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Four New Records of Grenadiers (Macrouridae, Gadiformes, Teleostei) from Korea

Seong-Yong Kim, Tomio Iwamoto*[1] *and Mamoru Yabe*

Laboratory of Marine Biology and Biodiversity (Systematic Ichthyology), Graduate School of Fisheries Sciences, Hokkaido University, 3-1-1 Minato-cho, Hakodate Hokkaido 041-8611, Japan
[1]Hokkaido University Museum, 3-1-1 Minato-cho, Hakodate, and California Academy of Sciences, 55 Concourse Drive, San Francisco, CA 94118 USA

ABSTRACT A taxonomic study of the family Macrouridae was conducted using fish collections deposited in the Department of Biology, Chonbuk National University, Chonju, Korea and the East Sea Fisheries Research Institute, Korea. Among these collections were specimens of four species belonging to the genera *Coryphaenoides* and *Coelorinchus*: *Coryphaenoides marginatus, C. microps, Coelorinchus (Abyssicola) macrochir*, and *C. formosanus*. These specimens represent the first records of the species from Korean waters and from the East Sea (Japan Sea). Only four species (*Coelorinchus longissimus, C. multispinulosus, C. japonicus*, and *C. parallelus*) had previously been recorded from the East Sea. The Korean names "Keun-nun-gin-ga-si-min-te" (for *Coryphaenoides marginatus*), "Jak-eun-nun-gin-ga-si-min-te" (for *C. microps*), "Gin-pal-kko-ri-min-te" (for *Coelorinchus macrochir*), and "Ta-i-wan-kko-ri-min-te" (for *Coelorinchus formosanus*) are herein given to these species.

Key words : *Coryphaenoides marginatus*, *C. microps*, *Coelorinchus* (*Abyssicola*) *macrochir*, *Coelorinchus formosanus*, Macrouridae, grenadiers, Korea, East Sea

INTRODUCTION

Fishes of the family Macrouridae (grenadiers, also called rattails) represent a large family composed of about 400 species in 30 or more genera, occurring in all oceans from tropical to high-latitude waters of the Arctic and Antarctic oceans (Iwamoto, 2008), although their greatest diversity lies in tropical and subtropical seas. They are primarily benthopelagic in life, and typically occupy depths of 200～2,000 m (Nelson, 2006), although a few live at depths exceeding 4,000 m. There have been numerous systematic studies of the family Macrouridae (Okamura, 1970; Marshall and Cohen, 1973; Iwamoto and Stein, 1974; Iwamoto, 1989; Cohen *et al.*, 1990), but this group has attracted little attention in Korea. Mori (1952) was the first to record a macrourid fish from Korea, *Coelorinchus japonicus* Temminck and Schlegel, 1842 from Pohang near the southeastern tip of the Korean Peninsula and within the East Sea. Chyung and Kim (1959) recorded *C. multispinulosus* Katayama, 1942 and *C. longissimus* Matsubara, 1943 from Pusan in the Korea Strait at the southern end of the East Sea. Katoh *et al.* (1956:331, after Yanai, 1950 [references not seen]) recorded *C. parallelus* (Günther, 1877) from the East Sea off the southwestern coast of the island of Honshu, Japan. The family Macrouridae was reported with a provisional key from Korea (Kim *et al.*, 2005).

In the course of investigating coastal fish collections from Korea, we recognized specimens of four macrourid species of the genera *Coryphaenoides* and *Coelorinchus* that represent new records for Korea. In this paper, we record these species and provide a key to the species of the family Macrouridae in Korea, along with their distributions.

Measurements and counts were made according to Iwamoto (1978): measurements were made to the nearest 0.1 mm with dial calipers. Radiographs by soft x-ray were used in counting the number of vertebrae. Fish specimens examined are deposited in the fish collections of the Department of Biology, Chonbuk National University, Chonju (CNUC) and are from the bottom trawl surveys of the East Sea Fisheries Research Institute, Korea (Fig. 1A, B). They were compared with specimens exa-

*Corresponding author: Seong-Yong Kim Tel: 81-138-40-5538, Fax: 81-138-40-5538, E-mail: kimsy@fish.hokudai.ac.jp

mined in the Hokkaido University Museum (HUMZ); National Science Museum, Tokyo (NSMT); Research Center for Biodiversity, Academia Sinica, Taipei (ASIZ); National Museum of Natural History, Washington DC (USNM); California Academy of Sciences, San Francisco (CAS); and Institute of Marine Sciences, University of the Philippines, Manila (UPIMS). The classification used follows that of Iwamoto *in* Cohen *et al.* (1990).

TAXONOMIC ACCOUNTS

Family Macrouridae
Genus *Coryphaenoides* Gunnerus, 1765
(New Korean genus name: Gin-ga-si-min-tae-sok)

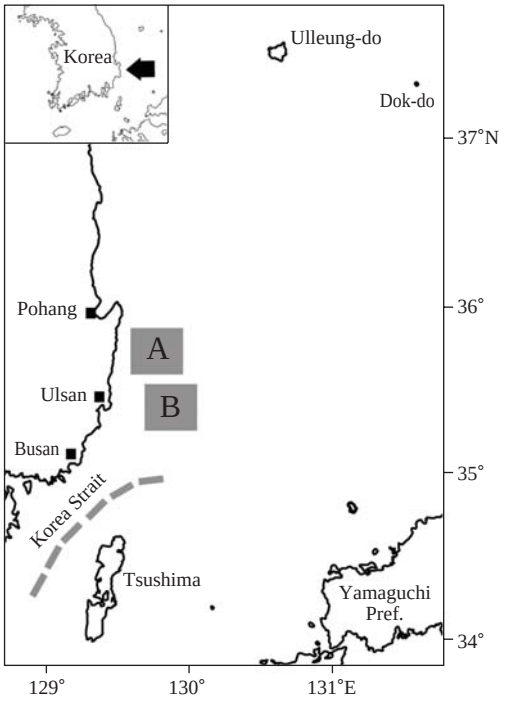

Fig. 1. Map of region around East Sea of Korea with collection localities plotted as square (A: off Gampo-eup, B: off Ulsan).

