New species of *Munidopsis* (Decapoda: Anomura: Galatheidae) from hydrothermal vent in Okinawa Trough and cold seep in Sagami Bay

Sherine Sonia Cubelio, Shinji Tsuchida and Seiichi Watanabe

Abstract— Three new species of galatheid crabs, *Munidopsis ryukyuensis* n. sp. and *Munidopsis longispinosa* n. sp., both associated with hydrothermal vents in the Hatoma Knoll, East China Sea, and *Munidopsis naginata* n. sp. associated with hydrothermal vents in the Hatoma Knoll and cold seep in Sagami Bay are described and illustrated. Their affinities to closely related species are discussed. The records of *Munidopsis* species associated with hydrothermal vents in the West Pacific Ocean are increased to seven. The habitat of the new species is briefly described. Distributional patterns of vent associated *Munidopsis* in the West Pacific is briefly discussed.

Introduction

Since the first discovery of hydrothermal vents on the Galapagos Rift in 1977 (Corliss *et al.*, 1979), numerous biological communities endemic to such chemosynthetic environments have been reported (Desbruyères *et al.*, 1982; Hessler & Lonsdale, 1991; Tunnicliffe, 1991; Ohta & Laubier, 1987; Hashimoto *et al.*, 1989; Paul *et al.*, 1984; Embley *et al.*, 1990) and galatheid crabs of the genus *Munidopsis* (Anomura: Galatheidae) are found to be common species in such environments (Williams, 1988; Williams & Van Dover, 1983; Williams & Baba, 1989; Baba & de Saint Laurent, 1992; Baba, 1995, 2005; Macpherson & Segonzac, 2005; Martin & Haney, 2005; Desbruyères *et al.*, 2006). Around Japan, different types of hydrothermal vent fields have been found in the two major oceanic areas to the south of the main archipelago, namely, the Izu- Ogasawara Island Arc and the Okinawa Trough in the East China Sea (Ishibashi & Urabe, 1995; Kimura *et al.*, 1988). Five active vent sites, such as Dai-Yon Yonaguni, Minami-Ensei and Hatoma Knolls (Fig. 1), Iheya Ridge and Izena Calderon have been located in Okinawa Trough (Hashimoto *et al.*, 1995). In Hatoma Knoll, *Munidopsis* are abundant along with the other galatheid crab, *Shinkaia crosnieri* Baba & Williams, 1998, deepsea mussels, *Bathymodiolus platifrons*; provannid gastropods, *Provanna glabra* and alvinocaridid shrimps, *Alvinocaris longirostris* (see

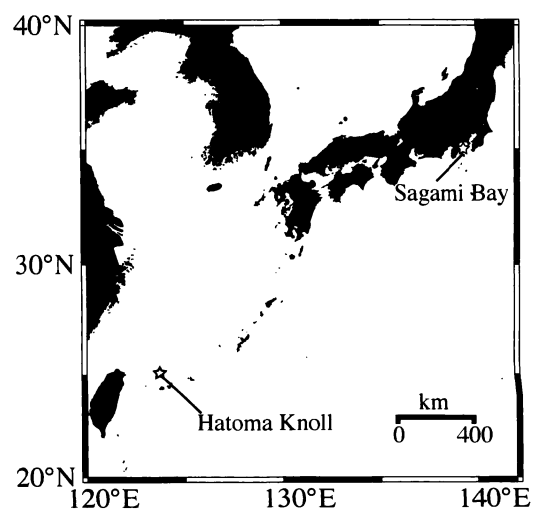

Fig.1. Locality map of Hatoma Knoll and Sagami Bay from where the specimens have been collected.

Kojima, 2002).

Munidopsis currently comprises more than 200 species worldwide with nine reported only from active hydrothermal vent fields (Williams, 1988; Williams & Van Dover, 1983; Williams & Baba, 1989; Baba & de Saint Laurent, 1992; Baba, 1995, 2005; Macpherson & Segonzac, 2005; Osawa *et al.*, 2006; Schnabel & Bruce, 2006; Desbruyères *et al.*, 2006). So far, four species of *Munidopsis* have been described from the West Pacific hydrothermal vents such as *M. marianica* Williams & Baba, 1989 from Mariana Back Arc Basin, *M. starmer* Baba & de Saint Laurent, 1992 and *M. sonne* Baba, 1995 from North Fiji Back Arc Basin and *M. lauensis* Baba & de Saint Laurent, 1992 from Lau and North Fiji Back Arc Basins. In the East Pacific, three species occur in vent fields, namely, *M. alvisca* Williams, 1988, *M. lentigo* Williams & Van Dover, 1983 (Martin & Haney, 2005; Desbruyères *et al.*, 2006), and *Munidopsis* sp. near *M. recta* Baba, 2005 (the material reported by Van Dover *et al.* (1985) under *M. subsquamosa* Henderson, 1885; see Baba (2005) and Macpherson & Baba in Desbruyères *et al.*, 2006)). In the Mid-Atlantic Ridge, two species, *M. acutispina* Benedict, 1902 and *M. exuta* Macpherson & Segonzac, 2005 are found. Here we describe two new species of *Munidopsis* found around the hydrothermal vent site in Hatoma Knoll, Okinawa Trough, East China Sea and a third species associated both with vents in Hatoma Knoll, Okinawa Trough and cold seep in Sagami Bay.

Materials and Methods

The material reported here was collected by manned submersible *Shinkai 2000* and ROV *Hyper-Dolphin* with their support ship *Natsushima* of Japan Agency for Marine-Earth Science and Technology (JAMSTEC). Measurements of specimens, given in millimeters (mm), indicate the carapace length including the rostrum. Type specimens are deposited in the crustacean collections of The National Science Museum, Tokyo (NSMT) and JAMSTEC. Abbreviations used in the text include: P1, first pereopod (cheliped); P2-4, second to fourth pereopod (first to third walking legs); P5, fifth pereopod.

Taxonomy

Order Decapoda
Superfamily Galatheoidea Samouelle, 1819
Family Galatheidae Samouelle, 1819
Genus *Munidopsis* Whiteaves, 1874

Munidopsis ryukyuensis, new species
(Figs. 3a, 4)

Material examined. —Holotype: ovigerous female, 17.37mm (NSMT–Cr 16867), Hatoma Knoll, Okinawa Trough, ROV *Hyper-Dolphin*, dive HD # 399, 24° 51.48′ N 123° 50.51′ E, 1480m, 26 April 2005.

