

First Record of *Campyloderes macquariae* Johnston (Kinorhyncha, Cyclorhagida, Centroderidae) from the North Pacific

Young Hee Song and Cheon Young Chang

(Department of Biology, College of Natural Sciences, Taegu University,
Kyungsan 712-714, Korea)

ABSTRACT

Campyloderes macquariae Johnston, 1938 is reported from South Korea. Specimens were obtained from the washings of subtidal sediments, holdfasts of macroalgae, and various invertebrates. This is the first record for genus *Campyloderes* from the North Pacific. Affinities with its congeners and the variability within species are discussed, with the confirmation of several morphological details by scanning electron microscopy.

Key words: Taxonomy, Kinorhyncha, Cyclorhagida, Centroderidae, *Campyloderes macquariae*, North Pacific, Korea

INTRODUCTION

Since the discovery of kinorhynchs in 1841, 140 species belonging to 15 genera of 10 families in 2 orders have been known as valid. However, in the North Pacific, taxonomic studies on kinorhynchs are relatively scanty as compared with those in other seas such as the Atlantic, and only 18 species are recorded.

From the Northwest Pacific, 12 species are currently recognized. The first report of kinorhynchs from this area was *Echinoderes masudai* Abe, 1930 from Japan, which is considered as a species

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* Corresponding author: Cheon Young Chang

E-mail: cychang@taegu.ac.kr, Tel: 053-850-6454

indeterminata (Higgins, 1983; Adrianov and Malakhov, 1999). The subsequent record was *E. chefouensis* Lou, 1934 from a Chinese coast of the Yellow Sea. *Echinoderes dujardinii* Claparède had been reported from Japan by Tokioka (1949) and Sudzuki (1976a, b), but those reports are currently regarded as misidentifications (Higgins, 1983; Adrianov and Malakhov, 1999), for *E. dujardinii* is confined to European waters only. Recently, Adrianov (1989) described six species from Russian seas of the East Sea (Peter the Great Bay), including *E. asiaticus*, *E. filispinosus*, *E. multisetosus*, *E. orientalis*, *Kinorhynchus yushini* and *Pycnophyes tubuliferus*, of which *E. asiaticus* was relegated to a new genus *Cephalorhyncha* and *E. orientalis* is considered as nomina dubia (Adrianov and Malakhov, 1999). Higgins and Shirayama (1990) recorded *Dracoderes abei* from Hiroshima, the first valid species known from Japan. Quite recently, Adrianov and Malakhov (1999) described *P. furugelmi* and *P. schornikovi* from Peter the Great Bay, and *D. orientalis*, *E. koreanus* and *E. ulsanensis* with the report of *K. yushini* and *P. tubuliferus* from an southeast coast of the Korean Peninsula.

The genus *Campyloderes* was established by Zelinka (1913) to accommodate a new species *C. vanhoeffeni* from the Antarctic and its adjacent seas. As the second species *C. macquariae* was recorded from Macquarie Island, the Australasian Antarctic by Johnston (1938), this rarely known genus had been considered as an Antarctic genus, before the third species *C. adherens* was found from the west coast of Sweden by Nyholm (1947). Thereafter, only *C. macquariae* of the three species in the genus was reported additionally from other seas, that is, from New Caledonia (Higgins, 1967) and England (Moore, 1973). Although the previous reports already suggested the possibility of ubiquitous distribution, the presence of *C. macquariae* has not been confirmed in the North Pacific yet.

This article deals with the redescription of *Campyloderes macquariae*, based upon the specimens collected from South Korea. Furthermore, the affinities with its congeners and variability within the species are discussed, as well as the confirmation of several morphological details using scanning electron microscope.

MATERIALS AND METHODS

Materials were obtained from subtidal bottom sediments, or from the washings of subtidal macroalgae and the various benthic invertebrates, which were collected by fishing net at Jeju Island and Gangreung in the south or east coasts of South Korea.

They were filtered in the field through nylon net (67 µm in pore diameter) after freshwater rinsing for less than a minute for freshwater shock, to be fixed with 5% buffered formalin.

