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Coreoperca maruoi, a new species of freshwater percoid fish from the Miocene of Iki Island, Nagasaki, Japan

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ABSTRACT — A percoid fish from the Middle Miocene freshwater beds of Iki Island, Nagasaki, Japan is described as a new species, †*Coreoperca maruoi* of the family Sinipercidae. It is characterized by having a large head, 13 abdominal and 18 caudal vertebrae, 13 dorsal fin spines and 13 soft rays, 3 anal fin spines and 9 soft rays, the wide fifth hypural exhibiting a groove near the ventral margin. Based on fossil records, it is proposed that the ancestor of sinipercids arose in the shallow seas of eastern Asia before Miocene or in the Early Miocene.

KEY WORDS: *Coreoperca maruoi*, Chojabaru Formation, Iki Group, Middle Miocene, new species, Sinipercidae.

INTRODUCTION

Fish fossils from Iki Island in Nagasaki Prefecture are representatives of the Miocene freshwater fishes in Japan. The fossils have been found in diatomite beds of the Early to Middle Miocene Chojabaru Formation in the Iki Group. These consisted of 8 or 9 species of cyprinids, two species of sinipercids, one bagrid, two gobiids, and one mastacemberid (Hayashi, 1975). Jordan (1919) described *Iquius nipponicus* as the first fossil fish to have been given a scientific name from Japan and placed it provisionally in the herring family Clupeidae, though he recognized some resemblances to cyprinids. Thereafter it has been placed in the family Cyprinidae (Tomoda, et al., 1973; Hayashi, 1975). Watanabe and Uyeno (1999) described a bagrid fish, *Pseudobagrus ikiensis*.

In the present study, a new fossil percoid fish belonging to the genus *Coreoperca* of the family Sinipercidae is described from Iki Island, and the origin of this family is discussed. All Recent species of the family Sinipercidae are distributed in East Asian freshwaters, and fossil species have been described from Japan and China. Extant and fossil members of the genera *Siniperca* and *Coreoperca* listed in the table 1 of Yabumoto and Uyeno (2000) as well as †*C. fushimiensis* and †*C. kaniensis* are compared with the holotype of †*C. maruoi* sp. nov.

SYSTEMATIC PALEONTOLOGY

Infraclass Neopterygii REGAN, 1923

Order Perciformes BLEEKER, 1859
Family Sinipercidae ROBERTS, 1993
Genus *Coreoperca* Temminck and SCHLEGEL, 1843
†***Coreoperca maruoi*** sp. nov.
(New Japanese name: Iki-mukashi-oyanirami)

Diagnosis: This species differs from other fossil and Recent congeners by the following combination of characters: large head (standard length about 2.7 times length between snout and cleithrum); 13 abdominal and 18 caudal vertebrae; 13 dorsal fin spines and 13 soft rays; 3 anal fin spines and 9 soft rays; serrated ventral margin of preopercle; and wide fifth hypural having a groove near ventral margin.

Etymology: The species name honors Mr. Toshiteru Maruo, who collected and donated the holotype.

Horizon: The specimen was discovered from the rock belonging to the Middle Miocene Chojabaru Formation (15.3 Ma: personal comment from Kimura in Watanabe and Uyeno, 1999) in the Iki Group. Diatomite at Hachiman, Ashibe, Iki Island Nagasaki Prefecture, Japan.

Holotype: KMNH (Kitakyushu Museum of Natural History and Human History) VP 100,261. 96.9 mm SL, an almost complete specimen missing the posterior part of the caudal fin.

Description: Body depth moderate; head large (Figs. 1, 2). Standard length about 2.8 times body depth (34.7 mm) and 2.7 times head length (36.0 mm). Dorsal and ventral profiles of body moderately convex.

Length of cranium about 2.7 times its depth at posterior

Fig. 1. †*Coreoperca maruoi* sp. nov., holotype, KMNH VP 100,261 from Chojabaru, Iki Island, Nagasaki, Japan. SL 96.9mm. A, part; B, counterpart. Scale bar equals 20 mm.

margin of orbit. Length of ethmoid region about half of otic and occipital regions. Eye large. Anterior margin of mesethmoid moderately convex. Outline from frontal to mesethmoid smooth (Fig. 3). Most of prevomer covered by palatine with only lateral portion exposed. Sensory canal (neurocranial lateral line) running inside, not forming a tube on dorsal roof of frontal. A large opening facing medially at middle of frontal, and another opening facing antero-laterally at distal edge in middle of anterior half of the bone. Mesethmoid with slightly convex antero-dorsal margin articulating with frontal. Nasal with its anterior portion widened (Fig. 3). Anterior portion of parasphenoid almost straight, gradually widening anteriorly, and behind parasphenoid wing, located at level of posterior end of orbital, narrowest part of bone. At this point, bone slightly curved dorsally. Dorsal surface of anterior portion of parasphenoid forming a groove. Parietals separated by supraoccipital. Supraoccipital crest moderately developed. Lateral edges well developed on both sides of supraoccipital. Exoccipital disarticulated, but showing articulation facet for atlas. Other otic bones disarticulated and not distinct (Fig. 3).