1. *Coryphaenoides marginatus* Steindachner and Döderlein, 1887

(Fig. 2; Table 2)

(New Korean name: Keun-nun-gin-ga-si-min-tae)

Coryphaenoides marginatus Steindachner and Döderlein, 1887: 284 (holotype in Natural History Museum, Vienna; from Tokyo, Japan); Jordan and Gilbert, 1904: 609; Jordan, Tanaka and Snyder, 1913: 415, fig. 387 (listed); Gilbert and Hubbs, 1916: 164-166 (43 spec., East China Sea and Suruga Gulf [Pacific coast], 271 ~ 805 m); Okamura, 1970: 136-140, pl. 30, text-fig. 54-55 (43 specimens, southern Japan and East China Sea, 250 ~ 790 m).

Coryphaenoides awae Jordan and Gilbert, 1904: 608-609, fig. (holotype CAS-SU 8547; off Tokyo Bay, Japan); Gilbert and Hubbs, 1916: 166-167 (measurements of holotype); Okamura, 1970: 139-140 (synonymized *C. awae* with *C. marginatus*).

Specimens examined. CNUC 36808 (40.0 HL, 207 mm TL); off Gampo-eup, Gyeongju-si, Gyeongsangbuk-do, Korea; 35°53′584″N, 129°38′337″E; 115 m depth (Fig. 1); temp. surface 13.4°C, bottom 2.6°C; 21 March 2006. HUMZ 170850 (35.2 mm HL, 200 mm TL); Tashi,Taiwan; May 2000. HUMZ 195630 (65.5 mm HL, 385 mm TL); Numazu fish market, Shizuoka-Prefecture, Japan; 27 Nov. 2005. NSMT P124479 (56.8 mm HL, 335 mm TL); Suruga Bay, Japan. NSMT P6859 (63.8 mm HL, 362+ mm TL); Suruga Bay, Japan; 34° 57.1′N, 131°41.8′E, 320 ~ 600 m. NSMT P46099 (4 of 11; 37.3 ~ 53.6 mm HL, 204+ ~ 280+ mm TL); Suruga Bay, Japan, 34°59.6′N, 138°44.7′E, 310 ~ 680 m. NSMT P11247 (40.2 mm HL, 222 mm TL); Suruga Bay, Japan, 1 April 1967.

Diagnosis. This species is distinguished from other members of the genus in the western North Pacific by the combination of pelvic-ray count (7 ~ 8, usually 8); greatly prolonged serrated spinous first-dorsal fin ray measuring about 1.5 ~ 2.5 of HL (serrations become reduced in size and number in larger individuals); body scales deciduous, densely covered with short spinules

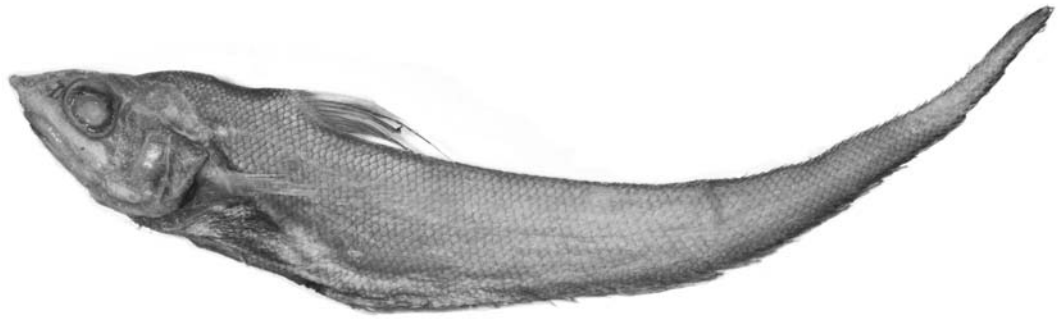

Fig. 2. *Coryphaenoides marginatus* Steindachner and Döderlein, 1887, CNUC 36808 (207 mm TL), from the East Sea, Gampo-eup, Gyeongju-si, Gyeongsangbuk-do, Korea.

arranged in numerous, slightly convergent rows in adults; preopercle broadly rounded, its posterior margin nearly vertical, the preopercle ridge nearly vertical and rounded at its ventral angle; a large, stout terminal snout scute; small, subinferior mouth, upper jaw 28～34% HL, posterior end of the maxilla reaches to below anterior one-third to one-half of orbit; rictus (mouth slit), however, falls well short of that, snout relatively short and narrow, protruding in front of mouth a distance less than, or slightly more than, diameter of pupil (more protruding in young); orbit 26～33% HL; internasal and interorbital narrow, 16～19% and 17～21% HL, respectively.

Description. Counts and measurements are given in Table 1. Body rather high, strongly compressed posteriorly. Head small, laterally compressed, greatest width about equal to postorbital length. Infraorbital ridge prominent, nearly extending backward to vertical from posterior margin of orbit. Mouth small, its rictus restricted posteriorly by lip folds, extending only to below nostrils. Teeth small, conical, in broad bands on both jaws, slightly enlarged on outer premaxillary series. Lateral line distinct, rising in a low curve anteriorly, and running parallel to, but above, mid-axis of body side posteriorly. Scales hexangular, moderate in size, rather deciduous; small scales covering head except for naked underside of snout, nakedness extending backward to along lower margin of suborbital region, narrow area surrounding nostrils, and gular and branchiostegal membranes and axillary fossa. Dorsal fin originating posterior to base of pectoral and of pelvic fins; anal fin inserted posterior to vent. Pectoral fin about as long as postorbital part of head. Pelvic fin inserted between pectoral and first dorsal.