Specimens were mounted in Hoyer's-125 medium (Higgins, 1988) on H-S slide (Shirayama *et al.*, 1993) after placing in a solution of 5% glycerin in 95% ethyl alcohol for 1-2 days, and observed under a differential interference contrast microscope with Nomarski optics. After examination, slides were sealed with nail polish. All drawings and measurements were prepared using a camera lucida.

Specimens for SEM examination were fixed overnight at 4°C in a 2.5% buffered glutaraldehyde, then followed by postfixation with 1% cold buffered osmium tetroxide. After dehydration through a

graded series of ethanol (60%, 70%, 80%, 90%, 95%, 100%, 100%) for 30 minutes each, the material was critical point dried, and coated with gold-palladium in a high evaporator, and then examined in a Hitachi S-520 scanning electron microscope operated at 20 kv.

Abbreviations used in the text, tables and figure legends mostly follow those of Pardos *et al.* (1998): LA-lateral accessory spine; LS (4)-lateral spine (of segment 4); LTS-lateral terminal spine; MSW (9)-maximum sternal width (on segment 9); MTS-midterminal spine; DS-dorsal spine; PS-penile spine; SL-sternal length; SS-sensory spot; SW(12)-standard width (on segment 12); TL-trunk length.

TAXONOMIC ACCOUNTS

Family Centroderidae Zelinka, 1896

Genus *Campyloderes* Zelinka, 1913

***Campyloderes macquariae* Johnston, 1938 (Figs. 1-2)**

Campyloderes macquariae Johnston, 1938, p. 1, Figs. 1-7; Higgins, 1967, p. 75, Figs. 1-2; Moore, 1973, p. 341, Figs. 2-3.

Material examined. 5 inds., Namae, Gangreung, 6 Oct. 2000, C. Y. Chang, J. M. Lee and Y. H. Song; 5 inds., Gisamun-ri, Gangreung, 7 Nov. 1999, J. M. Lee and Y. H. Song; 4 inds., Munseom I. off Seogwipo, Jeju I., 19 Jan. 1997, S. H. Kim; 8 inds., Munseom I. off Seogwipo, Jeju I., 26 Feb. 1999, J. M. Lee and Y. H. Song; 8 inds., Beomseom I. off Seogwipo, Jeju I., 3 Mar. 2000, J. M. Lee and Y. H. Song; 2 inds., Marado I., 7 Jun. 2001, H. S. Rho and J. W. Choi.

One specimen mounted in Hoyer's-125 medium on H-S slide have been deposited in the Natural History Museum, Ewha Womans University. All the remaining specimens are retained in the research collection of the authors.

Diagnosis. Segment 1 with 6 rows of scalids, each comprising 10, 20, 10, 10, 14, 14 scalids; segment 2 consisting of 14 placids, midventral placid more than 2 times wider than adjacent ones; middorsal spines present on segments 3-13; every middorsal spines flanked basally by a pair of oval-shaped cuticular spots; segment 3 representing a complete ring, with extremely long lateral spines; segments 4-13 each armed with 1 lateral spine, in addition to 1 accessory lateral spine on segment 7; lateral terminal spine rather short, about one third of trunk length; midterminal spine stout, about a half of LTS; LTS with irregularities of inner cavity anterolaterally near base; penile spines absent.

Redescription. Trunk length (TL) ranging 305.3-353.2 μm ($333.9 \pm 15.7 \mu\text{m}$, N = 17); maximum sternal width (MSW) at segment 9 ranging 73.4-89.4 ($79.5 \pm 4.2 \mu\text{m}$, N = 17), about a quarter of TL; standard width (SW) at segment 12 ranging 61.7-76.6 ($66.4 \pm 4.1 \mu\text{m}$, N = 14), about 20% of TL (Table 1).