Dentary with a band of small conical teeth; truncated at anterior end and forked at posterior portion. Coronoid wing about half of ventral wing in depth. Dentary recess small. Mandible sensory canal with three oblong foramina; posterior-most one longest, the others as half as the posterior-most one. Angular high. Primordial process steep; primordial ridge well developed. Mandible sensory canal foramen located at posterior end of angular. Retroarticular round at posterior end.

Premaxilla with a tooth band of small conical teeth, similar size as those of dentary. Postmaxillary process wide and deep. Anterior end of right premaxilla missing. Middle of right maxilla missing. Posterior portion of maxilla deep. Supramaxilla attaching to dorsal margin of posterior portion of maxilla.

Quadrate triangular and condyle for articulation with angular small. Symplectic inserting under quadrate. Little space present between symplectic and hyomandibular. Width of symplectic

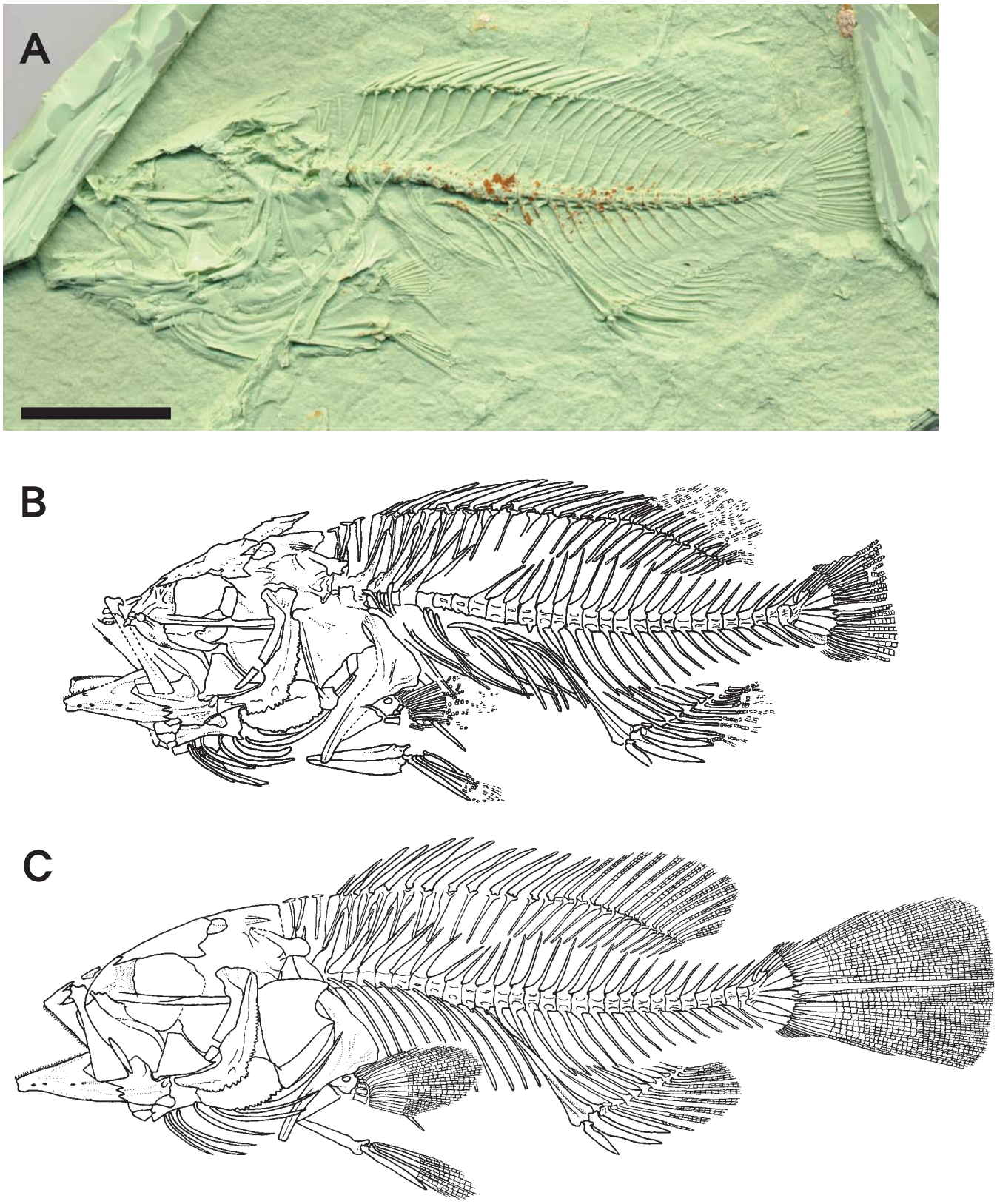

Fig. 2. A, latex peel of the holotype, KMNH VP 100,261, †*Coreoperca maruoi* sp. nov. from Chojabaru, Iki Island, Nagasaki, Japan. SL 96.9 mm; B, line drawing of A; C, restoration of †*C. maruoi* sp. nov. Scale bar equals 20 mm.