Coloration in alcohol. Tawny and brown body, dorsal surface of head light brown, and ventral surface of head pale. Upper part of suspensorium gray to blackish, breast and belly silvery. Branchial cavities blackish gray; branchiostegal membranes becoming darker toward posterior margin; oral lining and gill arches whitish.

Comparisons with other species. The only two Japanese species of *Coryphaenoides* with which *C. marginatus* is likely to be mistaken are *C. microps* and *C. nasutus*. *Coryphaenoides microps* is distributed primarily from the East China Sea to the Philippines; it can be distinguished from *C. marginatus* by its smaller orbit, broader interorbital, and longer spinous ray of first dorsal fin (Table 2 and Fig. 2). *Coryphaenoides nasutus* has a broad distribution, ranging from the northern island of Hokkaido south along the Pacific coast of Japan to the East China Sea and Taiwan, to the South China Sea and the Philippines. It differs from *C. marginatus* in having predominantly 9 pelvic-fin rays (although four smaller specimens --HUMZ 149933-149935, 149937-- had 8 each), decidedly convergent spinule rows on body scales, a broader snout (width between nasal ridges 20～25% HL vs. 16～18%), a broader interorbital (21～24% HL vs. 17～21%), less compressed and deep body, tail not as sharply tapered ventrally to a knife-edge in cross-section, and shorter spinous ray of first dorsal fin (about 75～125% HL, vs. about 122～187%).

Distribution. Known from southern Japan, East China Sea, South China Sea off Taiwan, Philippines (Okamura, 1970; Cohen *et al.*, 1990), and Korea (off Gampo-eup, Gyeongju-si, Gyeongsangbuk-do [Fig. 1A]; present study)

Remarks. The single CNUC specimen is relatively well preserved although most body scales are lost. The specimen represents a small immature individual that is far from maximum size, judging from the largest of Okamura's (1970) specimens, which was 550 mm TL, and the 620 mm holotype of *C. awae* Jordan and Gilbert, 1904, a species Okamura (1970: 136) synonymized with *C. marginatus*. The second spinous ray of the first dorsal fin was approximately equal to the length of the head and not the 1.5 to more than 2.0 times HL that according to Okamura (1970: 138) is characteristic of the species. However, there was some obvious early developmental damage to the ray, which presumably affected the final length. The almost complete absence of body scales (deciduous scales appears to be characteristic for this species) preclude making a firm judgment on the morphology and arrangement of scale spinules. A few 'half scales' remaining (along the mesial-dorsal line anteriorly on the tail) had short, reclined spinules arranged in parallel rows, not the convergent rows found in *C. marginatus*. We suggest that the spinules on full-sized scales become arranged in rows that are more convergent in larger individuals.

Coryphaenoides marginatus is apparently a common species in Suruga Bay and the East China Sea (Gilbert and Hubbs, 1916: 164; Okamura 1970: 140). Yatou (in Okamura *et al.* 1984) has recorded it from the Okinawa Trough in the East China Sea, a region that appears to be an area of overlap between *C. microps* and *C. marginatus*. An in-depth study of the two species and also *C. semiscaber* Gilbert and Hubbs, 1920 is warranted, as there remain some questions in our minds concerning characters that can be used to distinguish the three species and the distributional boundaries of each.

2. *Coryphaenoides microps* (Smith and Radcliffe, 1912)

(Figs. 3, 4; Tables 1, 2)

(New Korean name: Jak-eun-nun-gin-ga-si-min-tae)

Macrourus microps Smith and Radcliffe in Radcliffe, 1912:116-117, pl 25, fig. 2 (holotype USNM 72933, 43 cm; east coast Luzon, Philippines; 13°37′30″N, 123° 41′09″E, 560 fm [1,024 m]; Albatross st. 5470).

Coryphaenoides microps: Gilbert and Hubbs, 1920: 418-

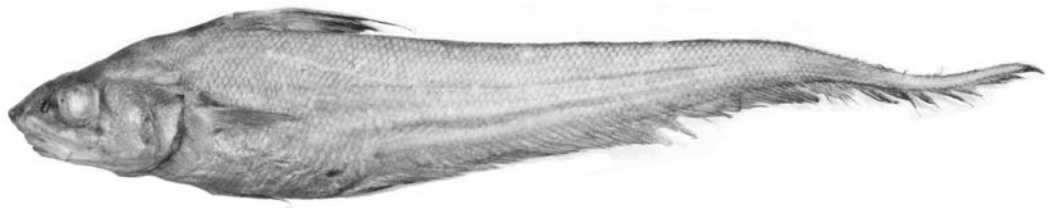

Fig. 3. *Coryphaenoides microps* (Smith and Radcliffe, 1912), CNUC 36807 (305mm TL), from the East Sea, Gampo-eup, Gyeongju-si, Gyeongsangbuk-do, Korea.

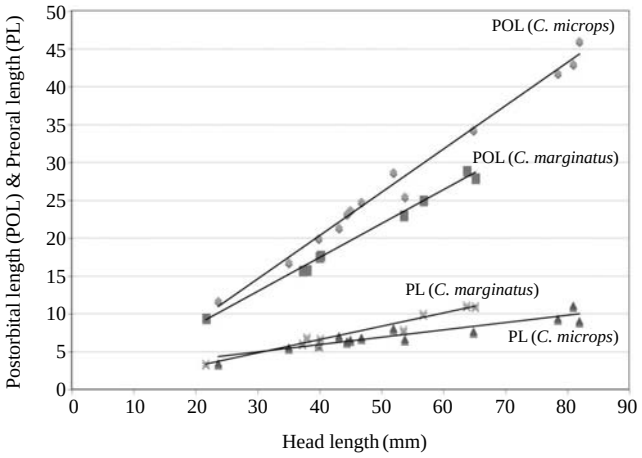

Fig. 4. Scatter diagram comparing measurements of the postorbital length and preoral length of *Coryphaenoides marginatus* and *C. microps*.