Segment 1 with mouth cone surrounded with a rosette of leaf-like processes, and with 6 rows of scalids, each comprising 10, 20, 10, 10, 14, 14 scalids from foremost row (row 1) to posteriormost row (row 6), as shown in Figs. 1C, 2B-C; row 1 of 10 thick, curved, tapering scalids issued from broad base with a sharp spine basally, each scalid banded with minute setules (usually

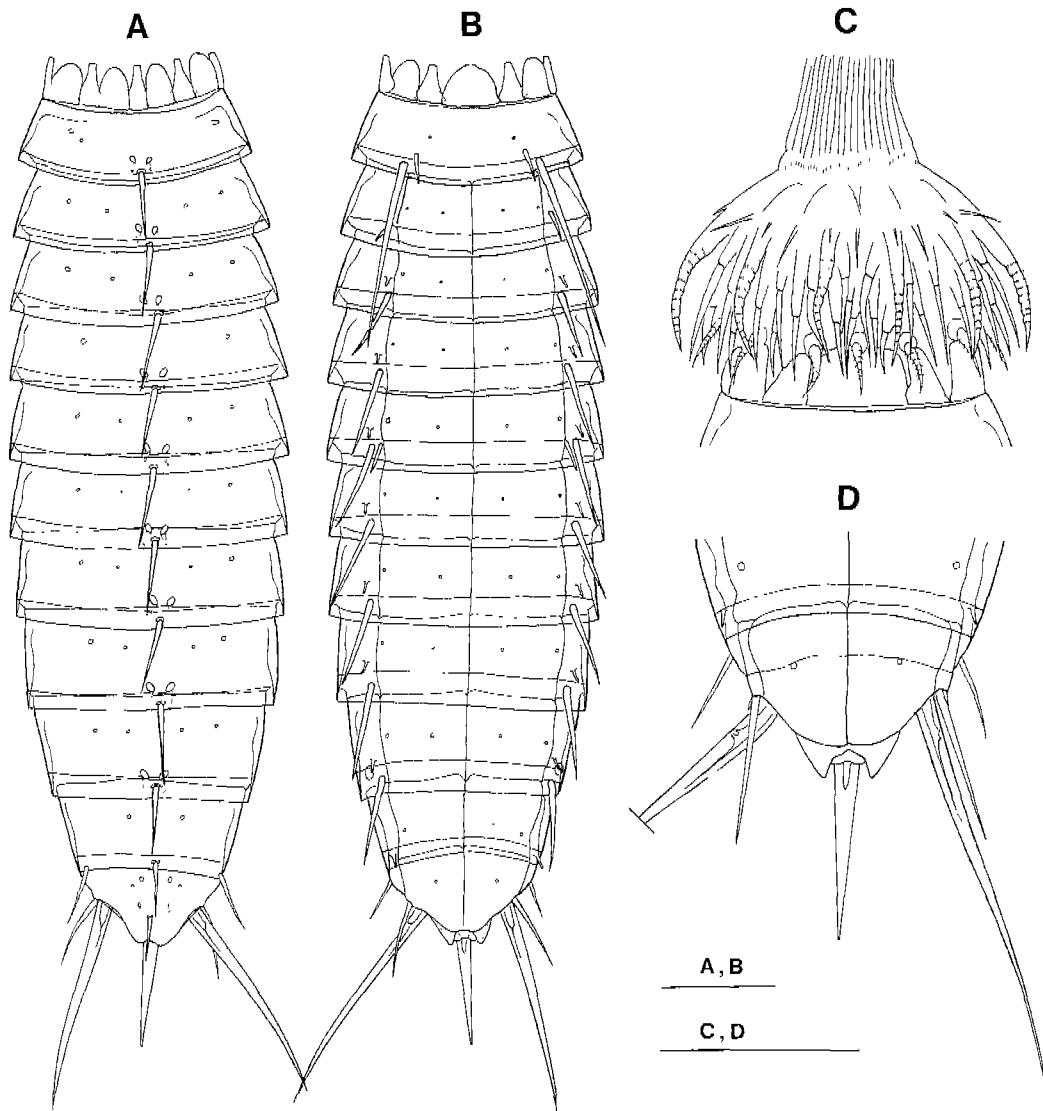


Fig. 1. *Campyloderes macquariae* Johnston. A, habitus, dorsal; B, habitus, ventral; C, segments 1-2, ventral; D, segments 12-13, ventral. Scale bars = 50 μ m.