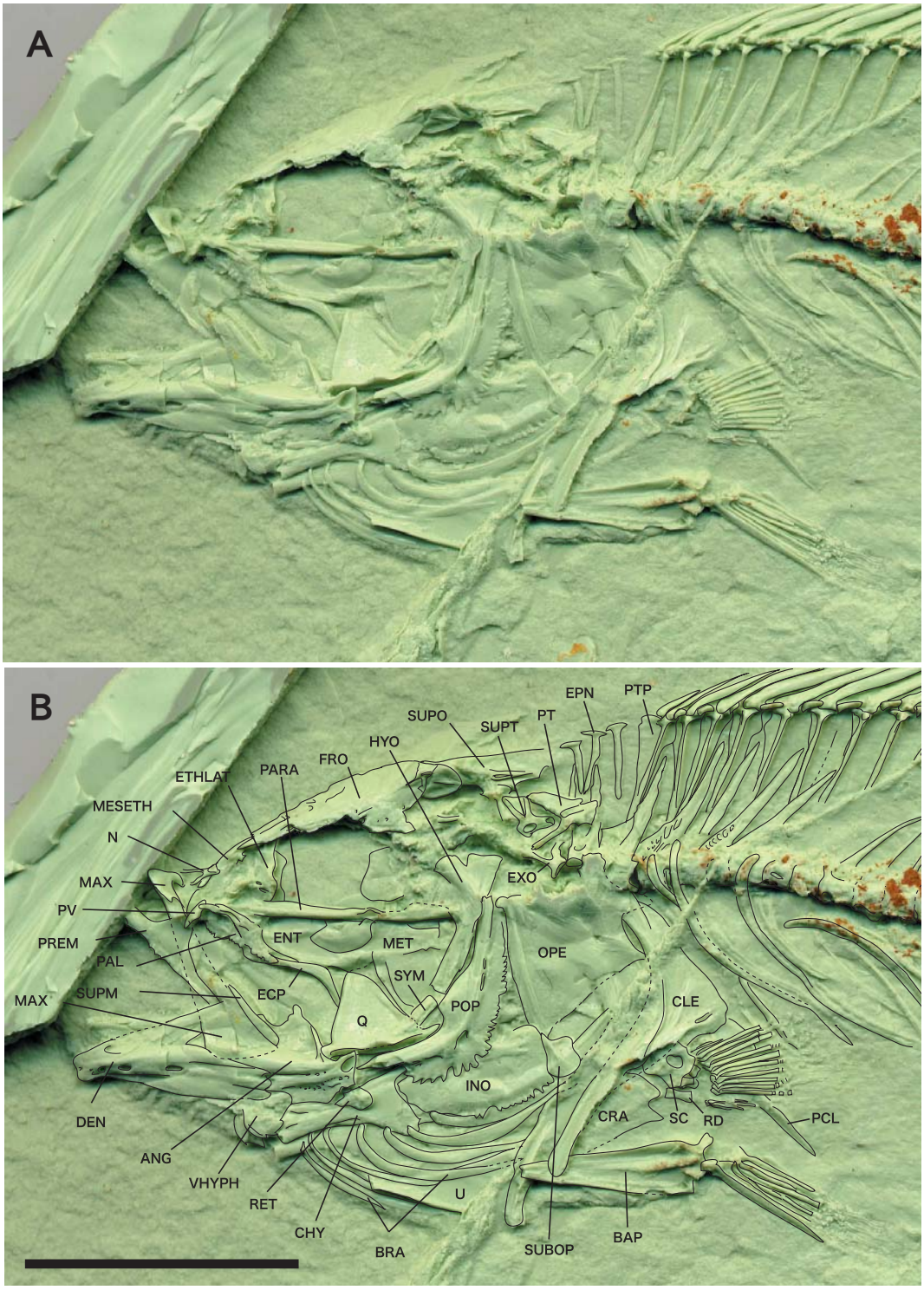

Fig. 3. A, latex peel of the head of the holotype, KMNH VP 100,261, †*Coreoperca maruoi* sp. nov. from Chojabaru, Iki Island, Nagasaki, Japan. SL 96.9mm; B, line drawing of A. ANG, angular; BAP, basipterygium; BRA, branchiostegal; CHY, ceratohyal; CLE, cleithrum; CRA, coracoid; DEN, dentary; ECP, ectopterygoid; ENT, endopterygoid; EPN, epineural; ETHLAT, lateral ethmoid; EXO, exoccipital; FRO, frontal; HYO, hyomandibular; INO, interopercle; MAX, maxilla; MESETH, mesethmoid; MET, metapterygoid; N, nasal; OPE, opercle; PAL, palatine; PARA, parasphenoid; PCL, postcleithrum; POP, preopercle; PREM, premaxilla; PT, posttemporal; PTP, proximal pterygiophore; PV, prevomer; Q, quadrate; RD, radial; RET, retroarticular; SC, scapula; SUBOP, subopercle; SUPM, supramaxilla; SUPO, supraoccipital; SUPT, supratemporal; SYM, symplectic; U, urohyal; VHYPH, ventral hypohyal. Scale bar equals 20 mm.

similar to that of ventral end of hyomandibular. Ectopterygoid thin, crescent-shaped, disarticulated from quadrate and palatine. Palatine with ventral surface bearing teeth and alveoli.

Metapterygoid with horizontal ridge forked posteriorly at upper portion of outer surface. Posterior end of metapterygoid covered by ventral arm of hyomandibular. Smooth-surfaced endopterygoid narrow anteriorly, broad posteriorly. Hyomandibular with long ventral shaft, and forked dorsal, anterior and posterior arms articulating with cranium. Strong posterior ridge of hyomandibular from upper portion to probably middle of ventral arm contacting preopercle.

