005). Recently, Escobar-Briones & Villalobos-Hiriart (2003) recorded an indeterminate species of *Alvinocaris* from non-chemosynthetic environments on the Banco Chinchorro in the northern Caribbean at depths of 176–203 m, although no information on morphology of the voucher specimens was provided. Komai & Segonzac (2005) revised *Alvinocaris*, and recognized eight named species in the genus, *A. lusca* Williams & Chace, 1982 (type species of the genus), *A. markensis* Williams, 1988, *A. muricola* Williams, 1988, *A. stactophila* Williams, 1988, *A. longirostris* Kikuchi & Ohta, 1995, *A. brevitelsonis* Kiku-

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chi & Hashimoto, 2000, *A. williamsi* Shank & Martin, 2003, and *A. dissimilis* Komai & Segonzac, 2005. *Alvinocaris leurokolos* Kikuchi & Hashimoto, 2000, has been transferred to a newly established genus, *Shinkaicaris* Komai & Segonzac, 2005, because of the presence of presumable apomorphies (i. e. the completely fused eyes, the absence of a postrostral median ridge on the carapace, and the possession of two or more rows of accessory spinules on the dactyli of the third to fifth pereopods) shared with other alvinocaridid genera, i.e. *Opaepele* Williams & Dobbs, 1995, *Chorocaris* Martin & Hessler, 1990, and *Rimicaris* Williams & Rona, 1986. Immediately after the manuscript of Komai & Segonzac's (2005) paper was accepted for publication, Webber's (2004) article reporting alvinocaridids from the Bay of Plenty, north of New Zealand, was published, in which *Alvinocaris niwa* Webber, 2004, was described as new and *Alvinocaris longirostris* was newly recorded. In spite of recent studies, however, a number of species of *Alvinocaris* remained unnamed (Komai & Segonzac, 2005), including a species recently discovered from methane seeps on the Blake Ridge Diapir (Van Dover et al., 2003), for which a possible relationship to *A. muricola* was suggested. In the present paper, we describe a new species, *Alvinocaris methanophila*, and report a new locality record for *A. muricola*, based on material collected from mussel beds at the Blake Ridge Diapir. Molecular data reported in Van Dover et al. (2003) suggest that the new species is most similar to *A. muricola*. Comparison with the material of *A. muricola* used by Komai & Segonzac (2005) enabled us to identify morphological differences between the two species. *Alvinocaris muricola* is represented by a single female specimen collected at one small outcrop of methane hydrate, where it was observed in close association with several other shrimp (including one specimen of *A. methanophila*).

Material and method

Most specimens of the new species were collected from mussel (*Bathymodiolus heckerae* Turner, Gustafson, Lutz & Vrijenhoek, 1998) beds at ODP site 996, Blake Ridge Diapir, 32°29.623'N, 76°11.467'W, 2155 m, during dives 3709–3712 by DSV *Alvin* in September 2001. The two specimens collected from a small outcrop of methane hydrate outside of the mussel beds (32°28.135’N, 76°11.486’W) during dive 3910 by DSV *Alvin* in July 2003 are referred to two separate species, *A. methanophila* n. sp. and *A. muricola*. Juveniles (with a postorbital carapace length 5.0 mm or smaller) were not included in the type series in order to avoid a risk of misidentification.

Specimens examined in this study are deposited in the Los Angeles County Museum of Natural History (LACM), U.S.A., Muséum National d'Histoire Naturelle, Paris (MNHN), France, Natural History Museum and Institute, Chiba (CBM), Japan, National Museum of Natural History, Smithsonian Institution (USNM), and Forschunginstitut Senckenberg, Frankfurt am Main (SMF). The size of the specimens is indicated by postorbital carapace length (CL) measured in mm from the level of the posterior margin of the

orbit to the midpoint of the posterodorsal margin of the carapace. The descriptive terminology follows Komai & Segonzac (2005). Data on the rostral length of *A. muricola*, used for comparison with the new species, is cited from Komai & Segonzac (2005).

For comparative purpose, the following specimens were examined.

Alvinocaris markensis: CBM-ZC 8281, 2 females (CL 11.2, 12.4 mm), MICROSMOKE, DSV *Nautile* dive MS 08, site Snake Pit-Les Ruches, Mid-Atlantic Ridge, 23°22.13'N, 44°57.13'W, 3480 m, baited trap, 21 November 1995; MNHN-Na 15051, 4 females (CL 13.7–18.1 mm), MICROSMOKE, DSV *Nautile* dive MS 16, site Snake Pit-Elan, 3500 m, baited trap, 29 November 1995; CBM-ZC 7041, 1 female (CL 13.0 mm), SEAHMA-1, DSV *Nautile* dive 186-04, Rainbow, Mid-Atlantic Ridge, 36°13.759'N, 33°54.169'W, 2292 m, slurp gun, 08 August 2002.

Alvinocaris muricola: Van Dover's reference collection, 2 males (CL 7.9, 8.3 mm), 12 females (CL 5.3–14.0 mm), 1 juvenile (CL 4.3 mm), DSV *Alvin* dive 3636, West Florida Escarpment, Gulf of Mexico, 26°01'N, 84°54.61'W, 3277 m, 29 October 2000; CBM-ZC 7042, 1 female (CL 18.5 mm), ZAÏROV, ROV *Victor 6000*, dive 74-14, Regab site, West equatorial African margin, 05°47.80'S, 09°42.60'E, 3151 m, claw jaw, 27–28 December 2000; CBM-ZC 8282, 2 males (CL 118, 15.3 mm), BIOZAIRE 2, ROV *Victor 6000*, dive 146-9, same site, slurp gun 1, 28 November 2001; SMF, 4 females CL 9.6–23.7 mm, M 56 Cruise (RV *Meteor*), stn GeoB 8203-1, Congo Fan, 04°48.57'S, 09°54.51'W, 3110 m, TV-grab, 10 December 2002.

Taxonomic account

Family Alvinocarididae Christoffersen, 1986

Genus *Alvinocaris* Williams and Chace, 1982

Alvinocaris methanophila n. sp. (Figs 1–4)

Alvinocaris sp. — Van Dover et al., 2003: figs 6E, F, 8D
Alvinocaris cf. *muricola*. — Van Dover et al., 2003: 292, table 1.