10-13 rings); rows 2-5 of spinoscalids with hooked spines, pointing posteriorly; each scalid alternatingly inserted between other two scalds of preceding and succeeding rows; trichoscalids of row 6 banded with minute setules, centered above each placid.

Segment 2 (neck) consisting of 14 distinctly defined truncate placids, midventral placid more than 2 times wider than adjacent ones, while middorsal placid becomes narrower anteriorly (Fig. 1A-B).

Trunk segments (segments 3-13) furnished with weakly striated pectinate fringe on each posterior border; posterior margin of fringe smooth without any serrulation or crenation. Dorsal

Table 1. Measurements (μm) for adult *Campyloderes macquariae* from South Korea.

Character	N	Range	Mean	SD	Character	N	Range	Mean	SD
TL	17	305.3-353.2	333.9	15.7	LA7	12	12.8-16.0	14.2	1.1
SW	14	61.7-76.6	66.4	4.1	LS8	16	39.4-48.9	45.6	2.6
MSW	17	73.4-89.4	79.5	4.2	LS9	16	31.9-51.1	45.7	4.6
LTS	16	98.9-130.9	112.5	10.6	LS10	16	38.3-51.1	45.8	4.0
MTS	17	42.6-57.4	49.6	4.9	LS11	16	39.4-53.1	45.0	4.5
DS3	14	23.4-36.2	30.3	3.6	LS12	7	23.4-30.9	26.5	3.0
DS4	14	22.4-40.4	33.7	4.1	SL3	13	19.1-36.2	29.1	4.6
DS5	15	29.8-43.6	35.0	3.9	SL4	16	20.2-31.9	26.8	3.1
DS6	16	27.7-43.6	36.0	4.6	SL5	16	21.3-31.9	27.1	2.6
DS7	13	25.5-42.6	38.0	5.0	SL6	16	23.4-31.9	28.2	2.3
DS8	14	29.8-46.8	37.5	4.8	SL7	16	21.3-33.0	28.2	3.4
DS9	16	26.6-45.7	37.3	5.9	SL8	16	23.4-33.0	29.5	2.5
DS10	15	31.9-52.1	39.2	6.4	SL9	16	27.7-35.0	30.9	1.8
DS11	16	31.9-57.4	40.3	7.0	SL10	16	27.7-34	32.5	2.3
DS12	11	16.0-29.8	24.1	4.0	SL11	16	26.6-37.2	33.2	3.1
DS13	8	20.2-24.5	21.6	1.5	SL12	16	27.8-35.1	31.3	1.6
LS3	14	81.9-102.1	90.9	5.9	SL13	12	34.9-2.3	34.9	2.3
LA3	10	9.0-17.0	14.4	2.4	SW/TL	15	0.17-0.24	0.20	0.02
LS4	13	10.6-19.1	13.9	2.5	MSW/TL	15	0.28-0.40	0.24	0.02
LS5	15	26.6-39.4	33.0	3.4	LTS/TL	16	0.27-0.38	0.33	0.04
LS6	16	34.0-45.7	40.3	4.1	MTS/LTS	16	0.41-0.48	0.44	0.02
LS7	15	35.1-48.9	41.8	3.5	LS3/TL	14	0.22-0.36	0.27	0.03

surface covered with innumerable oval shaped rashes, posteriorly directed and each bearing a minute hair, under SEM examination; ventral surface hirsute, each sternal plate with several rows of cuticular hairs (Fig. 2E). Every segments with well developed pachycycli (thickened anterior margins of trunk segments); eye spots and muscle scars not observed. Middorsal spines present on segments 3-13, increasing in length from segment 3 to segment 11, decreasing in length thereafter. Every middorsal spines flanked basally by a pair of cuticular spots (Fig. 1A), filled with numerous spinules (Fig. 2G), mixed in size ($2.6-2.8 \times 3.8-4.4 \mu\text{m}$) with generally oval shape (under light compound microscope, a horn- or funnel-shaped inner structure of the spot is shown rather pronouncedly, with its distal part tapering and hooked posterolaterally).