Paratypes: 3F, 18.36mm, 15.33mm, 16.94mm; 2M, 17.06mm (infected with rhizocephalan parasite), 11.02mm (JAMSTEC 059255- 059259), ROV *Hyper-Dolphin*, dive HD # 400, 24° 51.48′ N 123° 50.51′ E, 1480m, 26 April 2005; 1F ovigerous 18.44mm (JAMSTEC 027965), 24° 51. 48′ N 123° 50.51′ E, 1454m, *Shinkai 2000*, dive 2K # 1183; 2F, 21.20mm, 16.41mm (NSMT–Cr 16868, NSMT–Cr 16869), *Shinkai 2000*, dive 2K # 1183, 24° 51.20′N 123° 50.29′ E, 1454m, 20 May 2000; 1M, 18.82 mm (NSMT–Cr 16870), *Shinkai 2000*, dive 2K # 1185, 24° 51. 29′ N 123° 50.45′ E, 1487m, 24 May 2000.

Additional materials: 3F, 12.18mm, 13.64mm, 11.65mm, 2M, 10.86mm, 10.36mm (JAMSTEC 027265-69), *Shinkai 2000*, dive 2K # 1182, 24° 51.48′ N 123 50°. 51′E, 1480m, 19 May 2000; 2M, 9.31mm, 7.45mm (JAMSTEC 027270-71), *Shinkai 2000*, dive 2K # 1182, 24° 51. 48′N 123° 50. 51′E, 1480m, 19 May 2000.

Diagnosis. — Carapace, exclusive of rostrum, distinctly longer than broad, gastric region with transverse rugae occasionally feebly tuberculate. Rostrum almost straight horizontal in profile, triangular with fine lat-

Fig. 2. *In-situ* photo of Hatoma Knoll where *Munidopsis ryukyuensis* n. sp. is seen among the deep-sea mussels (inside photo is the close up view).

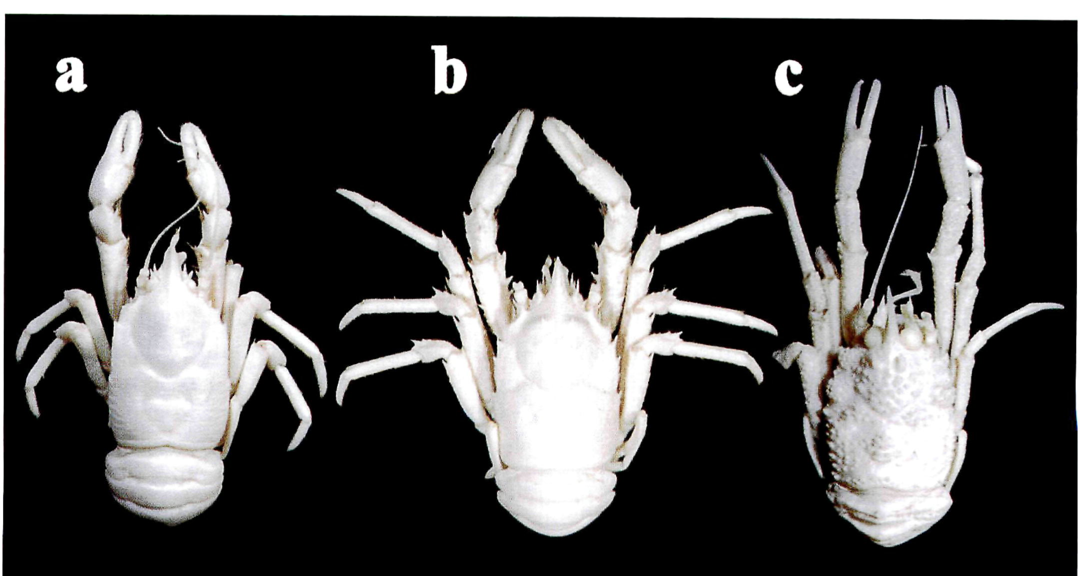

Fig. 3. a, *Munidopsis ryukyuensis* n. sp. holotype female, 17.37mm, dorsal; b, *Munidopsis longispinosa* n. sp. holotype male, 24.36mm, dorsal; c, *Munidopsis naginata* n. sp. holotype male, 17.44mm, dorsal.

eral serrations. Abdomen unarmed. Telson composed of 10 plates. Eyes moderate in size, well-exposed, smoothly ovate cornea. P1 with weakly developed, setose rugosites tending to be tuberculate in longitudinal lines, long plumose setose more dense ventrally along distomesial margin of merus. P2-4 relatively long and slender, often weakly tuberculate, dactyli setose, stout, ending in short, curved, corneous claw. Epipods absent from P1-4.

Description. — Carapace, exclusive of rostrum, distinctly longer than broad, moderately arched transversely, anterior and posterior bifurcations of cervical groove distinct. Rostrum 0.2 times length of carapace, straight horizontal in profile, triangular with fine lateral serrations often obscured, bearing distinct dorsal carina merging into anterior gastric region. Strongly oblique frontal margin sweeping to small antennal spine directly lateral to eyestalk. Gastric region moderately dilated, with transverse rugae occasionally feebly tuberculate, often obsolescent, with 2 longer anterior rugae consistent on epigastric region. Anterior branchial region also with rugae, lateral margin with small spine. Posterior branchial region with interrupted rugae more pronounced than those on anterior branchial region, lateral margin with small anterior spine. Pterygostomian flap with obliquely interrupted rugae distinct posteriorly, obsolescent anteriorly, ending in rounded margin.

Abdomen unarmed, transverse ridge on segments 2 & 3 with spare short stiff setae; segments 4, 5 and 6 considerably smooth, posteriomost with posteromedian margin almost transverse, posterior margin of lateral lobes convex. Telson composed of 10 plates, length–width ratio 0.76, n = 9, mid lateral plate fringed with long stiff setae, more pronounced in males.

Eyes well exposed, smoothly ovate cornea cupped within broad based movable ocular peduncle, extended into strong mesiodorsal spine directed laterally and reaching midlength of rostrum.

Basal article of antennular peduncle, exclusive of spines, somewhat longer than broad, distolateral inflation bearing tubular process often developed into small spines, distolateral spine well developed, distoventral margin scalloped, contiguous with small mesiodorsal spine. Antennal peduncle having segment 1 with flat ventral process ending in acute spine, and much smaller distolateral spine; segment 2 with short distolateral spine, segment 3 unarmed; and fourth with crenulated scalloped ending.

Third maxilliped basis with 2 or 3 small corneous spines in line with crest on ischium, ischium distoventrally with distinct spine, shorter than merus when measured in midlateral line, crista dentata armed with finely uniform evenly spaced corneous tipped spines. Merus small, often obsolescent spines on flexor margin and a small spine at distodorsal corner. Sternite at base of third maxilliped forming apposed lobe at either side of midline, irregularly serrate on margin.