419; Schcherbachev and Iwamoto, 1995: 300-301.

Specimen examined. CNUC 36807 (53.8 mm HL, 305 mm TL); off Gampo-eup, Gyeongju-si, Gyeongsangbuk-do, Korea; 35°53′584″N, 129°38′337″E; 115 m depth (Fig. 1); temp. surface 13.4°C, bottom 2.6°C; 21 March 2006. Holotype: USNM 72933 (82.0 mm HL, 413+ mm TL); Philippines, 13° 37′30″N, 123° 41′09″E, 560 fm [1,024 m], Albatross st. 5470. Paratypes: CAS-SU 2446 (2: 23.7～39.9 mm HL, 124+～187+ mm TL); off northern Luzon, Philippines, 18° 34′15″N, 121° 51′15″ E; 224 fm [410 m], 15 Nov. 1908. HUMZ 170850 (35.1 mm HL, 211 mm TL); Tashi, Taiwan. ASIZ P66786 (64.9 mm HL) and P63792 (78.5 mm HL, 367+ mm TL); Taiwan. UPIMS (81 mm HL, 380 mm TL); Philippines, MUSORSTOM II (no other data). UPIMS (5: 43.2～52.0 mm HL); Philippines, 13° 31.6′N, 120° 33′E, 326～240 m, MUSORSTOM II, St. 79, 1 Dec. 1980. CAS 224171 (35.3 mm HL, 190+ mm TL) and CAS 224172 (81.6 mm HL, 395+ mm TL); Tashi, Taiwan, 18 May 2005.

Diagnosis. Pelvic-fin rays 7～8; greatly prolonged serrated spinous first-dorsal-fin ray measuring about 1.8 to almost 3 times HL (serrations reduced in size and number in larger individuals); body scales deciduous, densely covered with short spinules arranged in numerous, subparallel rows; preopercle broadly rounded, its posterior margin nearly vertical, preopercle ridge nearly vertical and rounded at its ventral angle; a large, stout terminal snout scute; small, subinferior mouth, upper jaw 30～32% HL, maxilla extending posteriorly to below anterior quarter of orbit; snout relatively short and narrow, protruding in front of mouth a distance less than, or slightly more than, diameter of pupil (more protruding in young), preoral length 11～16% HL; orbit small 17～25% HL; internasal and interorbital narrow, 15～21% and 18～26%, respectively.

Description. The species is so closely similar in morphology to *C. marginatus* that the description of that species can be used for *C. microps* with the exception of the few character differences enumerated in the diagnosis, Table 1, and Fig. 2.

Coloration in alcohol. Tawny and warm-brown body, dorsal surface of head light warm-brown, and ventral surface of head whitish. Upper part of suspensorium gray to blackish, breast and belly pale. Fins dark brown. Branchial cavities dark gray; branchiostegal membranes becoming darker toward posterior margin.

Distribution. Known from South China Sea off Taiwan (Chiou *et al.*, 2004, Philippines (Gilbert and Hubbs, 1920: 418-419; Shcherbachev and Iwamoto, 1995: 300-301), and East China Sea and East Sea off Korea (off Gampo-eup, Gyeongju-si, Gyeongsangbuk-do [Fig. 1A]; present study).

Remarks. The presence of a second, closely similar species of *Coryphaenoides* in the CNUC collections came as a bit of a surprise. We had initially identified CNUC 36087 as *C. marginatus*, thinking it the same as CNUC 36088, although we were aware of its smaller orbit. It was not until we examined other specimens of *C. marginatus* and *C. microps* and compared various proportional measurements that we realized the error. Three proportional measurements in combination distinguish the two species (Table 1): *Coryphaenoides microps* has a smaller orbit, 17～23% HL [25% as an outlier] compared with 25～33% in *C. marginatus*, longer orbit-to-preopercle distance, 40～46% HL cf. 33～39%, and somewhat longer postorbital length 47～56% HL cf. 42

Table 1. Comparison of orbit diameter, postorbital length, preoral length, and orbit to preopercle Length in two species of *Coryphaenoides*

	Orbit diameter (% HL)																		
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	$\bar{x}$	SD
C. marginatus	–	–	–	–	–	–	–	–	1	–	1	2	2	1	1	–	1	28.89	2.3154
C. microps	1	1	1	2	3	4	1	–	1	–	–	–	–	–	–	–	–	21.07	2.0517
	Postorbital length (% HL)																		
	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56			$\bar{x}$	SD
C. marginatus	2	2	4	1	–	–	–	–	–	–	–	–	–	–	–			43.44	1.0138
C. microps	–	–	–	–	–	2	1	1	2	–	1	5	–	1	2			51.67	3.0158
	Orbit to preopercle length (% HL)																		
	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47			$\bar{x}$	SD
C. marginatus	2	–	–	2	1	1	3	–	–	–	–	–	–	–	–			36.67	2.3979
C. microps	–	–	–	–	–	–	–	2	1	–	2	2	2	3	2			41.13	2.4008

Fig. 5. *Coelorinchus macrochir* Günther, 1877, CNUC 37699 (204.9 mm TL), from the East Sea, Ulsan, Gyeongsangnam-do, Korea.

~48%. The low value (47% HL) for postorbital length of CNUC 36807 brings it closer to the trendline of *C. marginatus* in the scatter diagram Fig. 6. The preoral length is somewhat shorter in *C. microps*, 11~16% cf. 14~18% (usually 16~18%), but there is overlap (see also scatter diagram Fig. 6.+3) and CNUC 36808 actually falls within the trendline of *C. microps*. The length of the second spinous ray of the first dorsal fin has been considered somewhat distinguishing, but there is considerable overlap in this character also: (106%) 179~293% in *C. microps*, (85%) 122-215% in *C. marginatus*, based on our examined specimens.