Segment 3 (first trunk segment) representing a complete ring; sternal plate not divided. Extremely long lateral spines (Fig. 1B) inserted posterolaterally, often not reaching posterior margin of segment 6, about $91 \mu\text{m}$ long (ranging $81.9-102.1 \mu\text{m}$, $N = 14$; a little longer than a quarter of trunk length). Short adhesive tubes situated near posterior border, neighboring lateral spine a little anteromedially. A pair of sensory spots present nearly in the middle of both sternal plate and tergal plate.

Segments 4-13 divided by mesial line ventrally. Every sternal plates and tergal plates equipped

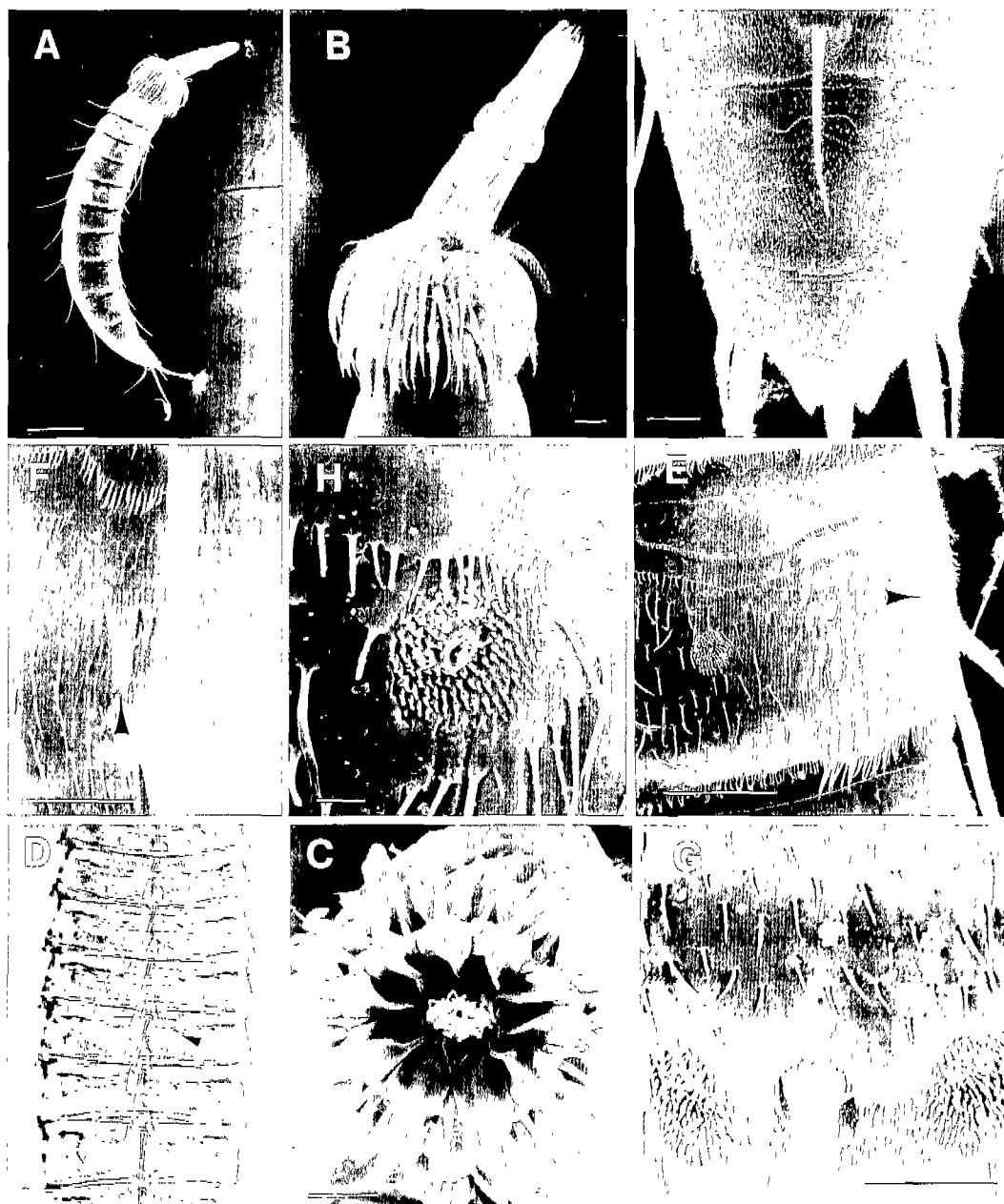


Fig. 2. *Campyloderes macquariae* Johnston. A, habitus, lateral; B, oral stylet and scapulae; C, scapulae, frontal; D, sternal plates of segments 4-10 (arrow indicating a sensory spot); E, left ventral plate of segment 7 (arrow indicating a lateral tube); F, lateral tube on segment 5 (arrow) and part of LS3; G, paired cuticular spots beside dorsal spine; H, sensory spot and cuticular hairs on ventral plate of segment 6; I, segments 11-13, dorsal (a variant). Scale bars = 1 μm (H), 5 μm (F, G), 10 μm (B, C, E, I), 50 μm (A, D).

with paired sensory spots (Fig. 2D): 2 pairs on both tergal and sternal plates of segments 4–11, 1 tergal pair and 2 sternal pairs on segment 12, and 2 tergal pairs and 1 sternal pair on segment 13; each spot having a centered pore densely surrounded with minute spinules (Fig. 2H).

Lateral spines present near tergal-sternal junctions of segments 4–13, except for segment 7 having an additional lateral accessory spine anteromedially; lateral spines of segment 12 relatively short and slender, situated rather dorsolaterally. Sieve plate situated at posteroventral edge of tergal plate of segment 11, just ahead of lateral spine.

Segment 13 pentagonal shaped, tapering posteriorly with blunt tip; distal portion of tergal plate protruding posteriorly, deeply incised by midterminal spine, passing over round posterior margin of sternal plate; posterolateral margin of tergal plate incised by lateral terminal spine, so sternal plate a little extending laterally beyond tergal plate (Fig. 1D).