P1 1.08–1.10 times as long as carapace including rostrum, with weakly developed, setose rugosites in longitudinal lines, long plumose setose more dense ventrally along distomesial margin of merus, distal margin of carpus and mesial margin of palm. Ischium with small distodorsal spine, merus with 2 strong spines terminally; mesial, ventral and lateral spines small or often obsolescent. Carpus with well-developed acute mesial spine somewhat proximal to juncture with palm; fingers about as long as palm, straightly fitting to each other on opposable margin, with minute intermeshing teeth at tips.

P2–4 relatively long and slender, P2 barely reaching or overreaching end of P1, 1.2 times carapace length, corresponding segments of respective legs nearly equal in length, except for meri decreasing posteriorly. Meri with small spines, often tuberculate, flexor margin also with obsolescent tubercular processes. Carpi with distinct spine on distodorsal corner, dorsolaterally with feebly tuberculate margin. Propodi 1.6 times as long as dactyli, flattish dorsal surface bordered laterally by rounded longitudinal ridge often bearing feeble tubercles. Dactyli setose, stout ending in short, curved, corneous claw preceded by 9–11 successively diminishing teeth on flexor margin, each tooth bearing short stiff setae arising from its base.

Epipods absent from P1–4.

Eggs 8–10, principal axis measuring 2.6 mm in diameter.

Variation. —In females, P2 is slightly shorter than P1 (cheliped) and reaches or slightly overreaches the tip of P1 when extended; in males, P2 is about the same length as P1, falling just short of end of P1 when extended. Telson is broader in females than in males. These variations are related to sexual dimorphism.

Etymology. — The specific name, *ryukyuensis*, refers to the Ryukyu Islands, southern Japan where the hydrothermal vent, Hatoma Knoll is located.

Japanese name. — Ryukyushinkaikoshioriebi.

Remarks. — The new species, *M. ryukyuensis* strongly resembles *Munidopsis lauensis* in general ornamentation of the body and appendages. The rostrum of the new species is broad triangular and straight in profile, whereas in *M. lauensis* it is narrow triangular and nearly straight or feebly upcurved in profile. The eyespine in *M. ryukyuensis* is longer, more than half the length of rostrum and directed almost laterally, whereas in *M. lauensis* eyespine though reaches the midlength of rostrum is almost directed straight forward. P2–4 dactyli in *M. ryukyuensis* are stout with terminal corneous claw strongly curved, whereas in *M. lauensis*, P2–4 dactyli are gradually narrowed distally with terminal corneous claw gently curved.

Munidopsis longispinosa, new species
(Figs. 3b, 5)

Material examined. — Holotype: 1M, 24.36 mm (NSMT–Cr 16874), Hatoma Knoll, Okinawa Trough, ROV *Hyper-Dolphin*, dive HD # 400, 24° 51.47′ N 123° 50.51′ E, 1481 m, 27 April 2005.

Diagnosis. — Carapace, exclusive of rostrum, distinctly longer than broad, with coarse stiff setae. Rostrum triangular, weakly carinate in dorsal midline, nearly straight, lateral margin with fine serrations. Abdomen unarmed and smooth with weak transverse ridges on segments, covered with setae. Telson composed of 9 plates. Eyes small and ovate, eyespine extending into elongated mesiodorsal spine, reaching midlength of rostrum. P1 with numerous spines, long and hairy. P2–4 relatively long and spinous, P2 not reaching end of P1. Epipods absent from P1–4.

Description. — Carapace, exclusive of rostrum, distinctly longer than broad, moderately arched from side to side, anterior and posterior bifurcations of cervical groove distinct, with coarse stiff setae. Mid cervical groove dividing carapace into anterior and posterior halves, anterior cardiac region with weak depression. Rostrum 0.23 times length of remaining carapace, broad triangular, weakly carinate in dorsal midline, nearly straight, lateral margin with fine serrations, dorsal surface with sparse short setae. Strongly oblique frontal margin sweeping to strong and long antennal spine, followed ventrally by oblique margin leading to distinct anterolateral spine. Gastric region highly inflated, with posterolateral depression on each side defining triangular subregion including meso-metagastic area, pair of epigastric spine followed by scale-like but tuberculate, elevated rugae bearing sparse short setae. Cardiac region with transverse moderate elevation preceded and flanked by distinct troughs. Lateral margins somewhat convex, with 5 spines, anterolateral spine smaller than antennal spine, directed straight forward, second spine larger than first, third and fourth spines moderately long, last one at midlength of carapace, longer and stronger than fourth spine. Pterygostomian flap with obliquely interrupted weak rugae, distinct posteriorly, anteriorly obsolescent, often with stiff setae, anterior margin angular.

Abdomen unarmed and smooth, segments 2–4 each bearing 2 ridges separated by shallow groove. Segment 6 transverse on posterior margin, posterolateral lobes rather indistinctly separated from posteromedian margin. Telson divided into 9 plates, lateral margin strongly convergent posteriorly, midlateral plate fringed with long stiff setae, length–width ratio 0.67.

Eyestalk of moderate size, smoothly small and ovate cornea cupped within broad based movable ocular peduncle extending into an elongated mesial spine, straight upward, overreaching midlength of rostrum accompanied by small lateral spine.

Basal article of antennular peduncle with minutely tuberculate dorsolateral carina distally continued into very long spine distodorsal spine and much smaller distolateral spine, latter spine separated by groove bordering inflated lateral surface bearing cluster of irregular small spines or spinnules, distoventral margin scalloped. Antennal peduncle well developed, first segment with flat ventral process ending in acute spine and much longer acute distolateral spine, second segment with well developed distolateral spine and minute distomesial spine, third and fourth segment with scalloped distal margin.

Third maxilliped basis with 5 to 6 corneous spines in line with crest on ischium. Ischium shorter than merus, with 22 closely placed denticles on crista dentata, extensor margin with distinct distal spine. Merus with 3 irregular acute spines all along flexor margin and strong spine at distodorsal margin. Sternal plastron slightly longer than broad, maximum width at sternite 7, sternite 3 forming apposed lobe at either side of midline, irregularly polygonal, finely crenulated, often well-produced, anterior lateral margin concave and finely serrate.

Epipods absent from P1–4.

P1 spinose, 1.4 times longer than carapace, with numerous short setiferous striae. Ischium with mesial row of several small spines on distal portion and one spine on distoventral margin. Merus with row of 4 mesiodorsal spines and 3 distal spines. Carpus highly setose, bearing strong spine on distodorsal corner preceded by 2 small spines. Propodus 1.7 times as long as dactylus, with few spines on distodorsal margin. Fingers straightly fitting to each other on opposable margins with tufts of stiff setae, relatively broad, semicircular ends with fine low teeth, not intermeshing.

