Descriptions of two new species of the genus *Copidognathus* and females of *Copidognathus jejuensis* (Acari: Halacaridae) from Korea

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(Accepted 17 July 2006)

Abstract

Two new species of marine Halacaridae, namely *Copidognathus quadriporosus* and *C. tetrarhachis*, are described from South Korea. *Copidognathus quadriporosus* n. sp. is closely allied with *C. brevipes* Viets and *C. tabellio* (Trouessart), but differs from them in having four porose areas on AE. *Copidognathus tetrarhachis* n. sp. is closely related to *C. ficipacus* Bartsch and *C. vulgaris* Bartsch. Dissimilarities among them are discussed. Females of *C. jejuensis* are described for the first time and illustrated with SEM.

Keywords: Copidognathus, Korea, marine Halacaridae, new species

Introduction

Earlier studies of marine halacarid mites from Korea revealed five species new to science, namely *Copidognathus koreanus* Chatterjee and Chang, 2003, *C. laevisetosus* Chatterjee, Lee and Chang, 2004, *C. jejuensis* Chatterjee and Chang, 2004, *C. fistulosus* Chatterjee and Chang, 2005, *Simognathus coreensis* Chatterjee and Chang, 2004, and two species recorded for the first time from Korea, namely *C. cerberoideus* Bartsch, 1991 and *C. polyporus* Bartsch, 1991 (Chatterjee and Chang 2003, 2004a, 2004b, 2005; Chatterjee et al. 2004). In the present paper two new species, *C. quadriporosus* n. sp. and *C. tetrarhachis* n. sp., and the female of *C. jejuensis* are described from the Korean coasts.

Materials and methods

Materials examined in the present study were collected from Jeju Island and Youngil Bay, South Korea among coralline sediments. Samples were filtered through a nylon net (pore diameter of 64 μm) after anaesthetizing halacarid mites with 7% MgCl₂ solution for about
30 min, rinsed with freshwater for osmotic shock, and then fixed and stored in 80% ethanol.

Halacarids were cleared in lactic acid and mounted in glycerine jelly. Drawings were prepared using a camera lucida under a differential interference contrast microscope with Nomarski optics.

Materials for scanning electron microscopy were prefixed overnight at 4°C in 2.5% glutaraldehyde, then followed by post-fixation in 2% cold osmium tetraoxide. After dehydration through a graded series of ethanol (50–100% at 10% intervals) for 30 min each, the material was critical-point dried, and coated with gold–palladium in a high evaporator, and then examined with a scanning electron microscope (Hitachi S-520) operated at 20 kV.

Type specimens are deposited in the Department of Biology, Daegu University, Korea.

The following abbreviations are used in the text and figure legends: AD, anterior dorsal plate; AE, anterior epimeral plate; ds1–6, dorsal setae 1–6 on idiosoma; GA, genitoanal plate; GO, genital opening; OC, ocular plate; PD, posterior dorsal plate; PE, posterior epimeral plate; PGS, perigenital setae; P1–4, first to fourth palpal segments; SGS, subgenital setae.

Description

**Family HALACARIDAE** Murray, 1877

**Subfamily COPIDOGNATHINAE** Bartsch, 1983

**Genus Copidognathus** Trouessart, 1888

*Copidognathus quadriporosus* new species

(Figures 1, 2)

*Material examined*

Holotype: male (DB00034), Gugye (36°19’03”N, 129°22’45”E), Yeongdeok, South Korea, 18 April 2001 (C. Y. Chang and J. M. Lee). Paratypes: one female (DB00035), one male (DB00036), Masan-ri, South Korea, 4 November 2004 (C. Y. Chang and T. Chatterjee).

*Additional materials.* One male, Jocheon, Jeju Is., 25 January 2003 (C. Y. Chang and J. M. Lee); one male, Gugye, Yeongdeok, Korea, 18 April 2001 (C. Y. Chang and J. M. Lee); three females and three males, Masan-ri, Korea, 4 November 2004 (C. Y. Chang and T. Chatterjee).