Material examined. ODP site 996, Blake Ridge Diapir, 32°29.623'N, 76°11.467'W, 2155 m, DSV *Alvin*, slurp gun. HOLOTYPE: LACM CR 2001-030.1, ovigerous female (CL 12.8 mm), dive 3710, Pot 5, 26 September 2001. PARATYPES: CBM-ZC 8283, 1 female (CL 12.6 mm), dive 3709, Pot 1, 25 September 2001; CBM-ZC 8284, 1 female (CL 6.4 mm), dive 3709, Pot 3; LACM 2001-030.2, 1 female (CL 7.0 mm), 1 male (CL 6.8 mm), same data as holotype; LACM 2001-032.2, 3 females (CL 8.3–8.7 mm), 4 males (CL 5.5–7.3 mm), dive 3711, Pot 1, 27 September 2001; LACM 2001-032.1, 1 ovigerous female (CL 8.6 mm), 5 females (CL 6.7–9.5 mm), dive 3711, Pot 5, 27 September 2001; Van Dover's reference collection, 3 females (CL 10.2–12.5 mm), 2 males (CL 6.4, 6.4 mm), dive 3711, Pot 9, 27 September 2001; MNHN-Na 15767, 1 female (CL 6.2 mm), 1 male (CL 7.0 mm), dive 3712, Pot 2; USNM 1074209, 1 ovigerous female (CL 9.0 mm), 5 females (CL 7.2–11.3 mm), 1 male (CL 6.9 mm), dive 3712, Pot 6, 28 September 2001;

LACM CR 2001-034.1, 1 male (CL 7.0 mm), Blake Ridge Diapir, 32°28.135'N, 76°11.486'W, 2167 m, dive 3910, slurp gun, 27 July 2003.

Non-type: LACM, 1 juvenile (CL 4.7 mm), dive 3711, Pot 5, 27 September 2001.

Description of adults. Body (Fig. 1A, E) moderately robust for genus; integument thin and soft, but not membranous; surface smooth.

Rostrum (Figs. 1A, C, D, 4A) directed downward or forward, straight, usually reaching distal margin of first segment of antennular peduncle to midlength of second segment in females (0.28–0.50 times as long as carapace), occasionally reaching or slightly overreaching distal margin of second segment of antennular peduncle in males (0.24–0.60 times as long as carapace); dorsal margin armed with 11–19 teeth, including 5–12 teeth on rostrum proper and 4–7 (usually 5–7) moderately large teeth on carapace posterior to level of orbital margin, posterior-most tooth arising from 0.21–0.34 of carapace length; ventral margin armed with 3–11 (most frequently 5–7) small, occasionally rudimentary teeth on anterior 0.30–0.70; lateral carina sharp. Carapace (Figs. 1A, B, C, 4A) 0.54–0.71 times as wide as long; postrostral median ridge moderately high, extending to 0.75–0.80 of carapace length, sloping anteriorly to rostrum, dorsal angle about 155° when sharpest; pterygostomial tooth strongly produced anteriorly particularly in large specimens (CL > 8.0 mm), far beyond tip of antennal tooth; post-antennal groove relatively deep, almost parallel to horizontal plane of carapace; branchial region somewhat inflated, thus lateral face notably convex.

Eighth thoracic sternite with long median spur directed anteroventrally.

Abdomen (Fig. 1E) rounded dorsally; pleura of anterior three somites broadly rounded; fourth abdominal pleuron with 1–4 teeth (most frequently 2 or 3) posterolaterally; fifth pleuron similarly armed with 1 strong posteroventral tooth and 2–4 additional smaller teeth. Sixth abdominal somite 1.50–1.70 times longer than height. Telson not reaching posterior margin of uropodal endopod, length 2.90–3.20 times anterior width and 4.90–5.20 times posterior width; armed with 6–8 dorsolateral spines on either side; posterior margin convex, armed with 2 pairs of spines at lateral angles and 12–14 plumose setae all longer than mesial pair of lateral spines.

Eye with cornea imperfectly developed, unfaceted though diffusely pigmented; corneal part ovate in general outline, but fused mesially, each with small upturned tooth or tubercle on anterodorsal surface.

Antennular peduncle (Fig. 1A, D) reaching or slightly overreaching distal margin of antennal scale. First segment with conspicuous proximal tubercle on dorsal surface laterally and strong distolateral tooth; dorsal surface with distinct longitudinal groove; statocerite sharp, overreaching distal margin of first segment, but not reaching mid-length of second segment. Second segment stout, 1.35–1.89 times as long as wide in females (1.63 on average, n = 24), 1.52–1.95 times as long in males (1.75 on average, n = 9), with small distomesial tooth. Lateral flagellum subequal to carapace in length; mesial flagellum somewhat longer than lateral flagellum.