P2–4 relatively long and slender, P2 longest. P2 not reaching end of P1, 1.3 times carapace length, corresponding segments of respective legs nearly equal in length except for meri successively decreasing posteriorly. Each merus with spiny dorsal crest ending in strong distal spine, ventrolateral margin with strong terminal spine followed by row of 5–6 spines proximally diminishing, all along with tubercular raised scales. Carpi with row of dorsal marginal spines, terminal one strongest. Propodi more setose, almost smooth and rounded, lacking any spines, almost twice as long as dactyli. Dactyli slender, flexor margin curved, acute corneous tip preceded by row of 10 spines on prehensile edge.

Etymology. — The Latin *longispinosa* referring to the long eyespine and lateral spines on carapace.

Japanese name. — Togenagashinkaikoshioriebi.

Remarks. — The carapace ornamentation and the eyespine link the new species to *M. verrilli* Benedict, 1902, from NE Pacific and Tasmania (Baba & Poore, 2002; Baba, 2005). However, *M. longispinosa* is distinctive in that fine lateral serrations are present on the rostrum, presence of additional small spine adjacent to epigastric spine, basal article of antennule with a smaller distolateral spine adjacent to longer distodorsal spine and telson composed of 9 plates.

M. longispinosa is also close to *M. nitida* A. Milne Edwards, 1880. However, in *M. nitida*, P1 is shorter than P2 (a feature of the *orophorhynchus* group) and epipods are present on P1.

Munidopsis naginata, new species
(Figs. 3c, 6)

Material examined. — Holotype: 1M, 17.44mm (NSMT–Cr 16871), Hatoma Knoll, Okinawa Trough, *Shinkai 2000*, dive 2K # 1359, 24° 51.60′ N 123° 50.38′ E, 1469m, 6 June 2002.

Paratypes: 1M, 13.66mm (JAMSTEC 050245), *Shinkai 2000*, 24° 51.60′ N 123° 50.38′ E, 1469m, 6 June 2002, dive 2K # 1359; 1M, 13.86mm (NSMT–Cr 16872), *Shinkai 2000*, dive 2K # 832, 35° 00.103′ N 139° 13.69 ′E, 1156m, 26 November 1995, Hatsushima, off Sagami Bay; 2F, 6.79mm, 15.74mm, 1M, 14.43mm (JAMSTEC 026511-026513), Hatsushima, off Sagami Bay, *Shinkai 2000*, dive 2K # 1203, 35° 00.99′ N 139° 13.75′E, 1026m, 10 August 2000; 1F 8.83mm (NSMT–Cr 16873), *Shinkai 2000*, dive 2K # 1144, 35° 00.99′ N 139° 13.75′E, 1120m, 11 October 1999.

Diagnosis. — Carapace dorsal surface covered with numerous setiferous processes like tubercles, anterior gastric region with a pair of broad, pointed truncate processes, cardiac region with median broad and pointed truncate process. Rostrum long and highly upturned at angle of 45° and minutely serrated laterally. Telson composed of 8 plates. Eyes large and subglobular. Abdominal segments 2–4, each with median protuberance, segment 6 with posterolateral lobes convexly produced and nearly convex posteromedian margin. P1–4 covered with tubular processes. Epipods present on P1–3.

Description. — Carapace, exclusive of rostrum, long as broad, sculptured, dorsal surface covered with numerous setiferous tubercle-like processes, anterior gastric region with pair of long and broad truncate processes followed by numerous setiferous tubercles, regions well delineated by furrows including distinct anterior and posterior cervical grooves. Cardiac region divided into anterior and posterior portions by deep transverse depression without tubercles, posterior part with median truncate process followed by setiferous tubercles. Rostrum highly upturned at angle of 45°, narrow and pointed, and minutely serrated laterally. Lateral limit of orbit distant from eye, ventral orbital margin with anteriorly directed tuberculate process near lateral extremity, front margin lateral to orbit concavely oblique. Lateral margins of carapace with protuberances, convexly convergent posteriorly, with weak constriction at end of cervical groove and between anterior and posterior branchial regions, anterior branchial region laterally inflated. Posterior margin of carapace somewhat concave, preceded by raised tuberculate ridge. Pterygostomian flap anteriorly ending in rounded margin, surface covered with small tubercles.

Abdominal segments 2 and 3, each armed with median protuberances, deeply sculptured transverse ridges, segment 4, 5 and 6 with numerous tubercles and granules, segment 6 convex posteriorly in middle, similar to lateral lobes, giving a trilobed appearance. Telson composed of 8 plates, length–width ratio 0.79 (N=7), mid lateral plate fringed with long stiff setae, more pronounced on males, markedly convex on distolateral margin.

Eyes prominent, well exposed, smoothly subglobular cornea cupped within broad based movable ocular peduncle bearing small rugose mesially, small subtriangular plate posterolaterally adjacent to eye and anterior to frontal margin.

Antennular peduncle basal segment cristate, dorsal margin with prominent distolateral spine accompanying row of spines, distomesial margin ending in small spine. Antennal peduncle long and slender, first segment with 2 rugae ventromesially, second with rugae mesially and laterally, third with spine on distomesial margin, fourth scalloped.

Third maxilliped with sparse short setae, basis cristate on mesial ridge, ischium with row of numerous teeth on crista dentata, merus broad with 3 strong spine on flexor margin and sharp spine at distal end. Carpus with granules on extensor border, lateral surface of ischium, merus and carpus with granules. Sternite at base of third maxilliped forming apposed lobe at either side of mid line, irregularly serrate on margin and divergent.

P1 long, slender and thin, 1.3 times longer than carapace, covered with tubercular processes with short blunt spines and serrated striae on merus to fingers. Ischium with short lateral spine, merus with principal distomesial spine, all along with small scale like tubercles. Carpus with distolateral row of tubercles. Propodus and dactylus spooned at tips, prehensile teeth pointed and crossing each other when closed.

P2–4 thin and slender, with numerous short serrated striae on mesial and lateral sides, P2 longest. P2 not reaching end of P1, 1.3 times longer than carapace. Meri with tubercular processes, with ventrolateral spine terminally. Carpi with tuberculate dorsolateral ridge in parallel with tubercular process. Propodi with tubercular process all along whole length, about 1.6 times as long as dactyli. Dactyli thin and strongly curving, ending in corneous tip, flexor margin entire with minute spinnules. P5 slender, with poorly developed cleaning brush on palm, somewhat flattened dactylus opposed by similar setae on distal end of propodus.

Epipods present on P1– 3.

Variation. — Females are smaller than males. The type materials containing both males and females exhibit only minor morphometric variations from the holotype.

Etymology. — From the Japanese word 'naginata', a type of Japanese traditional long sword, in reference to the shape of the rostrum. The name is considered as a substantive in apposition.

Japanese name. — Naginatashinkaikoshioriebi.

Remarks. — *M. naginata* n. sp. is characterized by the spinose and tuberculate processes on the dorsal surfaces and appendages, highly upturned rostrum, dorsolaterally cristate antennule and presence of 2 serrated epigastric protuberances and median processes on abdominal segments 2 and 3.