Anterior and dorsal ends of preopercle missing. Preopercle with serrations on ventral margin, being coarser than those of posterior margin. Small wing present at mid-anterior margin of preopercle. Two large oblong sensory canal openings, one at the corner between arms, the other with two small openings just below it on ventral arm (Fig. 3).

Interopercle with horizontal bulge at upper portion of outer surface: ventral margin with serrations almost same size as those of preopercle dorsal arm. Opercle with two posterior spines: dorsal portion indistinct and broken, ridge along anterior margin splitting in two ventrally.

Ventral hypohyals and ceratohyals of both sides visible. Epihyal being covered by interopercle. Anterior portion of ventral hypohyal with a rounded margin thicker than posterior portion. Depth of ceratohyal gradually narrowing from anterior end to middle portion, then gradually widening toward posterior end. Dorsal margin of ceratohyal covered by angular and retroarticular. No concavities for articulation with branchiostegals visible on ventral margin of ceratohyal. Seven branchiostegals: anterior four articulating on medial side, fifth one on lateral side of ceratohyal, and last two on lateral side of epihyal.

Posttemporal, cleithrum, scapula, coracoid, radials and postcleithrum all preserved. Ventral element of posttemporal a narrow shaft, dorsal one broad, exhibiting several dents on surface. Sensory canal portion of posttemporal forming a very short bony canal at base of dorsal and ventral arms, and shallow groove on posterior portion.

Trifurcate ventral element of supratemporal, in which dorsal canal longest, being preserved between dorsal and ventral arms of posttemporal. Cleithrum with wide posterior wing, and surface ornamented by several grooves at dorsal portion, ridge along anterior margin forming posterior border of gill slit. Shape of scapula and coracoid indistinct: scapula foramen visible at center of bone. Four radials present, and ventral one largest. Pectoral fin rays 16.

Ventral side of left basipterygium (pelvic girdle) exposed: anterior end inserted between cleithra, ridge running along outside margin of bone. Short postpelvic (ischial) process present at posterior inner corner of bone.

Pelvic fin with long spine slightly shorter than basipterygium, and disarticulated from basipterygium with five soft rays (Fig. 3).

Dorsal fin with 13 spines and 13 soft rays: first spine shortest (about half length of second one), second about three quarters of third one. Length of other spines almost same. Soft rays longer than spines, and dorsal margin of soft rays round. Dorsal pterygiophores 25 (Fig. 2). Three supraneurals with T-shaped dorsal ends present: first one shortest and last one longest: first and second ones inserted between first and second neural spines (Fig. 3). Anal fin with three spines and nine soft rays: soft rays longer than spines, first spine being about half length of second and third ones. Anal pterygiophores 11, first and second ones fused.

Disarticulated ribs being difficult to count, probably to be 11 in number (it two fewer than number of abdominal vertebrae in extant species of *Coreoperca*): ventral ends seeming to reach ventral margin of body.

Abdominal vertebrae 13. Caudal vertebrae18. Anteriormost five neural spines with grooves on lateral surface, fourth to sixth longest and inserted between pterygiophores of dorsal fin.

Hypurals five: first and third ones largest, fourth slightly larger than second one, second and third separated by a gape arising about mid-length. Epurals three, third beeing shortest. Caudal fin with 15 branched rays: eight in dorsal lobe, seven in ventral lobe (Fig. 4).

Small, thin cycloid scales covering body (Fig. 5): including cheek, opercle and bases of dorsal and anal fins. Estimated number of scales in longitudinal row about 55.

CONCLUDING REMARKS

The present fossil is identified as a fish belonging to the monophyletic family Sinipercidae (Roberts, 1993 and Shirai et al., 2003) on the basis of the combination of the following characters: 1) 31 vertebrae consisting of 13 abdominal and 18 caudal vertebrae; 2) 13 dorsal fin spines and 13 soft rays; 3) 3 anal fin spines and 9 soft rays; and 4) cycloid scales. The family Sinipercidae consists of two or three extant genera being considered as a monophyletic on the basis of the phylogenetic studies of morphology (Liu and Chen, 1994) and mtDNA (Shirai, et al., 2003), whereas the fossil genus †*Inabaperca* is monotypic (Yabumoto and Uyeno, 2000). The genus *Coreoperca* consists of three fossil and three Recent species, whereas the genus *Siniperca* is composed of one fossil and about ten extant species (or one extant species of the genus *Coreosiniperca* and one fossil and about ten extant species of *Siniperca*) (see Fang and Chong, 1932; Zhou et al., 1988; Liu and Chen, 1994).