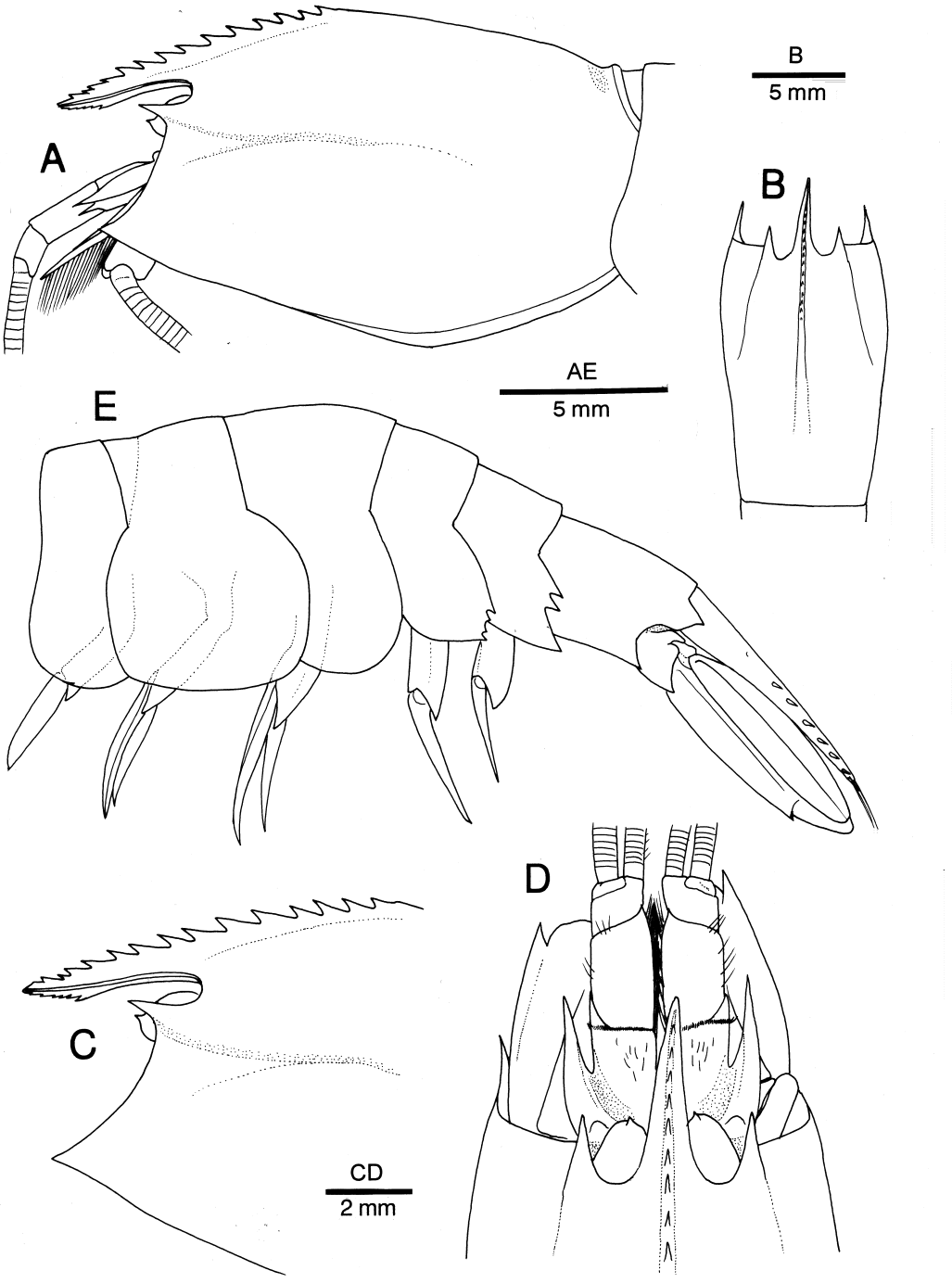

FIGURE 1. *Alvinocaris methanophila* n. sp. Holotype ovigerous female (CL 12.8 mm; LACM 2001-030.1) from the Blake Ridge Diapir, northwestern Atlantic. A, carapace and cephalic appendages, lateral view; B, carapace, dorsal view; C, anterior part of carapace and eye, lateral view; D, anterior part of carapace and cephalic appendages, dorsal view (setae partially omitted); E, abdomen, lateral view (setae and eggs omitted).

Antenna (Fig. 1A, D) with stout basicerite bearing strong ventrolateral and weak ventral teeth. Carpocerite stout, not reaching midlength of antennal scale. Antennal scale (Fig. 2A) 0.48–0.50 times as long as carapace, 1.70–1.85 times as long as wide; lateral margin straight or slightly convex, slightly diverging distally against dorsal median ridge; distolateral tooth moderately broad, directed forward, falling short of broadly rounded distal margin of blade.

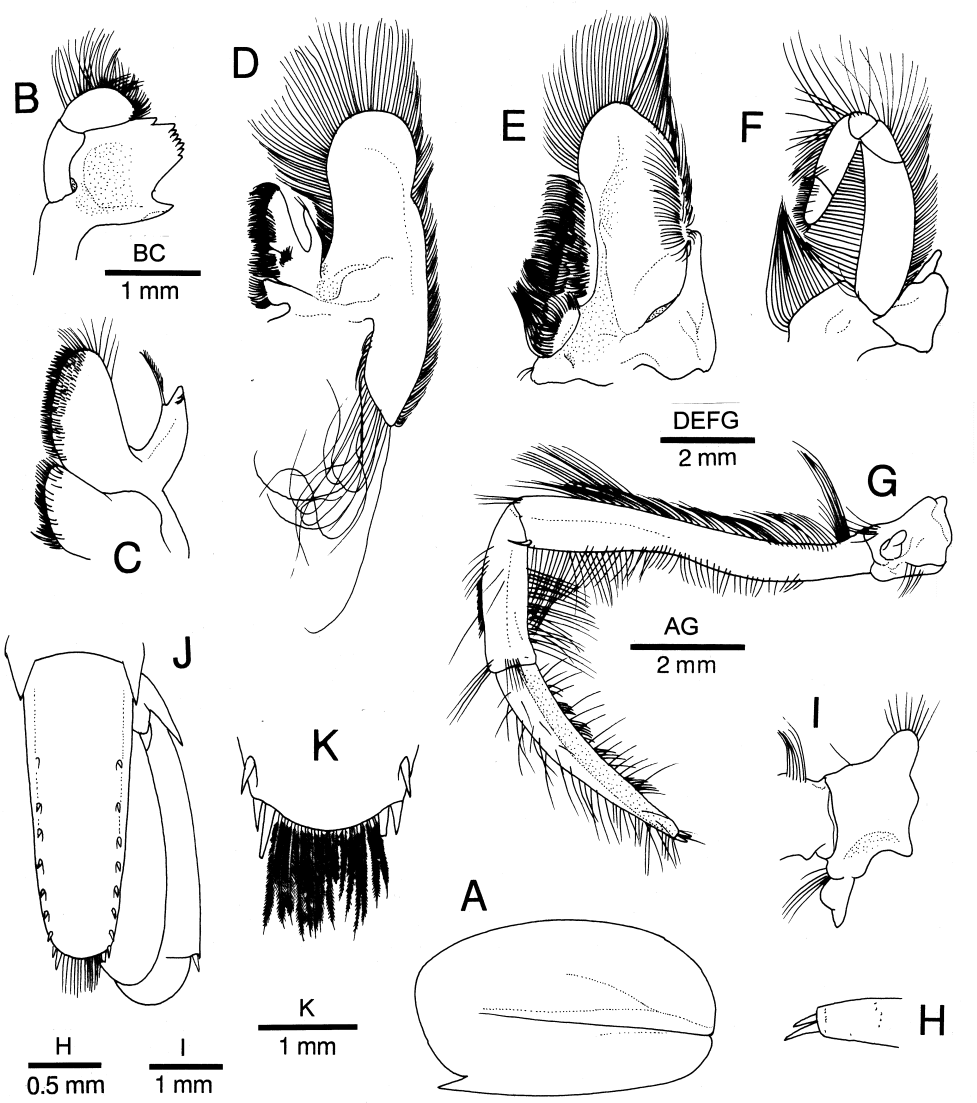

FIGURE 2. *Alvinocaris methanophila* n. sp. Holotype ovigerous female (CL 12.8 mm; LACM 2001-030.1) from the Blake Ridge Diapir, northwestern Atlantic. Left appendages. A, antennal scale, dorsal view (marginal setae omitted); B, mandible, dorsal view; C, maxillule, ventral view; D, maxilla, ventral view; E, first maxilliped, ventral view; F, second maxilliped, ventral view; G, third maxilliped, lateral view; H, same, distal part of ultimate segment, lateral view (setae omitted); I, same, basal part of antepenultimate segment and coxa, dorsal view; J, telson and right uropod, dorsal view (marginal setae on uropod omitted); K, posterior part of telson, dorsal view.