M. naginata n. sp. is most similar to the group of tuberculate species comprising *M. sonne* Baba, 1995, *M. taurulus* Ortmann, 1892 (redescription by Baba [2001]), *M. tasmaniae* Ahyong & Poore, 2004, *M. proales* Ahyong & Poore, 2004, *M. granosicorium* Williams & Baba, 1989, *M. papanui* Schanbel & Bruce, 2006 and *M. gibbosa* Baba, 1978. However, *M. naginata* can easily be distinguished from all these by dense tuberculate processes on dorsal surfaces, highly upturned rostrum and prominent median processes on abdominal segments 2 and 3.

M. naginata is very close to *M. sonne* in general features of carapace, abdomen and spinous third maxilliped. However, it differs from that species in having more prominent tubercles on the gastric and cardiac regions, a highly upturned rostrum and in the sixth abdominal segment, with the posterior margin convex in the middle, and left and right sides, hence giving a trilobed appearance.

M. gibbosa have more prominent protuberances on the abdomen and P1–4. The rostrum bears paired spines near midlength in *M. gibbosa*, whereas these spines are absent in *M. naginata*. The dorsolateral spine of the antennular basal article bears 3 additional spines in *M. naginata*, whereas these spines are absent in *M. gibbosa*.

The presence of epipods on P1–3 links *M. naginata* to *M. granosicorium*. However, the rostrum of *M. granosicorium* is not highly upturned as *M. naginata*. Also, posterolateral margin of sixth abdominal segment in *M. granosicorium* is almost transverse with posteromedian margin, whereas the same is convex posteriorly in middle, similar to lateral lobes in *M. naginata*.

Habitat Ecology. — In Hatoma Knoll, numerous chimneys of 1–3 m in height and two big chimneys of about 20 m in height emitting vigorous transparent hydrothermal fluids at about 300° C were seen in the video image. This site is characterized by a predominance of deep-sea mussels *Bathymodiolus platifrons* and galatheid crabs

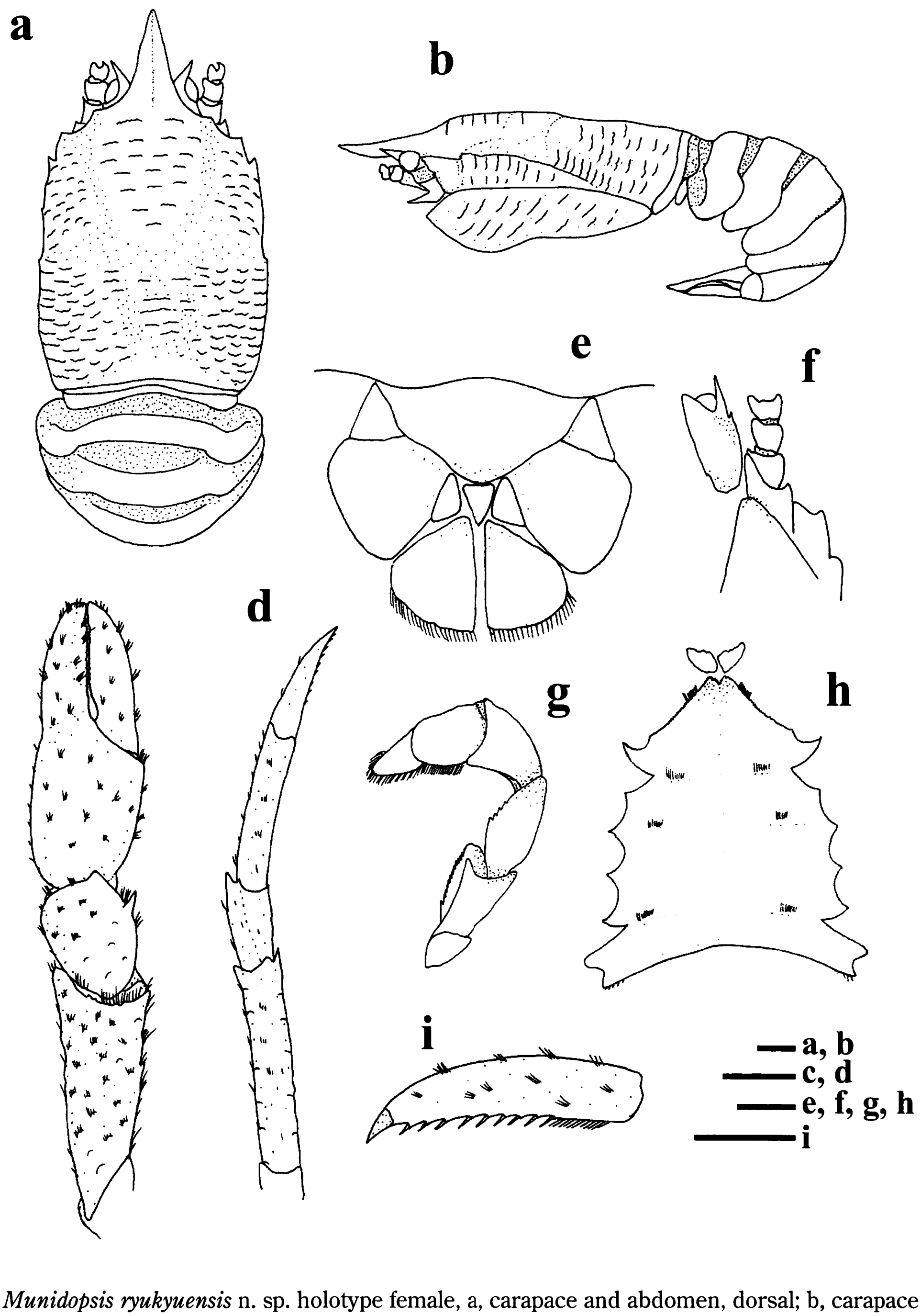

Fig. 4. *Munidopsis ryukyuensis* n. sp. holotype female, a, carapace and abdomen, dorsal; b, carapace and abdomen, lateral; c, right P1, lateral; d, right P2, lateral; e, posterior part of abdomen with telson; f, left antennule and antennal peduncle, ventral; g, endopod of right third maxilliped, lateral; h, thoracic sternum; i, dactylus of P2, lateral. Scales: a, b = 2mm; c, d = 3mm; e, g, h, i = 1mm; f = 2mm.