*Holotype male*

All dorsal plates separate. Idiosoma (Figure 1A) 337 μm long, 208 μm wide. Areolae and costae on dorsal plates with rosette pores, remainder of AD, OC, and PD plates foveate (Figure 1C). AD 108 μm long and 77 μm wide, anteriorly with small protuberance (Figure 1A); anterior areola with about 10 rosette pores, paired posterior areolae with 10–13 rosette pores each. Paired ds1 anterior to posterior areolae on AD; pair of gland pores near anterolateral margin on AD.

OC 89 μm long, 54 μm wide; length to width ratio about 1.6; each with two corneae; areolae with rosette pores medial to corneae and posterolateral to posterior cornea; gland
Figure 1. *Copidognathus quadriporosus* n. sp. (A–D) Male; (E) female. (A) Idiosoma, dorsal; (B) idiosoma ventral; (C) foveae between two costae on PD; (D) gnathosoma; (E) GA of female. Scale bars: 50 $\mu$m (A, B, E); 20 $\mu$m (C, D).
Figure 2. *Copidognathus quadriporosus* n. sp., male. (A–D) Legs I–IV. Scale bar: 20 μm.
pore lateral to posterior cornea adjacent to lateral margin of OC; pore canaliculus present nearly on lateral margin of OC; ds₂ located at anteromedial corner of OC. Brownish pigment found on upper cuticular layer near corneal zone. An elevated bar present laterally from middle to posterior side of OC.

PD 192 µm long, 135 µm wide; paired costae two to three rosette pores wide; anterior end of costa surpassing ds₃ but not reaching anterior end of PD; ds₃–ds₅ on PD; distance from ds₃ to ds₄ 53 µm and ds₄ to ds₅ 55 µm; gland pore lateral to costae between ds₄ and ds₅ (Figure 1A).

All ventral plates separate (Figure 1B). AE 98 µm long, 184 µm wide. AE with three pairs of setae and a pair of epimeral pores. Epimeral processes I–II well developed, coxal origin. Paired ventrolateral areolae containing rosette pores between insertions of legs I and II. AE with four porose areas of canaliculi in groups, located below anterior seta on AE, and between lateral and posterior setae on AE. Each PE with three ventral setae and one dorsal seta.

GA 168 µm long, 117 µm wide (Figure 1B). GO 44 µm long, 24 µm wide. Distance between anterior end of GO to that of GA 84 µm, about 1.9 times GO length; distance between posterior margin of GO to that of GA 36 µm. Spermatopositor large, reaching 58 µm anteriorly from anterior margin of GO and 29 µm apart from anterior margin of GO. Paragenital areolae well developed; 29 PGS, anterior PGS 24 µm apart from anterior margin of GO. Four pairs of SGS present.

Gnathosoma (Figure 1D) 121 µm long, 70 µm wide. Palp consisting of four segments. Rostrum elongate, extending up to proximal setae of P₄. P₁ and P₃ devoid of any seta; P₂ with one dorsal seta distally, P₄ with three long proximal setae, one minute distal seta. Proto- and deutorostral setae situated at tip of rostrum; tritorostral setae (long maxillary setae of rostrum) located just above middle of rostrum; gnathosomal base with a pair of setae (basirostral seta); distance between tritorostral seta and tip of rostrum 34 µm; distance between tritorostral seta and basirostral seta 49 µm. Gnathosomal base dorsally panelled, ventrolaterally porose. Rostral sulcus long, extending a little behind tritorostral setae. Tectum triangular.

Chaetotaxy of legs (Figure 2A–D): trochanter 1-1-1-0; basifemur 2-2-2-2; telofemur 5-5-2-3; patella 4-4-3-3; tibia 7-7-5-5; tarsus (PAS excluded) 7-4-4-3. Trochanters III and IV with distomedial spiniform process. Length to width ratio of telofemora I–IV: 1.7, 1.7, 1.6, 1.9, respectively. Telofemora sculptured with fovea. Telofemur III with two dorsal setae, devoid of any ventral seta. Telofemur IV with two dorsal, one ventral seta. Telofemora, patella and tibiae with distoventral and distal pararthrodial (articular) lamellae. Tibiae I and II proximoventrally with rudimentary lamellae, devoid of denticulation and spiniform extension. Length to width ratio of tibiae I–IV 2.4, 2.4, 3.2, 3.1, respectively. Arrangement of pectinate setae on tibiae I–IV: 2-2-1-0. Tarsus I with three dorsal setae, one solenidion (20 µm long), three ventral setae, two doublets eupathid PAS. Tarsus II with three dorsal setae, one solenidion (21 µm long), two eupathid PAS. Tarsus III with four dorsal setae, distance between two basal setae subequal with height of tarsus. Tarsus IV with three dorsal setae. All legs with two lateral claws and a bidentate median claw. Lateral claws with accessory process dorsally, finely pectinate ventrally.