Mouthparts typical of genus (Fig. 2B–F). Second maxilliped (Fig. 2F) moderately slender; epipod with simple podobranch. Third maxilliped (Fig. 2G) composed of 4 segments, overreaching antennal scale by 0.30–0.50 length of ultimate segment; ultimate segment distinctly longer than penultimate segment (= carpus), trigonal in cross section, truncate terminal margin with 2 or 3 spines (Fig. 2H), mesial face with several sets of obliquely transverse tracts of stiff setae; carpus also with grooming apparatus composed of transverse rows of stiff setae on mesial face; antepenultimate segment composed of completely fused merus, ischium and basis, flattened dorsoventrally, sinuously curved in dorsal view, bearing long marginal setae and 1 slender spine at ventrolateral distal angle; dorsal surface of antepenultimate segment with prominent tuft of short to long setae proximomesially (Fig. 2I); coxa (Fig. 2I) stout, with small projection dorsal to base of epipod; epipod directed laterally, slightly bi-lobed.

First pereopod (Fig. 3A, B) reaching about as far as third maxilliped, robust. Fingers curved downward and inward; outer surface of both fingers convex, inner concavity with opposed edges uniformly offset, closing without gape, each armed with fine row of closely set, tip of each finger slightly spooned. Palm stout, greatest height 0.65 length of chela at most. Carpus (Fig. 3C) cupped distally to receive palm; dorsodistal margin with blunt to subacute projection mesially; ventral surface flared into strong lateral ridge terminating in small to large tooth and smaller mesial ridge ending in smaller blunt tooth, surface between ridges with dense grooming setae and 1–3 small movable spines; mesial face with shallow depression. Merus and ischium strongly obliquely articulated in lateral view; merus sometimes inflated ventrally, occasionally with small subdistal tooth on ventrolateral margin; ischium always unarmed.

Second pereopod (Fig. 3D, E) shorter and more slender than first pereopod, not reaching distal margin of antennal scale. Fingers subequal to palm in length, each terminating in small corneous unguis crossing each other when closed, cutting edges without gape, each pectinate with single row of minute corneous teeth. Carpus slightly longer than chela. Merus and ischium obliquely articulated in lateral view. Ischium with 1 ventrolateral spine.

Third to fifth pereopods (Fig. 3F, H, I) moderately stout, generally similar in length and structure, usually setose, third reaching beyond distal margin of antennal scale by 0.40–0.50 length of propodus. Propodus-carpus combined shorter than merus-ischium combined in third, subequal in fourth, and longer in fifth. Dactyli (Fig. 3G, J) short (0.08–0.15 of propodi length), armed with 3–5 corneous spines on flexor margin. Propodi of third and fourth pereopods with slender spinules arranged in two rows on ventral surface; propodus of fifth pereopod with numerous spiniform setulose setae arranged in three or four rows on distal half of ventral surface (Fig. 3G, J). Carpi 0.50–0.65 of propodi length. Meri each with 1–3 movable spines ventrolaterally in third and fourth, unarmed or with 1 spine in fifth. Ischia with 1 or 2 ventrolateral spines in third and fourth pereopods, unarmed or with 1 spine in fifth.