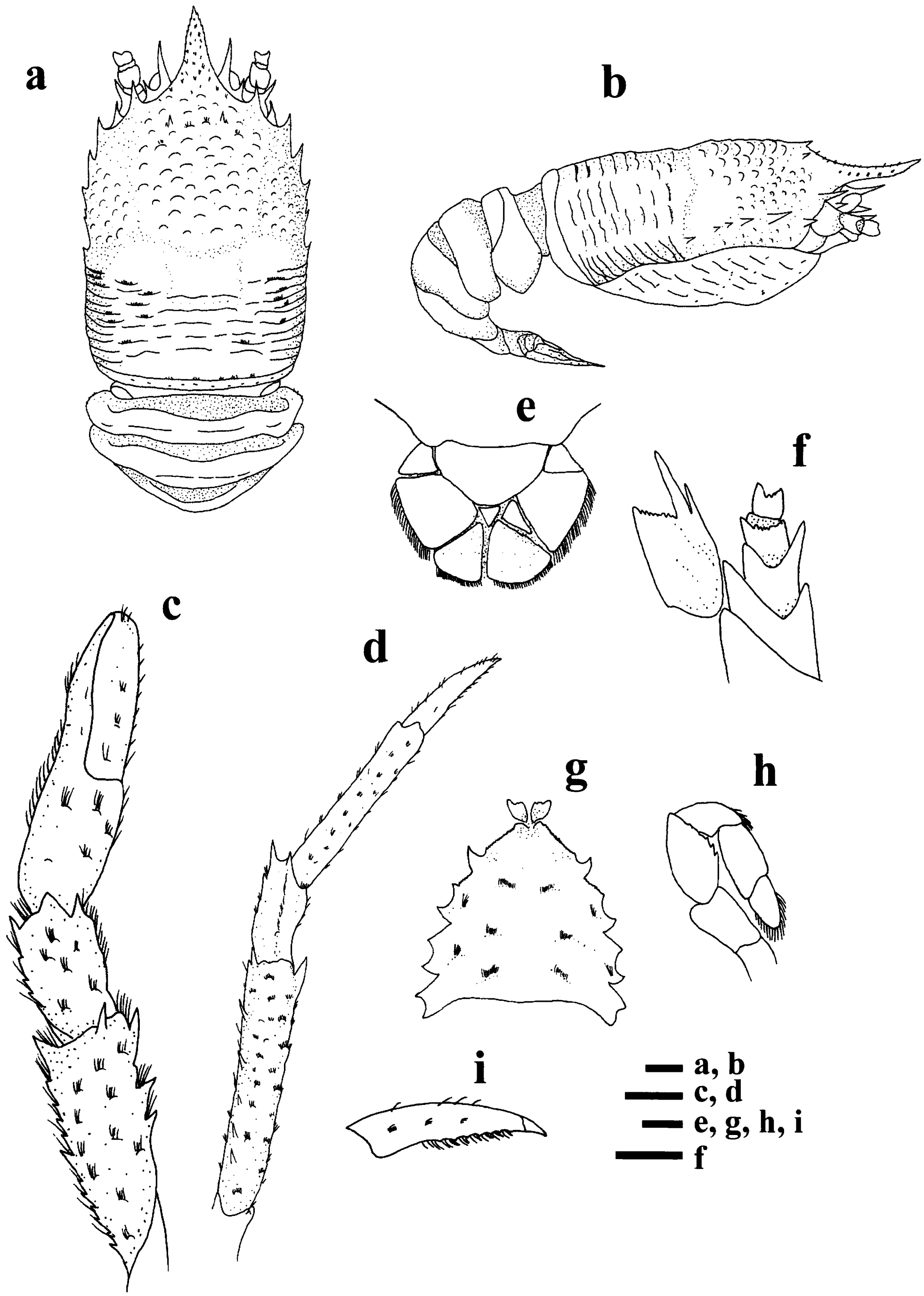

Fig. 5. *Munidopsis longispinosa* n. sp. holotype male, a, carapace and abdomen, dorsal; b, carapace and abdomen, lateral; c, right P1, lateral; d, right P2, lateral; e, posterior part of abdomen with telson; f, left antennule and antennal peduncle, ventral; g, thoracic sternum; h, endopod of right third maxilliped, lateral; i, dactylus of right P2, lateral. Scales: a, b = 2mm; c, d = 3mm; e, g, h, I = 2 mm; f = 2mm.