Female

Idiosoma 342 µm long. Costae two rosette pores wide, anterior end of costa not reaching ds₃. GA 169 µm long, 125 µm wide (Figure 1E). GO 70 µm long; paragenital areolae well
developed; ovipositor surpassing anteriorly 40 µm of GO, extending beyond anterior PGS. Distance between anterior end of GO to that of GA 85 µm, about 1.2 times GO length. Three pairs of PGS present; anterior pair 27 µm away from anterior end of GO and 55 µm away from anterior margin of GA; middle pair near the level of anterior margin of GO; third pair near posterior side of GO. Pair of SGS located at anterior sixth of GO.

**Variability**

Morphological variation was examined between the holotype and other specimens. In the holotype and in a female, costae on PD are two to three rosette pores wide and the anterior end of costa extends beyond ds 3, while in other specimens, costae are one to two rosette pores wide, and anterior ends do not reach up to ds 3. Anterior areola on AD contains about 10 rosette pores in the holotype, while from five to 10 rosette pores in other specimens according to individuals. Number of PGS in male ranges from 25 to 29. Rudimentary lamellae on ventral side of tibiae I and II are not found in most of the specimens examined. In a few specimens, tectum is obtuse-angled triangular with a very small, spinose tip. In many specimens, ostia are not prominent in porose areolae on ventrolateral side of gnathosomal base.

**Remarks**

*Copidognathus quadriporosus* n. sp. is allied with *C. tabellio* (Trouessart, 1894) from the North Atlantic, Mediterranean and Black Sea (Trouessart 1894, 1901; Viets 1940; André 1946; Bartsch 2001) and *C. brevipes* Viets, 1940 from the Mediterranean and Black Sea (Viets 1940; Bartsch 1975, 2001; Morselli and Mari 1985) in having the combination of the following characteristics: three areolae on AD; ds 1 ahead of posterior areola on AD; pair of gland pores located anterolaterally on AD; ds 2 located at anteromedial corner of OC; ds 3-5 present on PD; PD with two costae containing rosette pores; gland pores situating between ds 4 and ds 5 lateral to costa on PD; epimeral processes I–II well developed, and coxal origin; one pair of basirostral setae present; trochanters III and IV with distomedial process; telofemora III–IV with 0-1 ventral seta; pectinate setae on tibiae I–IV 2-2-1-0; tarsi III–IV with 4-3 dorsal setae. However, *C. quadriporosus* is distinguished from *C. brevipes* and *C. tabellio* by four porose areas on AE. Moreover, *C. tabellio* has brownish pigmentation anteriorly on AD and posteriorly on OC. *Copidognathus brevipes* is characterized by its short telofemora.

*Copidognathus lamelloides* Bartsch, 2000 from Europe (Bartsch 2000, 2001) looks somewhat similar to the present new species, but differs in many ways. Gland pores on AD are apart from each other in *C. lamelloides*. Setae ds 2 are located on membranous cuticle between OC and AD in *C. lamelloides*, while at anteromedial corner of OC in *C. quadriporosus*. One of the ventral setae on tibia IV is pectinate in *C. lamelloides*, while all ventral setae on the segment are smooth in *C. quadriporosus*.