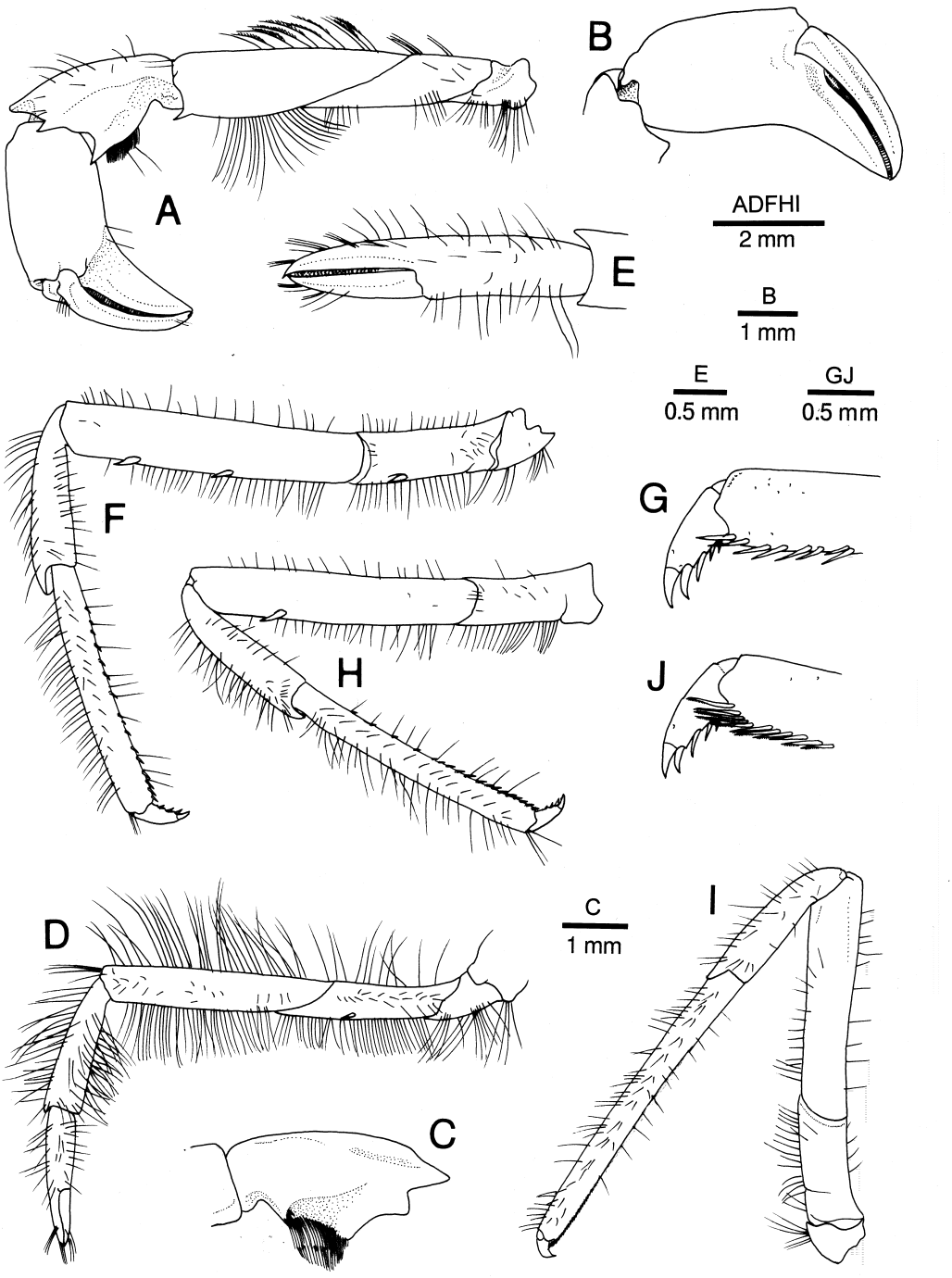

FIGURE 3. *Alvinocaris methanophila* n. sp. Holotype ovigerous female (CL 12.8 mm; LACM 2001-030.1) from the Blake Ridge Diapir, northwestern Atlantic. Left pereopods. A, first pereopod, lateral view; B, same chela, inner view; C, same, carpus, mesial view; D, second pereopod, lateral view; E, same, chela, outer view; F, third pereopod, lateral view; G, same, dactylus and distal part of propodus, lateral view; H, fourth pereopod, lateral view; I, fifth pereopod, lateral view; J, same, dactylus and distal part of propodus, lateral view.

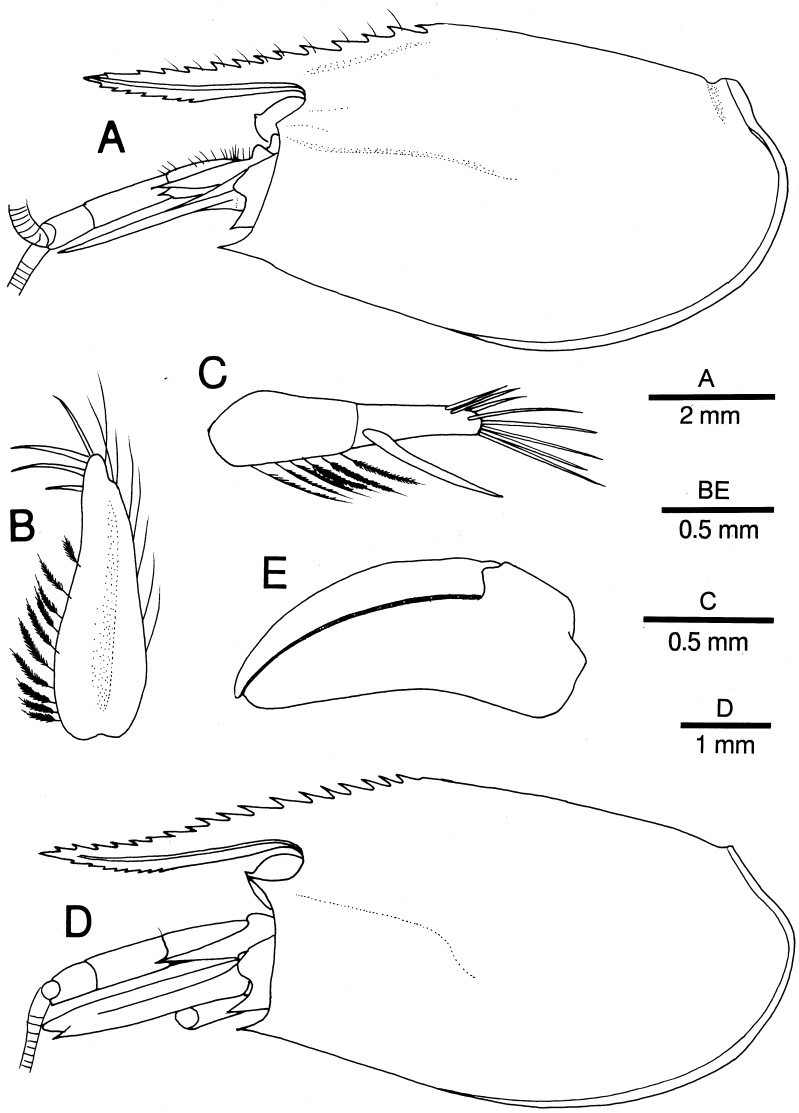

FIGURE 4. *Alvinocaris methanophila* n. sp. A–C, paratype male (CL 6.8 mm; LACM 2001-030.2); D, E, non-type, juvenile (CL 4.7 mm; LACM) from the Blake Ridge Diapir, northwestern Atlantic. A, D, carapace and cephalic appendages, in lateral view; B, endopod of first pleopod, ventral view; C, appendices interna and masculina of second pleopod, mesial view; E, chela of first pereopod, outer view.

Male first pleopod (Fig. 4B) with endopod about 0.60 length of exopod, distal part faintly bilobed; distomesial lobe with 4 long spiniform setae directed mesially or distomesially on mesial margin; distolateral lobe obsolete; endopod of female bluntly pointed distally, with fringe of plumose setae similar to those fringing remaining margins. Appendices internae on second to fourth pleopods not greatly reduced in size, but slender, that on second pleopod (Fig. 4C) simple, without terminal cluster of cincinnuli, but those on third and fourth pleopods with few cincinnuli; appendix interna on fifth pleopod better

developed than others, with terminal cluster of cincinnuli. Appendix masculina (Fig. 4C) moderately robust, slightly shorter than appendix interna, with about 10 long, terminal or subterminal bristles.

Uropod with rami subequal in length, exopod with small movable spine mesial to smaller distolateral tooth and sinuous diaeresis.