Lateral terminal spine (LTS) rather short, ranging 98.9–130.9 μm ($112.5 \pm 10.6 \mu\text{m}$, $N = 16$), about one third of trunk length ($\text{LTS}/\text{TL} = 0.33 \pm 0.04$, $N = 16$); midterminal spine (MTS) stout and much shorter, ranging 42.6–57.4 μm ($49.6 \pm 4.9 \mu\text{m}$, $N = 17$), a little less than a half of LTS; LTS with ‘irregularities’ (usually as 2 craters) of inner cavity anterolaterally near base (Fig. 1D).

Penile spines unknown, so no sex-discriminating characters noticed in outward appearances. Juveniles or pre-adults were not found among Korean samples.

Measurements and Variability. Meristic data on *C. macquariae* from South Korea are shown in Table 1. Measurements well agree in general with those of Antarctic specimens (Johnston, 1938) as well as with those of New Caledonian specimens (Higgins, 1967) and English specimens (Moore, 1973). Lateral spines of segment 3 are relatively short (the ratio to trunk length is 0.27 ± 0.03), nearly or not reaching the end of segment 6 in 13 of 14 specimens examined), while exceeding the posterior end of segment 7 in Higgins’ or Moore’s. Lateral terminal spines in Korean specimens also tend to be a little short (about one third of trunk length), against about 43–45% in Johnston’s, or about a half in Higgins’, while quite coincided in length with Moore’s.

According to the original description (Johnston, 1938), *Campyloderes macquariae* has dorsal spines on segments 3–13. However, in nine (32%) of 28 fully grown adults from South Korea examined by us, dorsal spines on segments 12 and 13 were absent (Fig. 2I). Moreover, they did not possess the lateral spine of segment 12, either. Johnston (1938) also mentioned the deficiency of the lateral spines of segment 12 in part of his specimens, and he thought that it was an sexual character, although later refuted by Higgins (1967). It appears that the variations in Korean population are not related with sex or localities.