*Copidognathus bavayi* (Trouessart, 1896) known from Vietnam, Malaysia (Trouessart 1896, André 1937, Bartsch 1993) looks similar in general appearance to the present new species, but is distinguished from *C. quadriporosus* on the following points: *C. bavayi* has four dorsal setae on tarsus IV, while *C. quadriporosus* has three dorsal setae in that segment; brownish pigmentation is found on posterior portion of OC and anterior part of PD in *C. bavayi*, while such pigmentation is absent in the present species.
Both *C. quadratus* Makarova, 1972 and *C. globulosus* Makarova, 1975 recorded from the Kuril Islands (Makarova 1972, 1975), adjacent to the type locality of the present species, are not allied with *C. quadriporosus*. *Copidognathus quadratus* differs from *C. quadriporosus* by the location of ds1 (present on membranous cuticle in *C. quadratus*, while on PD in *C. quadriporosus*), the number of costae on PD (four costae in *C. quadratus*, while two costae in *C. quadriporosus*). Moreover, *C. quadratus* has anterior pair of PGS in female near the anterior margin of GA, while away from the anterior margin of GA in *C. quadriporosus*. *Copidognathus globulosus* is distinguished from *C. quadriporosus* by the number of costae on PD (four costae in *C. globulosus*, while two costae in *C. quadriporosus*), the length of rostrum (rostrum elongate, extending near the proximal setae of P4 in *C. quadriporosus*, while near the anterior end of P2 in *C. globulosus*). Moreover, areolae on GA present lateral to GO in *C. quadriporosus*, while areolae on GA located lateral to GO and also on anterolateral side of GA in *C. globulosus* (cf. Makarova 1975, Figure 3J).

**Etymology**

The proposed specific name is taken from the characteristic of “four porose areas on AE”.

*Copidognathus tetrarhachis* new species

(Figures 3, 4)

**Material examined**

Holotype: female (DB00037), among coralline algae, Jocheon (33°32′54″N, 126°38′25″E), Jeju Island, South Korea, 25 January 2003 (C. Y. Chang and J. M. Lee). Paratypes: one female (DB00038), one male (allotype, DB00039), collection data same as holotype. Additional materials: three males, three females, collection data same as holotype.

**Holotype female**

All dorsal plates separate (Figure 3A). Holotype 326 μm long, 221 μm wide. Porose areolae and costae on dorsal plates with modified rosette pores, i.e. pits (panels) each with 3–13 canaliculi. AD 83 μm long, 88 μm wide, anteriorly with small protuberance. Three porose areolae on AD; anterior areola with 20–22 modified rosette pores, two oblong posterior areolae each with about 13–16 modified rosette pores; posterior areolae joining with anterior one, forming inverted “Y”-shaped areolae. Paired ds1 situated at joint of three areolae on AD, inserted close to each other; pair of gland pores near lateral margin on AD above level of ds1; setae ds2 located on membranous cuticle above anterior margin of OC. OC triangular, 59 μm long, 39 μm wide, length to width ratio about 1.5; with two corneae, posterior cornea faintly subdivided, porose areola on corneal zone; gland pore lateral to posterior cornea.

PD 133 μm long, 83 μm wide; with four costae; middle costae three panels wide; lateral costae one to two panels wide; lateral costa adjoining to lateral margin of PD. Dorsal setae of ds1–ds5 present on PD.

All ventral plates separate (Figure 3B). Setae on ventral plates longer than dorsal plates. AE 105 μm long, 194 μm wide; porose, canaliculi arranged in groups. AE with three pairs of setae and a pair of epimeral pores. Posterior margin of AE arched. PE with three ventral setae and one dorsal seta. GA 117 μm long, 102 μm wide; GO 71 μm long, 35 μm wide.
Figure 3. *Copidognathus tetrarhachis* n. sp. (A, B, D) Female; (C) male. (A) Idiosoma, dorsal; (B) idiosoma ventral; (C) idiosoma ventral; (D) gnathosoma. Scale bars: 50 μm.
Figure 4. *Copidognathus* tetrarhachis n. sp., female. (A–D) Legs I–IV. Scale bar: 50 μm.
Ovipositor surpassing 21µm from anterior margin of GO, distance between anterior margin of ovipositor to anterior margin of GA 8µm. Distance between anterior margin of GO to that of GA 29µm, about 0.4 times length of GO. Three pairs of PGS present; anterior pair near anterior margin of GA; middle pair below level of anterior margin of GO, third pair near posterior side of GO. Pair of SGS located at anterior sixth of GO.

Gnathosoma (Figure 3D) 108µm long, 82µm wide. Palp consisting of four segments. P₁ and P₃ devoid of any seta, P₂ with one dorsal seta distally, P₄ with three long proximal setae and one minute distal seta. Tip of rostrum extending near end of P₂. Protostegite and deutorostral setae situated at tip of rostrum, tritorostral setae (long maxillary setae of rostrum) located on anterior half of rostrum, gnathosomal base with two pairs of setae (basiscrostral setae). Ventrolateral side of gnathosomal base porose. Tectum truncate.