Coloration in life. Integument transparent except tips of dactyli of first pereopod, which are opaque white; internal tissues neutral to grayish; eyes pale orange, reflective.

Variations. Like other species of *Alvinocaris*, *A. methanophila* n. sp. exhibits considerable variations in the length and armament of the rostrum, armament of the fourth and fifth abdominal pleuron, and the shape of the chela of the first pereopod. The ratio of the rostral length to the carapace length ranges from 0.27 to 0.50 in females and from 0.24 to 0.60 in males. The second segment of the antennular peduncle can be more elongate in males than in females, although the proportional values partially overlap (Table 1). The shape of the chela of the first pereopod seems to be size-related. In juveniles, the palm is very short and the fingers are more than 4 times longer than the palm (Fig. 4E). In all adult specimens, the chela is stout with the palm subequal to or slightly shorter than the dactylus (Fig. 3B).

TABLE 1. Comparison among *A. methanophila* n. sp., *A. muricola* Williams, 1988 and *A. markensis* Williams, 1988.

	A. methanophila n. sp.	*A. muricola*	*A. markensis*
Branchial region of carapace	notably convex	notably convex	slightly convex
Second segment of antennular peduncle length/width	females: 1.35–1.89(1.63; n = 24) males: 1.52–1.95 (1.75; n=9)	1.91–2.26 (2.08; n=16) 1.92–2.48 (2.18; n=4)	1.79–2.00 (1.88; n=7) no data
Rostrum length/ carapace length	females: 0.28–0.50 males: 0.24–0.60	0.30–0.72 0.40–0.80	0.45–0.70* 0.74
Size of adults ovigerous females males:	CL 8.6–12.8 mm CL 5.5–7.3 mm	CL 14.5–23.8 mm* CL 6.0–15.7 mm*	CL 13.0–22.3 mm* CL 6.9–12.9 mm*
Habitat	cold seeps	cold seeps	hydrothermal vents

* after Komai & Segonzac (2005).

Juveniles are further different from adults in the following respects: the branchial region of the carapace is less convex (Fig. 4D); the posterior margin of the telson is usually armed with one median tooth; the palm of the first pereopod is very short, while the fingers are elongate (Fig. 4E); and the pereopods are less setose and less stout.

Distribution and Habitat. So far known only from methane seeps on the Blake Ridge Diapir, northwest Atlantic, off Carolina, 2155 m. Habitat and associated fauna were described in detail by Van Dover et al. (2003).

Etymology. The name is the combination of methane and the Greek "*philos*," to love, for association of the new species with methane seeps.

Remarks. Species of *Alvinocaris* exhibit only minor or subtle differences from one another (Williams, 1988; Kikuchi and Ohta, 1995; Komai and Segonzac, 2005). Species determination for juveniles and young individuals is usually very difficult, as the specific features are not fully differentiated in these stages (Komai and Segonzac, 2005). Therefore, the following comparison is restricted to adults. The new species is very similar to the two Atlantic species, *A. markensis* and *A. muricola*, both characterized by (1) the rostrum usually not reaching the distal margin of the antennal scale and bearing normally more than two ventral teeth, and (2) the posterior margin of the telson fringed with a row of long plumose setae, instead of a row of spines. Differences among the three species are summarized in Table 1. The notably convex anterior part of the branchial region of the carapace, one of the characteristics of the new species, is also seen in *A. muricola*, which occurs also in cold seeps. *Alvinocaris methanophila* n. sp. can be distinguished from *A. muricola* and *A. markensis* by the comparatively broader second segment of the antennular peduncle. The difference in the mean values between *A. methanophila* n. sp. and the other two species is significant (for the pair of *A. methanophila* n. sp. and *A. muricola*, females: $t = 11.58732$, degree of freedom 37, $P < 0.01$; males: $t = 3.26478$, degree of freedom 4, $P < 0.05$; for the pair of *A. methanophila* n. sp. and *A. markensis*, females: $t = 5.65519$, degree of freedom 18, $P < 0.01$). Although ranges of the relative length of the rostrum overlap between *A. methanophila* n. sp. and *A. muricola*, the female rostrum tends to be shorter in *A. methanophila* n. sp. than in *A. muricola* in the same size range (CL 6.2–12.6 mm; see Fig. 5). The rostrum of *A. markensis* is also usually longer than that of *A. methanophila* n. sp. (Table 1). It should be noted that, in females, the rostrum barely exceeds half of the carapace length in *A. methanophila* n. sp. The new species is characterized by its relatively small size. Female *Alvinocaris methanophila* n. sp. does not attain a carapace length of much more than 13 mm in CL, a size at which female *A. muricola* and female *A. markensis* have barely reached maturity. The available largest male of *A. methanophila* n. sp. is 7.3 mm in CL, while the largest male of *A. muricola* and *A. markensis* is 15.7 mm and 12.9 mm in CL, respectively (Komai & Segonzac, 2005). Furthermore, *A. methanophila* n. sp. and *A. muricola* are known from cold seeps, whereas *A. markensis* occurs exclusively at active hydrothermal vent sites so far.

Alvinocaris stactophila, known only from hydrocarbon seeps on the Louisiana Slope in the Gulf of Mexico, can be readily distinguished from *A. methanophila* n. sp. by the presence of a row of slender spines between the principal two pairs of spines at the posterolateral angles (Komai & Segonzac, 2005), instead of a row of plumose setae.

Alvinocaris williamsi, known only from hydrothermal vents at Menez Gwen on the Mid-Atlantic ridge, is characteristic in the relatively robust body and in having broad antennular peduncle and antennal scale (Komai & Segonzac, 2005). Furthermore, the ventral margin of the rostrum is unarmed or armed only with one tooth in *A. williamsi*, rather than bearing three to 11 teeth in *A. methanophila* n. sp.