Genus *Coelorinchus* Giorna, 1803
(New Korean genus name: Kko-ri-min-tae-sok)

3. *Coelorinchus* (*Abyssicola*) *macrochir* (Günther, 1877)

(Fig. 5; Table 2)
(New Korean name: Gin-pal-kko-ri-min-tae)

Macrurus macrochir Günther, 1877: 438, Enoshima, Kanagawa Pref. (original description). Günther, 1887: 148.

Abyssicola macrochir Goode and Bean, 1895: 417; Jordan and Snyder, 1900: 376; Jordan and Starks 1902 (1904): 607; Franz, 1910: 26; Gilbert and Hubbs, 1916: 183; Gilbert and Hubbs, 1920: 425; Kamohara, 1938: 71; 1952: 98; Masuda *et al.*, 1984: 96; Okamura and Kitajima, 1984: 221; Nakabo, 2002: 429; Shinohara *et al.*, 2005: 416.

Caelorinchus macrochir Shinohara *et al.*, 1996: 169; Shinohara *et al.*, 2001: 305.

Coelorinchus macrochir Cohen *et al.*, 1990: 171; Balanov, 2003: 565.

Specimens examined. CNUC 37699 (44.8 mm HL, 204.9 mm TL): off Ulsan, Gyeongsangnam-do, Korea; 35°16′921″N, 129°50′003″E; 158 m depth (Fig. 1); temp. surface 14.5°C, bottom 4.2°C; 25 March 2006. HUMZ 134999 (37.8 HL, 185.6 TL), HUMZ 135000 (40.7 HL, 198.4 TL), HUMZ 135001 (45.2 HL, 223.2 TL), HUMZ 135002 (43.1 HL, 205.6 TL): off Miyagi Prefecture, Japan; 17 Oct. 1994. HUMZ 135060 (38.8 HL, 193.2 TL), HUMZ 135061 (30.4 HL, 150.5 TL), HUMZ 135062 (36.9 HL, 179.9 TL): off Ibaraki Prefecture, Japan; 25 Oct. 1994.

Diagnosis. *Coelorinchus* (*Abyssicola*) *macrochir* is distinguished from other members of the genus *Coelorinchus* in the western North Pacific by its relatively blunt snout tip; large mouth, upper jaw decidedly longer than 1/3 length of head and extending to below posterior end of orbit; weak infraorbital ridge, strongly curved ante-

Table 2. Comparison of counts and measurements between the Korean, Japan, and Taiwan specimens the of Macrouridae species

	Coryphaenoide marginatus (n=9)	*C. microps* (n=15)	*Coelorinchus macrochir* (n=8)	*C. formasanus* (n=2)
Counts				
1st dorsal fin rays	II, 9~10	II, 8~10	II, 9~11	II, 8~9
Pectoral fin rays	I, 17~22	I, 18~21	I, 16	I, 16
Pelvic fin rays	7~8	7~8	7	7
Gill-rakers	2+8~10	1~2+7~9	2+9~10	1~2+8
TL mm / HL mm	204~385/ 21.7~65.2	124~395/ 23.7~81.6	150.5~198.4/ 30.4~57.9	154~165.9/ 38.1~44.5
Measurements (in HL)				
Snout length	29 (25~32)	30 (25~33)	31 (34~48)	42 (39~44)
Preoral length	16 (15~18)	14 (11~16)	28 (22~36)	32 (30~35)
Internasal width	17 (16~18)	18 (15~21)	30 (28~33)	27 (26~28)
Interorbital width	20 (17~21)	22 (18~27)	35 (32~37)	30 (27~32)
Orbit diameter	29 (25~33)	21 (17~25)	31 (27~33)	28 (27~28)
Suborbital width	12 (10~13)	13 (11~15)	12 (12~14)	13 (12~13)
Postorbital length	44 (42~45)	52 (47~56)	38 (36~40)	36 (34~40)
Orbit to preopercle	37 (33~39)	44 (40~47)	68 (65~70)	63 (61~65)
Upper jaw	30 (28~33)	31 (30~32)	35 (33~37)	31 (26~37)
Length barbel	11 (9~13)	10 (5~14)	9 (6~12)	19 (19~19)
Length 1st gill Slit	7 (5~15)	7 (6~8)	17 (14~19)	19 (17~21)
Preanal length	167 (155~175)	163 (162~190)	143 (108~152)	151 (150~152)
Pelvic to anal origin Length	52 (43~64)	59 (43~68)	42 (39~50)	57 (55~59)
Isth. to anal origin Length	94 (85~104)	99 (83~113)	74 (65~86)	85 (80~90)
Body depth (great)	81 (78~85)	80 (69~97)	66 (61~75)	67 (65~68)
Body depth (at Anal)	71 (60~76)	74 (67~90)	58 (51~68)	53 (49~56)
1D-2D interspace	28 (14~49)	21 (15~38)	42 (38~47)	42 (41~43)
Height 1D	145 (85~187)	236 (106~388)	49 (34~61)	42 (41~43)

riorly; suborbital region almost vertical; head relatively compressed, or at least not depressed anteriorly, higher than wide at middle of length; premaxillary teeth in roughly three series, mandibular teeth in two series.