Some specimens showed the variability in the number of sensory spots: 4 of 21 specimens possessed 3 pairs each on sternal plates of segments 7–9, and a few specimens had 1–2 additional spots on tergal plates of segments 5, 7–8.

Remarks. Three species are currently recognized in the genus *Campyloderes*: *C. vanhoeffeni* Zelinka, 1913, *C. macquariae* Johnston, 1938, and *C. adherens* Nyholm, 1947.

Campyloderes macquariae is evidently discernible from *C. adherens* which has rather huge body (nearly 600 μm long, against around 300 μm long in *C. macquariae*) and strikingly longer median terminal spine than lateral terminal spine. *Campyloderes macquariae* much resembles *C. vanhoeffeni* in having shorter median terminal spine. However, it is clearly discriminated from *C. vanhoeffeni* by the arrangement of head scalds (10–20–10–10–14–12 scalds in progressive order

from first row to sixth row, while 10-20-10-10-20-10 in *C. vanhoeffeni*), the shape of terminal tergal extension, and short lateral spine on segment 12 (even lacking in some Korean variants) as well as by the shape of lateroterminal spine. Emphasized as a good, consistent, diagnostic characteristic of *C. macquariae* by Moore (1973), the "irregularities of the inner cavity" of the lateral terminal spine were also found in nearly all Korean specimens (evidently shown in 18 of 21 specimens examined).

Besides some variants mentioned above, Korean specimens are fitted well with the original description, except a minor discrepancy of the relatively short lateral terminal spine, as already alleged in 'Measurements and Variability' section. Korean specimens are much coincided with English specimens (Moore, 1973), except the relatively shorter lateral spine of segment 3 only.

Paired cuticular spots flanking all middorsal spines except that of segment 13 were noted in the original description as "two small...elliptical...highly refracting depressions" (Johnston, 1938: 11), and confirmed in Moore's redescription. Our specimens consistently have the cuticular spots lacking a centered pore and filled with numerous spinules only as in Fig. 2G. The "verdünnte Stellen im Hautskelett" were first mentioned by Zelinka (1913) with the apparent expression in his illustration of Fig. 39-1, when he described *C. vanhoeffeni*. Considering the facts above, the cuticular spots might be a typical character of the genus *Campyloderes*, and supposedly shared by all the congeners, although they cannot be confirmed in *C. adherens*, for the description by Nyholm (1947) was prepared so insufficiently and inadequately without any succeeding reports on it thereafter.

Minute cuticular processes adjacent to lateral spines on segments 5-13 were examined by SEM study (Fig. 2F), which were not well represented in original description and Moore's redescription, or figured as simple spinules in Higgins (1967). A terminal pore shown at the end of the process suggests that it is supposedly related with an adhesive appendage.

Campyloderes macquariae was reported from the under surface of stones just below low tide mark (Johnston, 1938), coral detritus in 18 m depth (Higgins, 1967), and holdfasts of sublittoral kelp (Moore, 1973). Korean specimens were collected from the subtidal (12-28 m deep) muddy sediments containing lots of shell harshes, or by rinsing the holdfasts of sublittoral macroalgae (mostly sea trumpets, *Ecklonia cava* of brown algae) around Marado I. (the southernmost island of Korea; 33° 07' 01" N, 126° 16' 44" E) and two rocky islets (Peomseom I. and Munseom I.; 33° 13' 29" N, 126° 34' 14" E) off Seogwipo, Jeju Island. Some specimens were obtained from the washings of various benthic invertebrates, mainly hermit crabs (*Pagurus ochotensis*) and bristly tunicates (*Halocynthia* sp.), collected by fishing nets (gill nets casted in the coastal waters, 30-50 m deep) at the small ports (37° 56' 37" N, 128° 47' 17" E) near Gangreung located in the middle of the east coast of the Korean Peninsula.