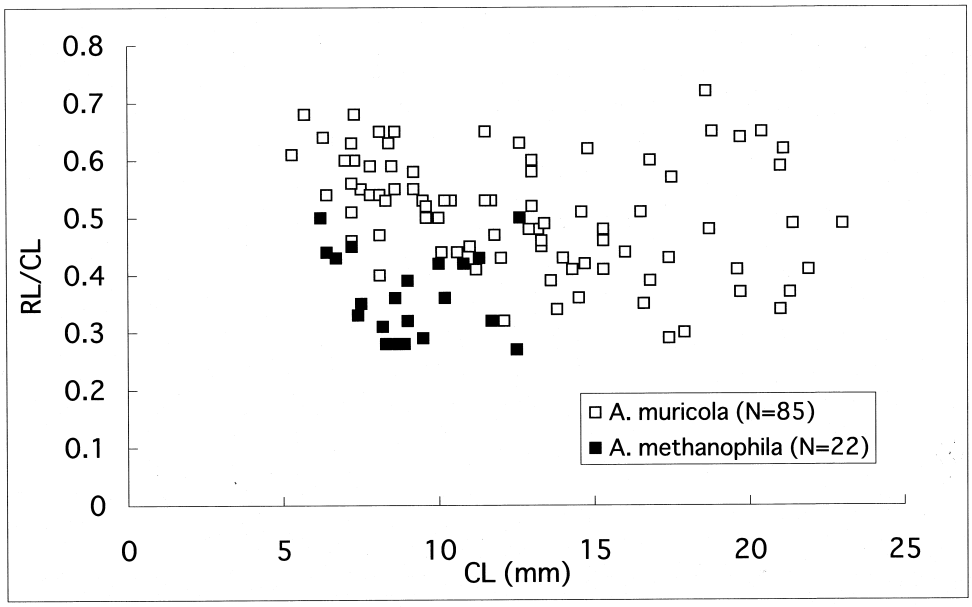

FIGURE 5. Scatter plot of the relative length of the rostrum (indicated by rostral length/carapace length against carapace length) between female *A. methanophila* n. sp. and female *A. muricola* Williams, 1988.

One female contained in samples collected during *Alvin* dive 3711 (LACM CR 2001-032.5) has not been identified satisfactorily to species level. In spite of its small size (CL 7.1 mm), the specimen is ovigerous (the ovigerous females of *A. methanophila* n. sp. are 8.6–12.3 mm in CL). Furthermore, it differs from other female specimens here referred to *A. methanophila* n. sp. in the slightly smaller teeth in the dorsal and ventral series of the rostrum (Fig. 6A), less produced pterygostomial tooth on the carapace, less convex branchial region (Fig. 6A), the posterior margin of telson armed with small median tooth (Fig. 6C), very short palm and elongate fingers of the first pereopod (Fig. 6D), and less robust third to fifth pereopods. We do not know whether these differences are of a specific nature, because only a single specimen is available for study. Many of these differences are size-related or subject to intraspecific variations in other *Alvinocaris* species (Kikuchi & Ohta, 1995; Kikuchi & Hashimoto, 2000; Webber, 2004; Komai and Segonzac, 2005). Therefore, final decision is deferred in the hope that more specimens will be collected in future surveys.

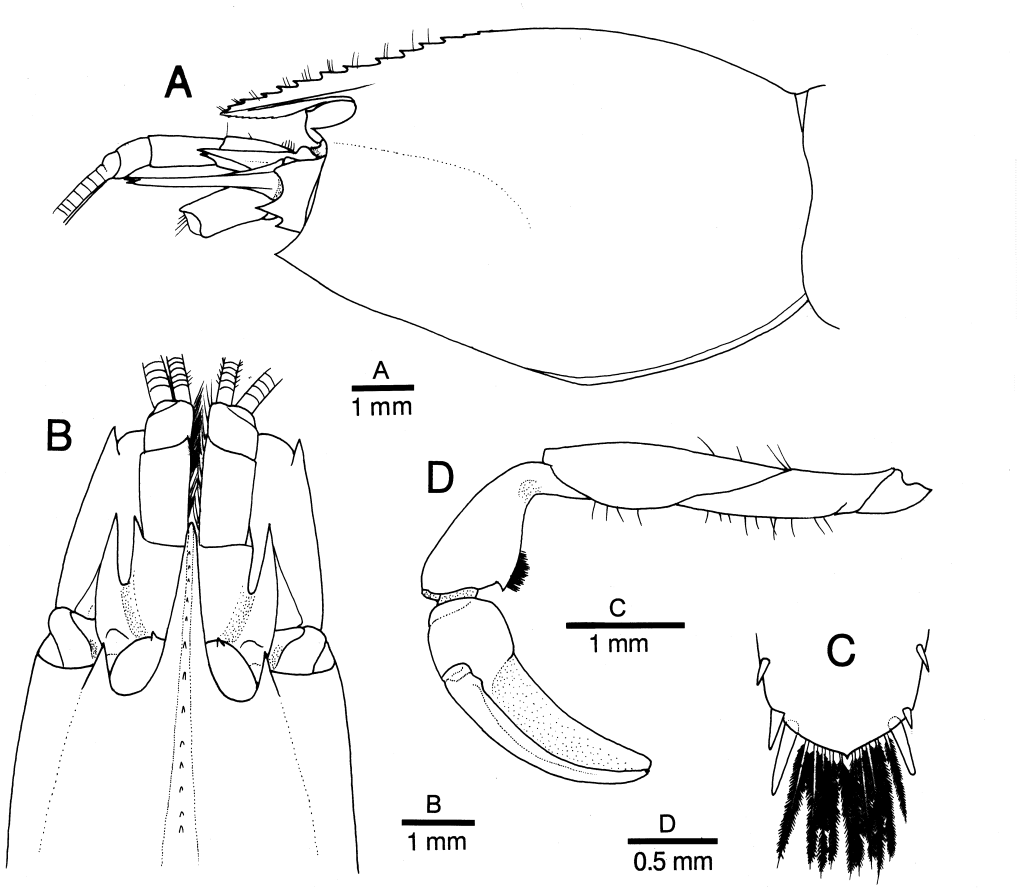

FIGURE 6. *Alvinocaris* sp. Ovigerous female (CL 7.1 mm; LACM CR 2001-032.5) from the Blake Ridge Diapir, northwestern Atlantic. A, carapace and cephalic appendages, lateral view; B, anterior part of carapace and cephalic appendages, dorsal view; C, posterior part of telson, dorsal view; D, first pereopod, lateral view.

Alvinocaris muricola Williams, 1988 (Fig. 7)

Restricted synonymy.

Alvinocaris muricola Williams, 1988: 268, figs 3, 4, 7; Komai & Segonzac, 2005: 1132, figs 2, 3, 8–14, 29.