Description. Counts and measurements are given in Table 1. Body moderately high and compressed. Head moderately long, compressed. Snout high, subconic, about as wide as deep above anterior end of premaxillary, and moderately projection beyond mouth. Orbit slightly oval, usually less than interorbital width. Mouth inferior, moderate in size; upper jaw much longer than 1/3 length of head, extending backward to below posterior rim of orbit. Teeth conical, triserial on upper jaw, biserial on lower jaw. Barbel slender. Lateral line distinct, continuous, very slowly ascending anteriorly with a long curve. Scales rather deciduous, covered with short, broad spinules, in 4~9 widely divergent rows; scales cover most of head except for gular and branchiostegal membranes, groove behind anterolateral margin of snout, and along posterior portion of occipital and postorbital ridges. Dorsal fin originating above middle of pectoral-fin base, second spine not serrated, nor filamentous. Anal fin inserted below end of first dorsal fin. Pectoral fin oblong, longer than length between outer pelvic fin and anal-fin origin.

Coloration in alcohol. Brownish or dusky-brown head and body. Upper part of suspensorium, breast and belly blackish; branchial cavities blackish but with hyoid area and posterior margin whitish.

Distribution. Known from Japan (Okinawa Trough, Pacific coast southward from Hokkaido), East China Sea (off Kagoshima Prefecture), Sea of Okhotsk (Balanov, 2003), and Korea (off Ulsan, Gyeongsangnam-do [Fig. 1B]; present study).

Comparisons with other species. *Coelorinchus macrochir* differs markedly from all other members of the genus in North Pacific waters. It is readily distinguished from *C. longissimus*, *C. multispinulosus*, *C. formosanus* and other members of the species group (recognized by some as subgenus *Quincuncia*) by its blunter, shorter snout and the absence of an elongated light organ (in subgenus *Quincuncia* fossa behind isthmus connected by long midventral dark stripe to second fossa immediately before vent). Two other congeners recorded from the East Sea, *C. parallelus* and *C. japonicus*, differ from *C. macrochir* in each having a long, stoutly armored, sharply pointed snout, and adherent scales with strong spinules arranged in sharp, high, keel-like rows.

Remarks. The CNUC 37699 specimen is relatively well preserved although most body scales are lost. The specimens we examined represent small to mid-sized immature adults that are far from maximum size, judging from the largest of Okamura's (1970) specimens, which was 680 mm TL. The CNUC specimen is the

Fig. 6. *Coelorinchus formosanus* Okamura, 1963, CNUC 37698 (165.9 mm TL), from the East Sea, Ulsan, Gyeongsangnam-do, Korea.

first record of *C. macrochir* from the East Sea. The discovery of *C. macrochir* in the southern part of the East Sea is somewhat anomalous in that the normal depth range of the species is 235 to 785 m (*fide* Okamura 1970: 148), but the maximal sill depth at the Korea Strait is only 150 m. The distribution of the species is somewhat unusual for a grenadier in ranging from southern Japan and the East China Sea, into the East Sea off the Korean coast, and northward along the Pacific coast of Japan to Hokkaido and into the southwestern Sea of Okhotsk (Balanov, 2003). That the only record of *C. macrochir* from the East Sea is of a single immature juvenile suggests that the species may as juveniles or larvae occasionally surmount the shallow sills of the basin, but those individuals do not fully develop to establish reproductive populations.

4. *Coelorinchus formosanus* Okamura, 1963

(Fig. 6; Table 2)

(New Korean name: Ta-i-wan-kko-ri-min-tae)

Coelorinchus formosanus Okamura, 1963: 37 (holotype: FAKU 35856; from Ta-shi, Taiwan); Masuda *et al.*, 1984: 97 (compiled); Iwamoto *in* Cohen *et al.*, 1990: 158 (compiled); Nakabo 2000: 430 (compiled); Randal and Lim, 2000: 595 (listed); Nakabo, 2002: 430 (compiled); Shinohara *et al.*, 2005: 416 (list).

Coelorinchus intermedius Chu and Lo, 1963: 173 (holotype in SFI. paratypes: SFI (5); from north of East China Sea, China). Okamura, 1963 (synonymized *C. intermedius* with *C. formosanus*).

Coelorinchus abbreviatus Chu and Lo, 1963: 174 (holotype in SFI. paratypes; SFI (3); from north of East China Sea, China); Okamura, 1963 (synonymized *C. intermedius* with *C. formasanus*).

Specimens examined. CNUC 37697 (38.1 mm HL, 154.07 mm TL); CNUC 37698 (44.5 mm HL, 165.9 mm TL): off Ulsan, Gyeongsangnam-do, Korea; 35°16′921″ N, 129°50′003″E; 158 m depth (Fig. 1); temp. surface 14.5°C , bottom 4.2°C; 25 March 2006.

Distinguishing features of the species. *Coelorinchus formosanus* can be distinguished from other members of the genus in the East China Sea and southern Japan (Okinawa) by its light organ very long; anus just in front of anal fin; snout long (43 to 45% of head length); large naked region on dorsal surface of snout; underside of head covered with scales both on tip of snout and behind mouth.

Description. Counts and measurements are given in Table 1. Body slender and compressed. Head slightly compressed. Snout long, sharply produced. Median and lateral processes of nasal bone not united. Body scales with spinules arranged in roughly divergent rows. Orbit oblong. Mouth small, wholly contained on underside of head. Teeth small, conical on both jaws. Lateral line distinct, with a long and low curve anteriorly. Scales on body widely hexangular, not deciduous, with short but sharp triangular spinules. Dorsal fin originating above pectoral base, the second spine not filamentous; anal fin inserted immediately behind vent; pectoral fin about as long as distance between posterior end of head and middle of pupil; outer pelvic ray slightly filamentous, but the tip far remote from vent.

Coloration in alcohol. Body light brown, with irregular and indefinite grayish markings dorsally and silvery reflections ventrally. Dorsal surface of head pale tawny; ventral surface paler. Upper part of suspensorium and belly grayish. Branchial cavities gray; branchiostegal membranes dusky, becoming whitish along posterior margin.