The present fossil has the following characters that place it in the genus *Coreoperca*: 1) the dorsal fin spines are short (relatively long in *Siniperca* and †*Inabaperca*); 2) the preopercle has a serrated ventral margin, not spinous (see Chen et al., 1999; Yabumoto and Uyeno, 2000; Zhang et al., 1985); 3) the third to fifth neural spines are not inserted deeply between dorsal

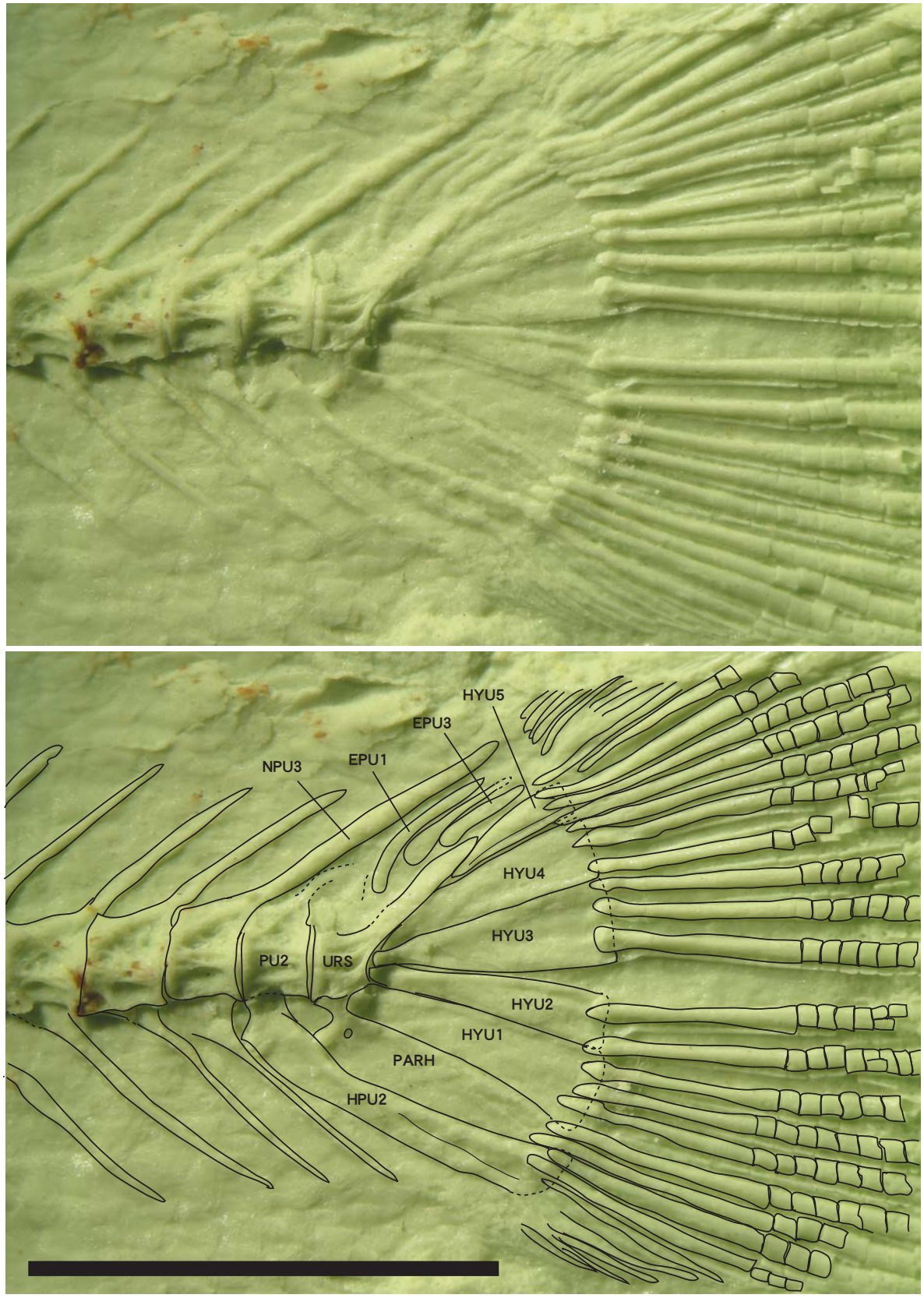

Fig. 4. A, latex peel of the caudal fin and skeleton of the holotype, KMNH VP 100,261, †*Coreoperca maruoi* sp. nov. from Chojabaru, Iki Island, Nagasaki, Japan. SL 96.9 mm. EPU, epural; HPU, haemal spine of preural centrum; HYU, hypural; NPU, neural spine of preural centrum; PARH, parhypural; PU, preural centrum; URS, urostyle. Scale bar equals 10 mm.