Material examined. LACM CR 2001-034.2, 1 female (CL 12.6 mm), ODP site 996, Blake Ridge Diapir, 32°28.135'N, 76°11.486'W, 2167 m, DSV *Alvin* dive 3910, slurp gun, 27 July 2003.

Distribution. Florida Escarpment in the Gulf of Mexico, 3277 m (Williams, 1988); Barbados Accretionary prism, 1697 m (Komai & Segonzac, 2005); West African equatorial margin, Congo Basin, 3113–3150 m (Komai & Segonzac, 2005); Blake Ridge Diapir, 2155 m (this study).

Remarks. The single female specimen collected from one small outcrop of methane hydrate differs from the specimens here referred to *A. methanophila* n. sp. in the proportionally longer rostrum (0.67 times of the carapace length), slender second segment of the antennular peduncle (1.96 times longer than wide) and narrower antennal scale (about 2.1 times longer than wide). Based on these features, combined with the notably convex branchiostegal region of the carapace, this female specimen is assigned to *A. muricola* with little hesitation.

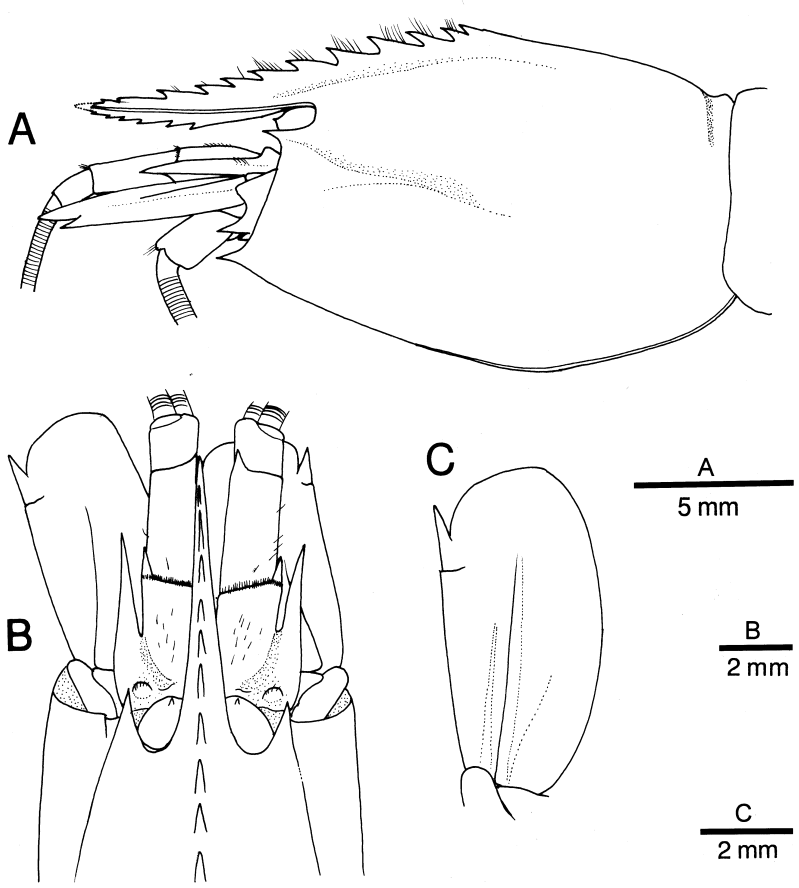

FIGURE 7. *Alvinocaris muricola* Williams, 1988. Female (CL 12.6 mm; LACM CR 2001-034.2) from the Blake Ridge Diapir. A, carapace and cephalic appendages, lateral view (antennular and antennal flagella omitted); B, anterior part of carapace and cephalic appendages, dorsal view (antennular flagella omitted); C, left antennal scale, dorsal view (marginal setae omitted).

Discussion

The present new species represents the fourth named species of *Alvinocaris* known from cold seeps; three species exclusively associated with seep communities, i.e. *A. muricola*, *A. stactophila* and *A. methanophila* n. sp., are so far restricted to the Atlantic Ocean.

Fujikura et al. (1996) reported the occurrence of *A. longirostris* at the seep site in Sagami Bay, Japan (Off Hatsushima site), but the authors indicated the existence of high-temperature anomalies at Off Hatsushima site. A molecular phylogenetic study by Shank et al. (1999) suggested that the analyzed vent-endemic *Alvinocaris* species (i.e. *A. markensis*, *A. lusca*, and undescribed species from Edison Seamount) are derived from the *A. stactophila* (seep) lineage. Morphologically, the two seep species, *A. methanophila* n. sp. and *A. muricola*, closely resemble the vent-endemic *A. markensis*. Preliminary analysis of 600 base pairs of the mitochondrial Cytochrome Oxidase I gene suggests that *A. methanophila* n. sp. is almost as different from *A. stactophila* as it is from vent shrimp in the genus *Rimicaris* (Van Dover et al. 2003). Since morphological differences among species of *Alvinocaris* are generally minor or subtle, it is difficult to infer phylogenetic relationships among the species using morphological characters (Shank et al., 1998). Therefore, molecular genetic comparisons will be powerful tools for investigation of the relationships among *Alvinocaris* species. The ongoing study by the second author will markedly improve our knowledge on the origin, evolution and radiation of these interesting shrimps.

There are some examples of sympatric occurrence of two or more congeneric species of *Alvinocaris*. Komai and Segonzac (2005) reported that *A. brevitelsonis* and *A. dissimilis* occurred sympatrically at hydrothermal vents on the Minami Ensei Knoll, Okinawa Trough. They also suggested the sympatric occurrence of two species, *A. stactophila* and an indeterminate species, at the Bush Hill hydrocarbon seep in the Gulf of Mexico. Webber (2004) reported on two species of *Alvinocaris*, *A. niwa* and *A. longirostris*, from hydrothermal vents in the Bay of Plenty, New Zealand. *Alvinocaris muricola*, which is abundant in mussel beds of the Regab site in the Congo Basin (Komai & Segonzac, 2005) and in mussel beds of the Florida Escarpment (Turnipseed et al., 2004), is so far absent in mussel beds of the Blake Ridge Diapir (although it is known at the Blake Ridge seep site from a single female associated with a methane-hydrate outcrop). Instead, *A. methanophila* n. sp. is abundant. The lack of *A. muricola* in Blake Ridge mussel beds may reflect competitive displacement by *A. methanophila* n. sp., although alternative hypotheses, including those related to delivery of larvae to Blake Ridge, can be postulated.

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