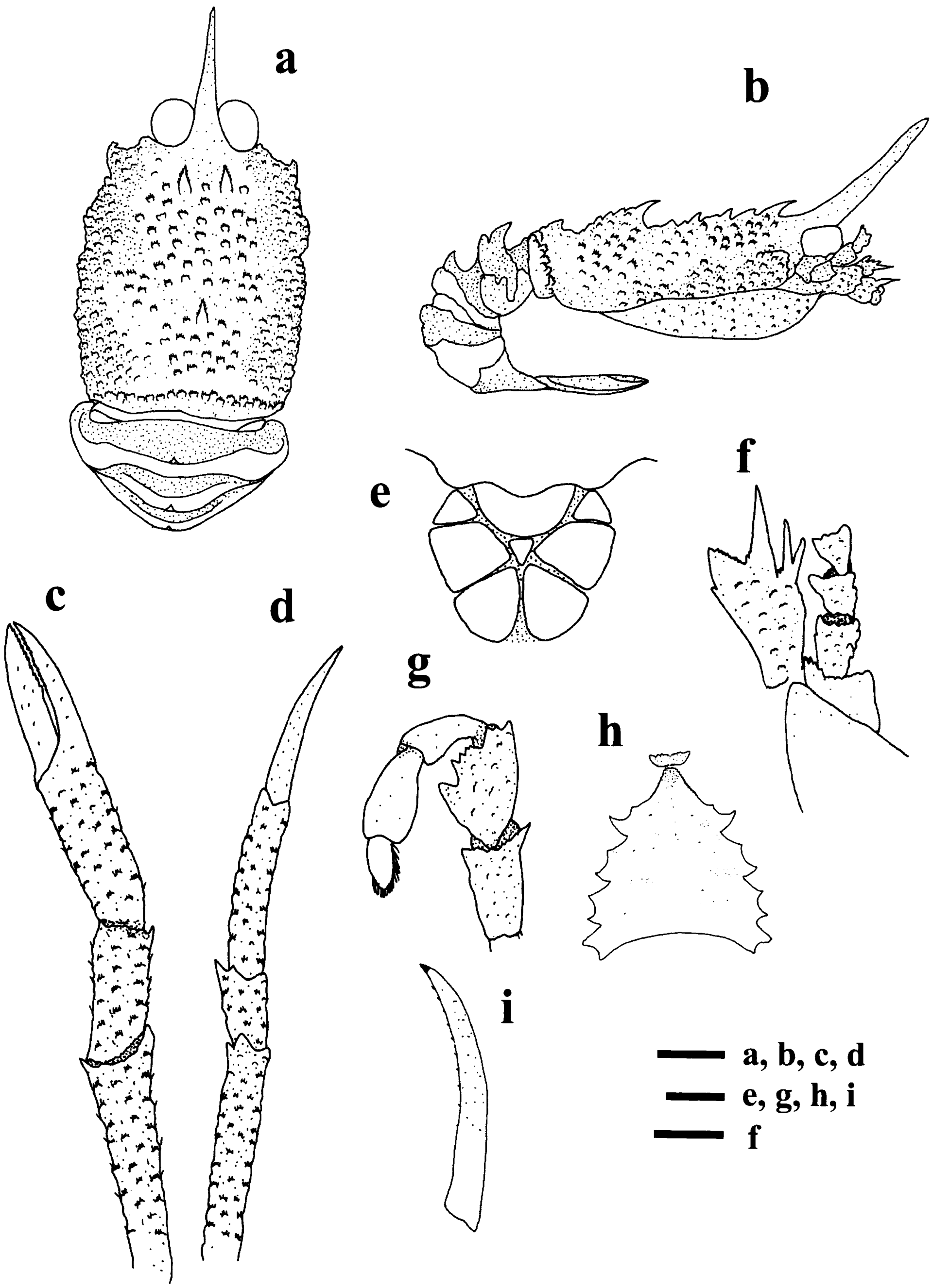

Fig. 6. *Munidopsis naginata* n. sp. holotype male, a, carapace and abdomen, dorsal; b, carapace and abdomen, lateral; c, right P1, lateral; d, right P2, lateral; e, posterior part of abdomen with telson; f, left antennule and antennal peduncle, ventral; g, endopod of right third maxilliped, lateral; h, thoracic sternum; i, dactylus of right P2, lateral. Scales: a, b = 2mm; c, d = 3mm; e, g, h, i = 1mm; f =2mm

Shinkaia crosnieri. The crabs were seen densely aggregated near the active chimneys where the temperatures were in the range 4–6.3°C (Tsuchida *et al.*, 2003). Gastropods *Provanna glabra* and limpets attached to bivalves, and numerous alvinocaridid shrimps were also seen in the vent area.

Many individuals of *Munidopsis ryukyuensis* n. sp. were seen in the video image. Usually, they were observed among bivalves or crawling slowly in the vicinity of the chimneys. They swim swiftly backwards beating their abdomen against the body when disturbed. No evidence of *M. ryukyuensis* preying on other benthic organisms was observed (Fig. 2).

Discussion

Munidopsis exhibits a wide distribution in the world's oceans and they comprise an important element of the macrofauna in reducing habitats such as hydrothermal vents, cold seeps, whale carcasses and decomposing wood in the deep-sea (Williams & Van Dover, 1983; Van Dover *et al.*, 1985; Williams, 1988; Williams & Baba, 1989; Baba, 1995, 2005). The new species records increase the number of *Munidopsis* from the hydrothermal vents of the West Pacific to seven.

The distributional pattern shown by vent associated *Munidopsis* in the West Pacific is noteworthy. *Munidopsis lauensis* inhabits the West Pacific vent sites such as Manus, Lau and North Fiji Back Arc Basins (Tunnicliffe, 1991; Baba & de Saint Laurent, 1992) and Brothers Seamount (Cubelio *et al.* (in press)), which are separated by a distance of about 4500km. It could be assumed that *M. lauensis* has a very wide distributional range. *Munidopsis starmer* and *M. sonne* reported only in North Fiji Basin (Baba & de Saint Laurent 1992; Baba 1995) and *M. marianica*, found only in North Mariana Back Arc Basin (Williams & Baba 1989), feature a narrow distribution. *Munidopsis ryukyuensis* n. sp. inhabits only Hatoma Knoll and is not found in any other vent sites in the Okinawa Trough. It could be possible that *M. ryukyuensis* n. sp. probably exhibits a narrow distribution. *Munidopsis naginata* n. sp. inhabits both Hatoma Knoll and Sagami Bay, which is separated by a distance of about 1600km from each other, suggesting a medium distributional range. The dispersal potential of larvae of different species of *Munidopsis* could account for the varying distributional patterns in the West Pacific vent fields, but no information is available to date.

Occurrence of *M. naginata* n. sp. in the Hatoma Knoll and Sagami Bay indicates that it is associated with both vent and cold seeps. There are reports of *Munidopsis* inhabiting both vent and cold seeps, such as *M. acutispina* Benedict, 1902 occurring in Lost City hydrothermal vent field in Mid-Atlantic Ridge and in cold seeps of the eastern Mediterranean Sea (Macpherson & Segonzac, 2005). Hence it is possible that *M. naginata* n. sp. is not endemic to vents but also inhabits other chemosynthetic environments, such as cold seeps, whereas *M. ryukyuensis* n. sp. occurring only in Hatoma Knoll, is probably a vent endemic species. This might be due to not only the larval dispersal, but also, the adaptation of these animals to such environments contributing to a variable distributional pattern of *M. ryukyuensis* n. sp. and *M. naginata* n. sp. In any case, there may be significant dispersal of *M. naginata* n. sp. between the vents in Okinawa Trough and cold seeps in Sagami Bay.

In spite of the cosmopolitan occurrence of *Munidopsis* in the deep-sea, many aspects of their biology is unknown. Traditional taxonomy coupled with genetic studies, which are ongoing, should greatly increase our understanding of distributional patterns, speciation and biogeography of *Munidopsis*.

Acknowledgements

We thank the captain and the crews of the R/V Natsushima, the operation team of manned submersible *Shinkai 2000* and ROV *Hyper-Dolphin* for their skillful effort in the collection of specimens. The manuscript also benefited from useful discussion with Dr. Enrique Macpherson of Centro de Estudios Avanzados de Blanes (CSIC), Blanes, Spain. We are also deeply grateful to Dr. Keiji Baba and Dr. Shane Ahyong for critically reviewing the draft of this manuscript and giving valuable suggestions. This research was supported partly by funding from Sasakawa Scientific Research Grant from The Japan Science Society.

Literature Cited

Ahyong, S.T., & Poore, G. C. B., 2004. Deep-water Galatheidae (Crustacea: Decapoda: Anomura) from southern and eastern Australia. Zootaxa, 474: 1–76.

Baba, K., 1979. First records of chirostylid and galatheid crustaceans (Decapoda: Anomura) from New Caledonia. Bulletin of Muséum national d'Histoire naturelle, Paris, (4) Section. A, 1: 521–529.

———, 1995. A new squat lobster (Decapoda: Anomura: Galatheidae) from an active thermal vent area in the North Fiji Basin, SW Pacific. Crustacean Research, 24: 188–193.

———, 2001. Redescriptions of two anomuran crustaceans, *Uroptychus japonicus* Ortmann, 1892 (Chirostlyidae) and *Munidopsis taurulus* Ortmann, 1892 (Galatheidae), based upon the type material. Crustacean Research, 30: 147–153.