Distribution. Known from the East China Sea, off southern Japan (Okamura, 1970; Cohen *et al.*, 1990), Taiwan, and Korea (Fig. 1B).

Remarks. Although the CNUC specimens are rather poorly preserved and most body scales are lost, they are confidently assignable to *C. formosanus* based on comparison with other HUMZ specimens and the excellent, detailed descriptions by Okamura (1963, 1970). The specimens represent small to mid-sized immature adults that are far from maximum size, judging from the largest of Okamura's (1970) specimens, which was 250 mm TL. Although the species has been known from the East China Sea and off southern Japan since originally described, these specimens from off the Ulsan coast, Gyeongsangnam-do, of Korea represent the first record of the species from Korea and the East Sea.

DISCUSSION

The East Sea is a large, deep basin, much of which exceeds 2,000 m depth. It forms almost the entire eastern boundary of the Korean Peninsula, extending northward along the Maritime Province of Russia to the tip

of Sakhalin Island at a latitude higher than 50˚N. On the entire eastern side of the sea are two of the major islands of Japan, Honshu and Hokkaido. Shallow sill depths (deepest in the Korea Strait at 140 m) restrict the ingress of deepwater benthic fishes from the East China Sea in the south, from the Pacific Ocean at the Tsugaru Strait between Honshu and Hokkaido, and in the far north, from the Okhotsk Sea at the Soya (La Pérouse) Strait between Hokkaido and Sakhalin Peninsula, and the narrow strait between Sakhalin and the mainland. Warm northward-flowing waters from a branch of the Kuroshio Current enter the basin from the south through the Korea Strait and travel mostly along the coast of Japan, while cold waters from the Okhotsk Sea and the Oyashio Current of the North Pacific flow into the basin through the northern straits. Much of the deep bottom and intermediate water masses in the basin are formed in place during the cold winter months.

The East Sea is a biologically unique and productive body of water that supports major fisheries of warm-water and cold-water species of fish and invertebrates. There are impressive numbers of species of invertebrates and vertebrates (including 1,130 fish species [Kafanov *et al.*, 2000] numerous pinnepids, and a few whale species) found in the basin, many of which appear seasonally, with their presence at any given locality, and the timing of their occurrences, determined in large part by their ability to tolerate waters of varying temperatures and salinities. The absence of a truly deep-water benthopelagic fishes is not surprising owing to the shallow sill depths, which apparently prevent transit of most such individuals into the basin from rich adjacent waters. Many shallow-water fishes and invertebrates, however, make the passage through the straits at various life stages and are able to proliferate, at least as temporary if not permanent residents. The absence of an archaic deep-water fauna can be explained by its history: during Pleistocene times, what is now a deep basin was once a shallow sea or lake, and there apparently is no evidence of a previous deepwater connection with the Pacific or the two adjacent seas.

Nishimura (1965, 1966, 1968, 1969, 1982), in a brilliant series of papers on the zoogeography of the East Sea, has provided an exceptionally clear picture of the physical and biological dynamics occurring within this unique body of water. In discussing the deep-water fishes that penetrate into the sea from the East China Sea, he hypothesizes that they are likely transported there as epipelagic larva and settle down onto the broad continental shelf in the San'in District off the southwestern coast of Honshu and "occasionally even reproduce there, since the bottom water covering the shelf of this region is warm enough even in midwinter...to permit these subtropical species to do so" (Nishimura 1969: 117). They are unlikely to survive in more northerly regions, however, because of the narrow shelf north of Wakasa Bay and its close proximity to deep cold waters. Nishimura concluded that the East Sea acts "as a dead end" to the majority of these deep-water tropical and subtropical invaders, because even if adults survive and propagate in the southern parts of the sea, their pelagic eggs and larvae will be driven northward by prevailing currents, where they will perish when they settle to the bottom in the cold deep waters of the north.

Only four species of the diverse deep-water fish family Macrouridae had previously been recorded from the East Sea: *Coelorinchus multispinulosus* Katayama, 1942, *C. japonicus* (Temminck and Schlegel), *C. longissimus* Matsubara, 1943, and *C. parallelus* (Günther). *Coelorinchus multispinulosus* is a widely distributed grenadier known from southern Japan to northeastern Taiwan and into the East China Sea off Japan. It is one of the shallowest-living of all grenadiers in the North Pacific, frequenting depths from 50 m to around 350 m. It appears to be an exception to Nishimura's concept of the East Sea acting as a dead-end to subtropical species, as substantial and widespread populations are found along the southeastern margins of the sea (Yamada *et al.*, 2007). The abundant population of the species in shallow (50～335 m) waters off Jeju Island (Yamada *et al.* 2007: 312) near the mouth of the Korea Strait can provide a vast pool of recruits that use the Kuroshio Current to invade the East Sea.

Coelorinchus japonicus is widespread in tropic to subtropic waters of the Indo-Western Pacific and confined off Japan to southern waters from Kanagawa Prefecture to Nagasaki, to the Okinawa Trough, and apparently in the East Sea. Mori (1952: 72) recorded the species off Pohang on the southeastern coast of the Korean Peninsula and later (Mori 1956: 10) off the north coast of Hyogo Prefecture on the southwestern coast of Honshu, Japan, along with *C. multispinulosus*. Okamura (1970: 186) questioned Mori's 1952 record of *C. japonicus*, without explaining why, although the absence of specimens to confirm the identification may have been the reason. Lindberg and Legesa (1965: 257-258) reported *Coelorinchus parallelus* (Günther, 1877) as occurring in the East Sea off the San'in district and the Oki Islands off Japan, based on Katoh *et al.* (1956; after Yanai, 1950 [neither reference seen]). Okamura (1970) and subsequent Japanese workers seem to have ignored that record from the East Sea (perhaps, as with *C. japonicus*, because of the absence of known voucher specimens). The species is widely distributed and recorded from southern Japan, the East China Sea, the Philippines, Australia and New Zealand, and possibly the Indian Ocean; it inhabits depths of 630 to 990 m. We have been unable to locate specimens that would validate the presence of *C. japonicus* and *C. parallelus* in the East Sea, and so must consider their occurrence there as questionable.