Distribution. Macquarie I. (southwest of New Zealand), New-Caledonia, England, South Korea.

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REFERENCES

- Adrianov, A. V., 1989. The first report on Kinorhyncha of the Sea of Japan. *Zool. Zhur.*, **68**: 17-27.
- Adrianov, A. V. and V. V. Malakhov, 1999. Cephalorhyncha of the world ocean. KMK Scientific Press Ltd., Moscow, pp. 1-328.
- Higgins, R. P., 1967. The Kinorhyncha of New Caledonia. In: Expedition Française sur les Récifs Coralliens de la Nouvelle-Calédonie, **2**: 75-90.
- Higgins, R. P., 1983. The Atlantic barrier reef ecosystem at Carrie Bow Cay, Belize. II, Kinorhyncha. *Smithson. Contr. Mar. Sci.*, **18**: 1-132.
- Higgins, R. P., 1988. Kinorhyncha. In: Introduction to the Meiofauna (Eds. R. P. Higgins and H. Thiel). pp. 328-331. Smithsonian Institution Press, Washington, D.C.
- Higgins, R. P. and Y. Shirayama, 1990. Dracoderidae, a new family of the cyclorhagid Kinorhyncha from the inland sea of Japan. *Zoological Science*, **7**: 939-946.
- Johnston, T. H., 1938. Report on the Echinoderida. *Sci. Repts. Australasian Antarctic Expedition (1911-1914)*, **10**(1): 1-13.
- Moore, P. G., 1973. *Campyloderes macquariae* Johnston, 1938 (Kinorhyncha: Cyclorhagida) from the Northern Hemisphere. *J. Nat. Hist.*, **7**: 341-354.
- Nyholm, K.-G., 1947. *Campyloderes*-an "Antarctic" genus of *Echinoderida* off the west coast of Sweden. *Ark. Zool.*, **39A**(13): 1-36.
- Pardos, F., R. P. Higgins and J. Benito, 1998. Two new *Echinoderes* (Kinorhyncha, Cyclorhagida) from Spain, including a reevaluation of kinorhynch taxonomic characters. *Zool. Anz.*, **237**: 195-208
- Shirayama, Y., T. Kaku and R. P. Higgins, 1993. Double-slided microscopic observation of meiofauna using an HS-slide. *Benthos Research*, **44**: 41-44.
- Sudzuki, M., 1976a. Microscopical marine animals scarcely known from Japan. I. Micro- & meiofauna around Kasado Island in the Seto inland sea of Japan. *Proc. Japan. Soc. Syst. Zool.*, **12**: 5-12.
- Sudzuki, M., 1976b. Recent portraits of wild biota in Japan. II. The inland sea of Japan around Kasado Island, Yamaguchi Prefecture. *Obun Ronso*, **7**: 11-32.
- Tokioka, T., 1949. Notes on *Echinoderes* found in Japan. *Publ. Seto Mar. Biol. Lab.*, **1**: 67-69.
- Zelinka, C., 1913. Die Echinoderen der Deutschen Südpolar Expedition 1901-1903. *Deutsche Südpolar-Expedition*, **14**(Zoologie 6): 419-436.

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북태평양에서 처음으로 보고하는 *Campyloderes macquariae* Johnston
(등문동물문, Cyclorhagida목, Centroderidae과)

송 영 희 · 장 천 영
(대구대학교 자연과학대학 생물학과)

요 약

제주도와 강릉 일대 해안에서 채집한 등문류 1종, *Campyloderes macquariae* Johnston을 재기재하여 보고한다. 표본은 조하대의 저질, 해조류의 근경부, 그리고 어망에 걸려 나온 여러가지 무척추동물을 행군 뒤 플랑크톤 넷트에 걸려 채집하였다. *Campyloderes*속은 북태평양 해역에서는 최초로 기록된다. 근연종간 형질 비교와 종내 변이를 고찰하였으며, 일부 형질은 주사전자현미경을 사용하여 그 미세구조를 확인하였다.