Chaetotaxy of legs (Figure 4A–D): trochanter 1-1-1-0; basifemur 2-2-2-2; telofemur 5-5-2-2; patella 4-4-3-3; tibia 7-7-5-5; tarsus (PAS excluded) 7-4-3-3. Arrangement of pectinate setae on tibiae I–IV: 1-2-1-1. Telofemora I and II with ventral areola containing canaliculi. Tarsus I with three dorsal setae, one solenidion, three ventral setae, two doublets eupathid PAS. Tarsus II with three dorsal setae, one solenidion, two doublets eupathid PAS. Tarsi III and IV with three dorsal setae. All legs with two lateral claws and a bidentate median claw. Lateral claws with accessory process dorsally, pectinate ventrally.

**Allotype male**

Idiosoma 315µm long. GA 144µm long, 108µm wide (Figure 3C). GO 47µm long, 24µm wide, surrounded by 17 PGS; distance between anterior end of GO to that of GA 54µm, about 1.1 times of GO length. Four pairs of SGS present, first, second and fourth pairs thin, while third pair thick and spur-like (Figure 3C). Gnathosomal base with two pairs of setae (basiscrostral setae).

**Variability**

Idiosoma length ranges from 320 to 350µm in five females examined and from 313 to 320µm in four males. Number of PGS in four male specimens examined ranges from 17 to 21.

**Remarks**

In having the characteristics of three porose areolae fused to each other to form an inverted-"Y" on AD, triangular OC, ds₁ closed to each other, gnathosoma with two pairs of basiscrostral setae, telofemora I and II with ventral porose area, tibia I with a small blunt spinose seta, and tibiae II–IV with 2-1-1 arrangement of pectinate setae, *Copidognathus tetrarhachis* n. sp. should be designated as a member of the *C. pulcher* group (cf. Bartsch 1984, 1998). Among the congeners of this species group, the present species is closely related to *C. ficipacus* Bartsch, 1992 from Moorea Bora Bora, Society Islands (Bartsch 1992) and *C. vulgaris* Bartsch, 1998 from Rottnest Island, western Australia (Bartsch 1998) in sharing large GO in female and ovipositor little apart from anterior margin of GA. However, *C. tetrarhachis* differs from them as follows: there are four costae on PD in *C. tetrarhachis*, while two costae in *C. ficipacus* and *C. vulgaris*; length to width ratio of OC about 1.5 in *C. tetrarhachis*, while 1.9–2.0 in *C. ficipacus* and *C. vulgaris*; anterior areola on AD is relatively wider in *C. ficipacus* (cf. Bartsch 1998, Figure 4G); anterior margin of GA is
rounded in female of *C. ficipacus*, while truncated in *C. tetrarhachis*; male has five to seven pairs of maxillary setae on gnathosomal base in *C. vulgaris*, while two pairs in *C. tetrarhachis*. Moreover, *C. tetrarhachis* has modified rosette pores on areolae and costae of dorsal plates, while simple porose panels in *C. ficipacus* and *C. vulgaris*.

Two species of *Copidognathus pulcher* group have been recorded from adjacent area, namely *C. manicatus* (Trouessart, 1899) from Cochinchina (South Vietnam) (Trouessart 1899; André 1937) and *C. uniscutatus* Bartsch, 1984 from Mactan Island, Cebu, the Philippines (Bartsch 1984). There are four costae on PD in *C. tetrarhachis*, while two costae in *C. manicatus*; female GO relatively larger in *C. tetrarhachis*, and the distance between anterior margin of female GO and that of GA is about 0.4 of GO length in *C. tetrarhachis*, while about 0.85 of GO length in *C. manicatus* (cf. André 1937, Figure 2v). *Copidognathus uniscutatus* Bartsch is easily distinguished from *C. tetrarhachis* by having fused dorsal plates.

In *C. magnipalpus* (Police, 1909) of the *C. pulcher* group, the lateral costae are known to vary from absent to almost half the length of the middle costae (Bartsch 1975, 2001). In *C. tetrarhachis*, the two lateral costae on PD apparently and consistently exist without such length variation throughout all materials examined. It needs further investigation to know whether such variability might exist in other species, too. So, for the specific determination, other characters along with lateral costae should be taken into consideration.