The substantially deeper depth range of these two species, as compared with *Coelorinchus multispinulosus*, *C. formosanus*, *C. longissimus*, and *C. macrochir* cast doubt on their ability to surmount the shallow sill depths at the southern end of the East Sea.

The depth ranges of *Coryphaenoides microps* (about 300～1,024 m), *C. marginatus* (227～1,062 m, most commonly below about 300～400 m), and *Coelorinchus macrochir* (235～785 m) are considerably greater than those of *C. multispinulosus*, *C. formosanus*, and *C. longissimus*. *Coryphaenoides marginatus* and *Coelorinchus macrochir* also have a much broader distribution off Japan than those species (Hokkaido to the East China Sea, and *C. macrochir* has been recorded also from the southeastern Okhotsk Sea) (Balanov, 2003). One might speculate how these deeper-living species were able to breach the formidable barrier of the shallow Korea and Tsushima straits and whether there is a viable population of the species in the East Sea, or are they simply expatriates representing a dead-end population. That the specimens of *Coryphaenoides marginatus*, *C. microps*, and *Coelorinchus macrochir* here recorded are juveniles, far from their maximum adult size, may suggest that they represent only strays into the sea and that they may have gained access as pelagic eggs or larvae. The capture of a large adult (550 mm TL) of *Coelorinchus macrochir* from the Okhotsk Sea suggests another avenue of entry for that species into the East Sea: via the La Pérouse Strait between Hokkaido and Sakhalin. The thermal tolerance of *C. macrochir* is rather remarkable; in the southern portions of its distribution, Okamura (1970: 148) reports temperatures of 5～10°C in the depths (235～785 m) frequented by the species, whereas bottom temperatures of less than 1°C to about 4.5°C are the norm in the Okhotsk Sea (Orlov and Tokranov, 2008: 236). It is apparent that much remains to be learned about the grenadiers of this unique body of water.

Key to genera and species of family Macrouridae from Korea

1a. Upper jaw falls short of reaching below posterior 1/3 of orbits; rakers present on lateral side of first gill arch; spinous ray of first dorsal fin greatly elongated, with a serrated leading edge ····· 2
1b. Upper jaw extends to posterior 1/3 of orbits or beyond; rakers absent on lateral side of first gill arch; spinous ray of first dorsal fin not prolonged, length ＜HL, with smooth leading edge ····· 3
2a. Spinous ray of first dorsal fin about 1.2～1.9 times HL; preoral length 15～18% HL, orbit diameter 26～33%, postorbital length 42～45; length orbit to preopercle 33～39% ····· *Coryphaenoides marginatus*
2b. Spinous ray of first dorsal fin about 1.8～2.9 times HL; preoral length 11～16% HL, orbit diameter 17～25%, postorbital length 47～56%, length orbit to preopercle 40～47% ····· *Coryphaenoides microps*
3a. Vent far removed from anal fin, about midway between pelvic-fin bases and anal fin origin ····· *Coelorinchus macrochir*
3b. Vent immediately before or close to anal fin origin ····· 4
4a. Light organ short, confined to immediately before vent and lacking anterior fossa (dermal window) on chest; small naked regions on dorsal surface of snout; spinules on scales strong ····· 5
4b. Light organ long, an anterior fossa on chest connected by a dark stripe to light organ in front of vent; large naked regions on dorsal surface of snout; spinules on scales minute ····· 6
5a. Spinules on scales in parallel to subparallel keel-like rows, the middle row distinctly enlarged; median and lateral processes of nasal bone not united ····· *Coelorinchus parallelus*
5b. Spinules on scales in widely divergent keel-like rows, the middle row not especially enlarged; median and lateral processes of nasal bone united along anterolateral snout margin ····· *Coelorinchus japonicus*
6a. Underside of head with broad margin of scales below anterior end of snout and on preopercle behind mouth ····· *Coelorinchus formosanus*
6b. Underside of head with scales on tip and anterolateral margin of snout, but otherwise naked ····· 7
7a. Dark markings on body indistinct; nasal fossa scaly along posteroventral margin; upper jaw length about equal to orbit diameter ····· *Coelorinchus longissimus*
7b. Vermiculated dark markings on body distinct; nasal fossa entirely naked; upper jaw length longer than orbit diameter ····· *Coelorinchus multispinulosus*

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한국산 민태과 Grenadiers (대구목) 어류 4 미기록종

김성용 · Tomio Iwamoto[1] *· Mamoru Yabe*

Graduate School of Fisheries Sciences, Hokkaido University, Japan.
[1]Hokkaido University Museum, Japan and California Academy of Sciences, San Francisco, USA

요 약 : 한국 동해안에서 채집된 민태과 어류 표본을 검토한 과정에서 *Coryphaenoides* (속명신칭: 긴가시민태속)에 포함되는 2종 *Coryphaenoides marginatus* (국명신칭: 큰눈긴가시민태), *C. microps* (국명신칭: 작은눈긴가시민태)과 *Coelorinchus* (속명신칭: 꼬리민태속)에 속하는 2종 *Coelorinchus macrochir* (국명신칭: 긴팔꼬리민태), *C. formosanus* (국명신칭: 타이완꼬리민태)은 한국미기록종으로 확인되어 사진과 함께 재기재하고 한국 동해안에 분포하는 민태과 (Macrouridae) 2속 8종의 속 및 종검색표를 제시하였으며 지리적 분포에 대하여 기록하였다.

찾아보기 낱말 : Macrouridae, 민태과, 긴가시민태속, 꼬리민태속, 한국미기록종