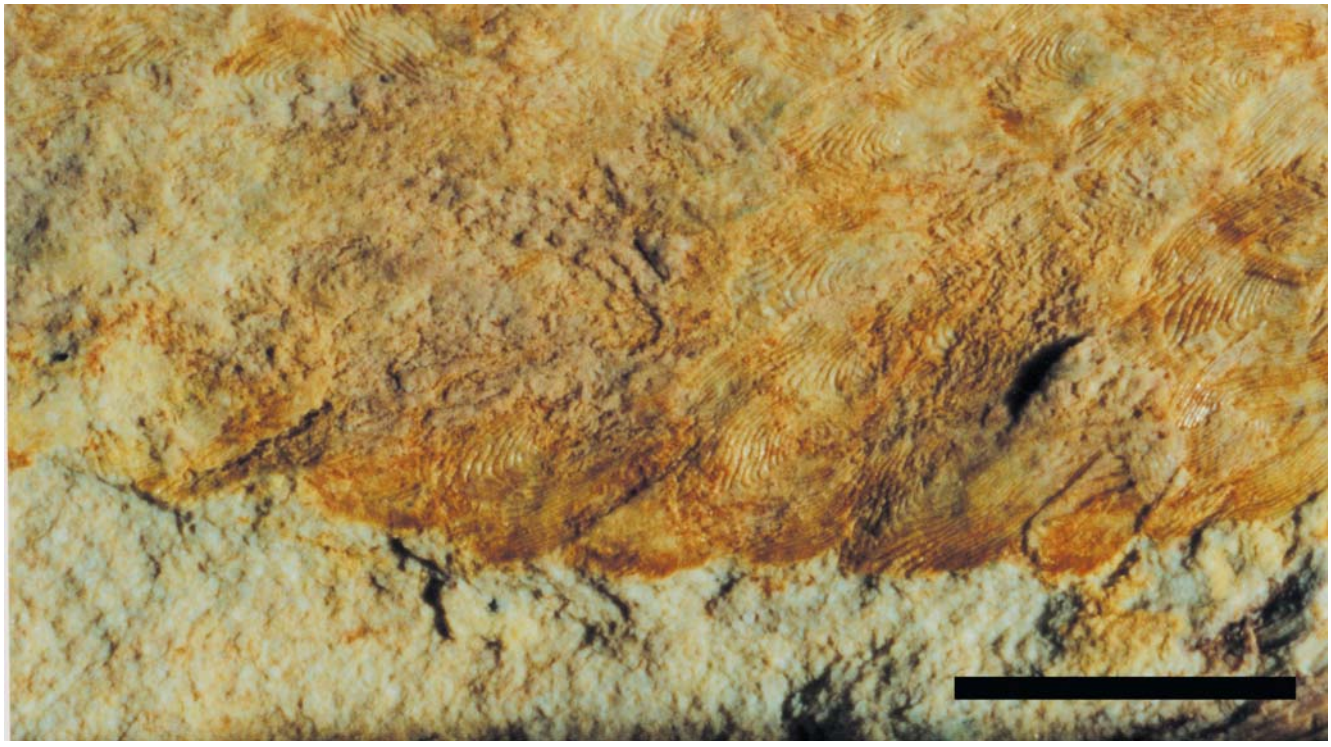

Fig. 5. Scales of the abdominal region behind the pelvic fin of the holotype, KMNH VP 100,261, †*Coreoperca maruoi* sp. nov. from Chojabaru, Iki Island, Nagasaki, Japan. SL 96.6 mm. Scale bar equals 2 mm.

pterygiophores (inserted deeply in *S. chuatsi* and *S. sherzeri*); 4) scales are relatively large (number of scales is about 55, less than 66) (see Chen et al., 1999). The genus *Coreoperca* consists of the following fossil and extant species: †*C. kaniensis* Ohe and Hayata, 1984 and †*C. fushimiensis* Ohe and Ono, 1975 from the Miocene of Kani, Gifu, Japan, †*C. shandongensis* Chen, Liu and Yan, 1999 from the Middle Miocene of Shandong, China; *C. herzi* Herzenstein, 1896 distributed in the Korean Peninsula; *C. kawamebari* (Temminck and Schlegel, 1843) distributed in the southwestern part of Honshu, the northern part of Kyushu, Japan and the southern end of the Korean Peninsula; and *C. whiteheadi* Boulenger, 1900 distributed in Hainan Island and the southwestern and southeastern parts of China.

† *C. maruoi* sp. nov. differs from other congeners by having a large head, a large fifth hypural, different meristic characters and SL/HL proportion as shown in Table 1. †*C. maruoi* sp. nov. has the same dorsal and anal fin ray counts as *C. herzi*, but the ratio of the length between the snout and the cleithrum to the standard length is different (SL/HL 2.7 in †*C. maruoi* vs. 2.8 – 3.3 in *C. herzi*) and the ventral margin of the preopercle of †*C. maruoi* is differently serrated (*C. herzi* consists of four spines) (Fig. 6). This new species differs from *C. kawamebari* in having a larger head (SL/HL 2.7 in †*C. maruoi* vs. 3.9 – 3.3 in *C. kawamebari*). †*C. maruoi* sp. nov. differs from *C. whiteheadi* in having nine anal soft

Table 1. Comparison of vertebrae, dorsal and anal fin ray counts of †*Coreoperca maruoi* sp. nov. and congeners. Dorsal and anal fin counts of extant species are taken from Fang and Chong (1932) and Zhou et al. (1988). The number of vertebrae and the proportion are based on the examination of X-rays of the specimens listed in table 1 of Yabumoto and Uyeno (2000) in this study. HL, length between the snout and the cleithrum.