**Etymology**

The proposed specific name *tetrarhachis* (*tetra*, Gr. four; *rhachis*, Gr. ridge or rib on the back) alludes to the “four costae” on PD, one of the discriminative characteristics from the related species.

**Copidognathus jejuensis** Chatterjee and Chang, 2004

(Figure 5)

*Copidognathus jejuensis* Chatterjee and Chang 2004a, p. 192, Figures 1A–F, 2A–J.

**Material examined**

Ten females, five males, Masan-ri (36°01'06"N, 129°29'27"E), Youngil Bay, South Korea, 4 November 2004 (C. Y. Chang and T. Chatterjee), among coralline algae.

**Female**

Idiosoma 334–360 µm long. AD 107 µm long, 85 µm wide. OC 90 µm long, 43 µm wide (length to width ratio about 2.1) in one side, while 87 µm long, 44 µm wide (length to width ratio about 2.0) in other side. PD 129 µm long, 103 µm wide. PD truncate anteriorly. Posterior margin of AE arched. GA 156 µm long, 113 µm wide. GO 59 µm long, 27 µm wide. Ovipositor small going 13 µm anteriorly from the anterior margin of GO. Distance between anterior margin of GO to that of GA 70 µm, about 1.2 times length of GO. Three pairs of PGS present, first pair anterior to GO, second pair below the level of anterior margin of GO, third pair beside posterior part of GO (Figure 5D). One pair of SGS present.

Rostrum tip almost reaching distodorsal end of P₂ (Figure 5C). Rostral sulcus long, extending beyond tritostostral setae posteriorly.
Figure 5. *Copidognathus jejuensis* Chatterjee and Chang, female (SEM photographs). (A) Idiosoma, dorsal; (B) idiosoma, ventral; (C) gnathosoma; (D) GA; (E) tibia and tarsus I; (F) tibia and tarsus II; (G) tarsus tip and claws of leg III; (H) tarsus tip and claws claw of leg IV. Scale bars: 100 µm (A, B); 50 µm (C–F); 10 µm (G, H).
Telofemora I and II with ventromedial and ventrolateral lamellae. Lateral edge of ventrolateral lamella on telofemur I uneven. Telofemora III and IV with large ventrodistal and smaller distal lamellae. All patella and tibiae with distoventral and distal lamellae. Tibiae I and II each with two denticulate processes proxiemoventrally (Figure 5E, F). Tarsus III with four dorsal setae and two smooth PAS, while tarsus IV with three dorsal setae and two plumose PAS. Two anterior dorsal setae on tarsi III and IV plumose in nature that are clearly found under SEM study. Lateral claws with accessory process dorsally and pectinate ventrally. Lateral claws of leg I consist of less tines than in claws of legs II–IV. Lateral claws of legs II–IV with about 17–20 tines (Figure 5G, H).

**Variability**

Edge of ventrolateral lamella of telofemur I varies from slight to very uneven and in some specimens almost serrated. In some specimens ventrolateral lamellar edge of telofemur II is also uneven. Length to width ratio of OC varies from 1.8 to 2.1. Posterior tip of OC varies slightly among individuals: in some specimens it is slightly blunt while in others more pointed; in some specimens this variation is even found in right and left side of OC also. Length of rostral sulcus varied from 0.65 to 0.74. The position of tritorostral setae ranged from 0.45 to 0.53 of rostrum length from the tip of rostrum.

**Remarks**

The male of *Copidognathus jejuensis* Chatterjee and Chang was earlier recorded from Jejudo Island, Korea (Chatterjee and Chang 2004a). The female of this species is recorded here for the first time. SEM structure of male tarsus IV shows two plumose PAS. Female tarsus IV also shows similar plumose PAS. There is no sexual dimorphism found on PAS in this species.

**Acknowledgements**

We are grateful to Dr J. M. Lee, Daegu University, Korea for helping to take the SEM pictures of *Copidognathus jejuensis*. The first author (T.C.) is indebted to the Brain Pool Program, Korea. This research was partly supported by a Daegu University Research Grant, 2006.

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