———, 2005. Deep-sea chirostylid and galatheid Crustaceans (Decapoda: Anomura) from the Indo-Pacific, with a list of species. Galathea Report, 20: 317 pp.

———, & de Saint Laurent, M., 1992. Chirostylid and galatheid crustaceans (Decapoda: Anomura) from active thermal vent areas in the southwest Pacific. Scientia Marina, 56: 321–332.

———, & Poore, G. C. B., 2002. *Munidopsis* (Decapoda: Anomura: Galatheidae) from southeastern Australia. Crustaceana, 75: 231–252.

Corliss, J. B., Dymond, J., Gordan, L., Edmond, J. M., Von Herzen, R. P., Ballard, R. D., Green, K., Williams, D., Bainbridge, A., Crane, K., & Van Andel, T. H., 1979. Submarine thermal springs on the Galapagos Rift. Science, 203: 1073–1083.

Cubelio, S.S., Tsuchida, S. & Watanabe, S., 2007. Vent associated *Munidopsis* (Decapoda: Anomura: Galatheidae) from Brothers Seamount, Kermadec Arc, Southwest Pacific with description of one new species. Journal of Crustacean Biology, 27: 513–519.

Desbruyères, D., Crassous, P., Grassle, J., Khripounoff, A., Reyss, D., Rio, M., & Van Praeft, M., 1982. Donnés écologiques sur un nouveau site d' hydrothermalisme actif de la ride du Pacifique oriental. Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences, Paris, 295: 489–494.

———, Segonzac, M., & Bright, M., (eds) 2006. Handbook of deepsea hydrothermal vent fauna. Denisia 18: 544 pp.

Embley, R. W., Eittreim, S. L., Mchugh, C. H., Normark, W. R., Rau, G. H., Hecker, B., Debevoise, A. E., Green H. G., Ryan, W. B. F., Harrold, C., & Baxter, C., 1990. Geological setting of chemosynthetic communities in the Monterey Fan Valley system. Deep-Sea Research I, 40: 1241–1258.

Hashimoto, J., Jollivet, D., & Kaiyo 88 Shipboard party, 1989. The hydrothermal vent communities in the North Fiji Basin: Results of Japan–France Cooperative Research onboard KAIYO 88. La Mer, 27: 62–71.

———, Ohta, S., Fujikura, K., & Miura, T., 1995. Microdistribution pattern and biogeography of the hydrothermal vent communities of the Minami–Ensei knoll in the Mid–Okinawa Trough, Western Pacific. Deep Sea Research, 42 : 577–598.

Hessler, R. R., & Lonsdale, P. F., 1991. Biogeography of Mariana Trough hydrothermal vent communities. Deep Sea Research, 38: 1681–1709.

Ishibashi, J., & Urabe, T., 1995. Hydrothermal activity related to Arc-Back arc magmatism in the Western Pacific Back Arc Basins. In: B. Tyler (ed), Tectonics and Magmatism. Plenum Press, New York, 451–495 pp.

Kimura, M., Ueda, S., Kato, Y., Tanaka, T., Yamato, M., Gamo, T., Sasaki, H., Kato, S., Izawa, E., & Oomori, T., 1988. Active hydrothermal mounds in the Okinawa Trough back arc basin, Japan. Tectophysics, 145: 319–324.

Kojima, S., 2002. Deepsea chemosynthesis–based communities in the northwestern Pacific. Journal of Oceanography, 58: 343–363.

Macpherson, E., & Segonzac, M., 2005. Species of genus *Munidopsis* (Decapoda, Anomura, Galatheidae) from the deep Atlantic Ocean, including cold seeps and hydrothermal vent area. Zootaxa, 1095: 1–60.

Martin, J. W., & Haney, T. A., 2005. Decapod crustaceans from hydrothermal vent and cold seeps: a review through 2005. Zoological Journal of Linnaean Society, 145: 445–522.

Ohta, S., & Laubier, L., 1987. Deep biological communities in the subduction zone of Japan from bottom photograph taken during Nautile dives in the Kaiko project. Earth and Planetary Science Letters, 83: 392–342.

Paul, C. K., Hecker, B., Commeau, R., Freeman-Lynde, R. P., Neumann, C., Corso, W. P., Golubic, S., Hook. J. E., Sikes, E., & Curray, J., 1984. Biological communities at Florida Escapement resemble hydrothermal vent taxa. Science, 226: 965–967.

Schnabel, K. E., & Bruce, N. L., 2006. New records of *Munidopsis* (Decapoda, Anomura, Galatheidae) from New Zealand with description of two new species from a seamount and underwater canyon. Zootaxa, 1172: 49–67.

Tsuchida, S., Fujiwara, Y., & Fujikura, K., 2003. Distribution and population structure of galatheid crab *Shinkaia crosnieri* (Decapoda, Anomura, Galatheidae) in the southern Okinawa Trough. Japanese Journal of Benthology, 58: 84–88. (In Japanese with English abstract)

Tunnicliffe, V., 1991. The biology of hydrothermal vents: ecology and evolution. Oceanographic Marine Biology Annual Review, 29: 319–407.

Van Dover, C. L., Factor, J. R., Williams, A. B., & Berg, C. J. Jr., 1985. Reproductive patterns of decapod crustaceans from hydrothermal vents. In: Jones, M.L., (ed), Hydrothermal Vents of the Eastern Pacific: an Overview. Bulletin of the Biological Society of Washington, 6: 223–227.

Williams, A. B., 1988. New marine decapod crustaceans from waters influenced by hydrothermal discharge, brine and hydrocarbon seepage. Fishery Bulletin, 86: 213–287.

———, & Baba, K., 1989. New squat lobsters (Galatheidae) from the Pacific Ocean: Mariana Back Arc Basin, East Pacific Rise, and Cascadian Basin. Fishery Bulletin, 87: 899–910.

———, & Van Dover, C. L., 1983. A new species of *Munidopsis* from submarine hydrothermal vents of the East Pacific Rise at 21° N (Anomura-Galatheidae). Proceedings of the Biological Society of Washington, 96: 481–488.

Addresses: (SSC) Laboratory of Population Biology, Tokyo University of Marine Science and Technology, 4-5-7 Konan, Minato-ku, Tokyo, 108-8477, Japan; Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2-15 Natsushima-cho, Yokosuka, Kanagawa, 237-0061, Japan; (ST) Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2-15 Natsushima-cho, Yokosuka, Kanagawa, 237-0061, Japan; (SW) Laboratory of Population Biology, Tokyo University of Marine Science and Technology, 4-5-7 Konan, Minato-ku, Tokyo, 108-8477, Japan.

E-mails: (ST) tsuchidas@jamstec.go.jp