	D	A	V	SL/HL
†*C. maruoi* sp. nov	XIII, 13	III,9	31(13+18)	2.7
C. kawamebari	XI-XIII, 11-13	III, 8~10	29-30(13+16-17)	2.9 - 3.3
C. herzi	XIII, 13	III, 9	31-32(12-13+18-20)	2.8 - 3.3
C. whiteheadi	XII-XV, 12-16	III, 10-12	33(15+18)	3.0
†*C. shandongensis*	XII, 13	III, 9-10	30(13+17)	2.4
†*C. kaniensis*	XII, 13	III, 9,	28(12+16)	2.8
†*C. fushimiensis*	-	-	(>9+17)	-

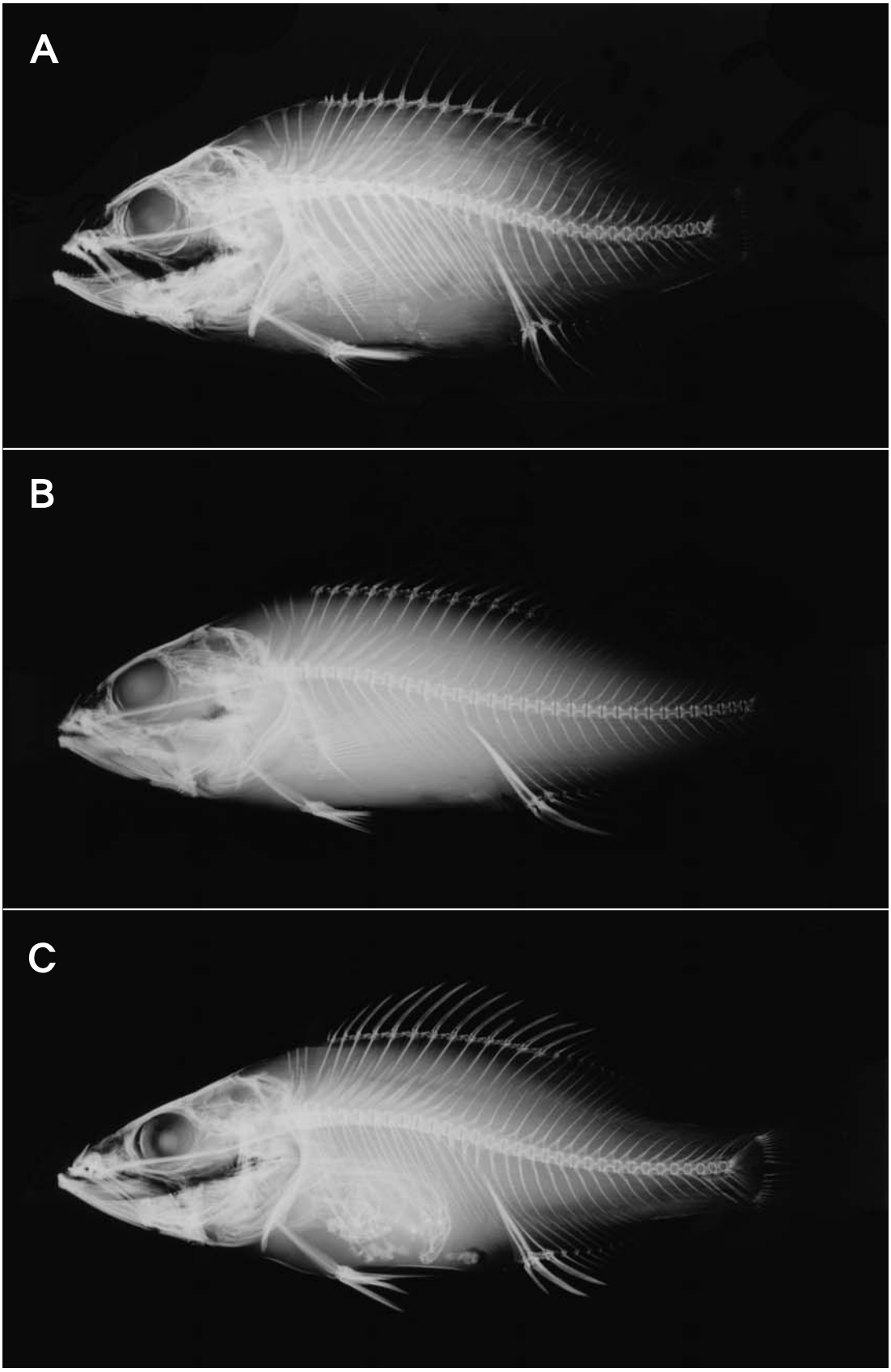

Fig. 6. X-rays of three Recent species of the genus *Coreoperca*. A, *Coreoperca kawamebari*, SL, 76.0 mm; B, *C. herzi*, SL, 101.0 mm; C, *C. whiteheadi*, SL, 79.2 mm.

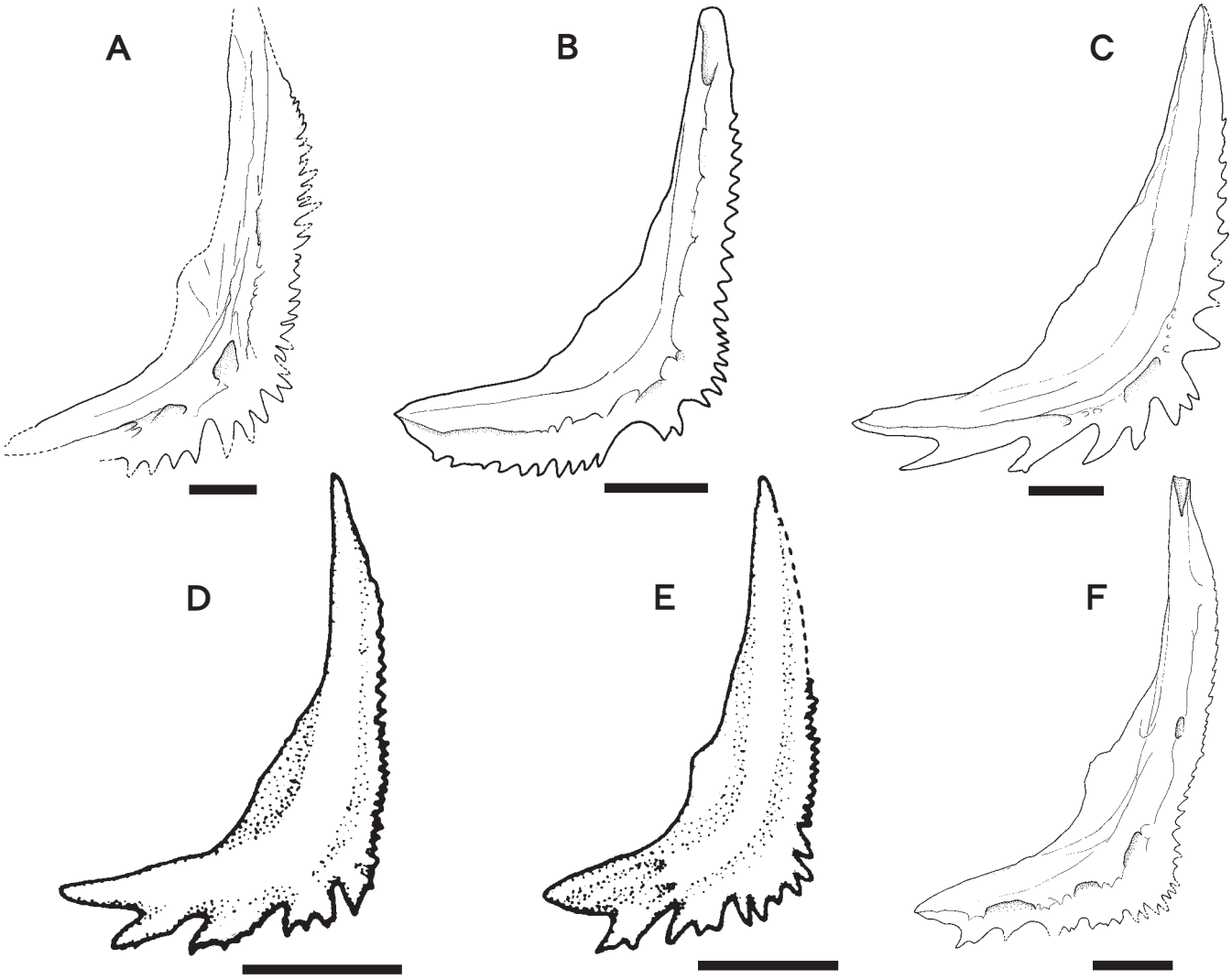

Fig. 7. Preopercles of the genus *Coreoperca*. A, †*Coreoperca maruoi* sp. nov. ; B, *C. kawamebari*; C. *C. herzi*; D and E, †*C. shandongensis* (from Chen et al., 1999); F, *C. whiteheadi*. Scale bars equal 5 mm.

rays (10 – 12 in *C. whiteheadi*), a larger head (SL/HL 2.7 in †*C. maruoi* vs. 3.0 in *C. whiteheadi*) and slightly larger serration of the ventral margin of the preopercle than *C. whiteheadi* (Fig. 6). The present new species differs from †*C. shandongensis* in having 13 dorsal fin spines (12 in †*C. shandongensis*), 31 vertebrae (30 in †*C. shandongensis*), a smaller head (SL/HL 2.7 in †*C. maruoi* vs. 2.4 in †*C. shandongensis*) and the serration of the ventral margin of the preopercle, being weaker than †*C. shandongensis* (Fig. 6). †*C. maruoi* sp. nov. is distinguished from †*C. kaniensis* by having 13 dorsal fin spines (12 in †*C. kaniensis*) and 31 vertebrae (28 in †*C. kaniensis*). It also differs from †*C. fushimiensis* in having 18 caudal vertebrae (17 in †*C. fushimiensis*).

Nishimura (1967) proposed that sinipercid fishes had originated in the East China Sea at the beginning of the Pleistocene, and the speciation had occurred in the Middle to Late Pleistocene, but the following fossil records show clearly that *Coreoperca* and *Siniperca* already had existed in the Early Miocene: †*C. shandongensis* from the late Early Miocene Shangwang Formation in Shandong Province, China (Chen, et al., 1999), †*C. fushimiensis* Ohe and Ono, 1975 and †*C. kaniensis* Ohe and Hayata, 1984 from the Middle Miocene Mizunami Group, and †*C. maruoi* (this study) and *Siniperca* (Hayashi, 1975: the specimen shown at the bottom on pl. 44 is considered to belong to the genus *Siniperca* by having a spinous ventral margin of the preopercle) from the Middle Miocene Chojabaru Formation in Iki Island, Japan.

Ohe (1984) suggested that the counts of the dorsal, anal and pelvic fin rays and the vertebrae, and the marginal caudal fin of species of the genus †*Tungtingichthys* from the Late Eocene to the Early Oligocene in China correspond to those of his hypothesized ancestor of *Coreoperca* and *Stereolepis*. However, †*Tungtingichthys* differs from sinipercids by having ctenoid scales (cycloid scales in sinipercids), one opercular spine (2 in sinipercids), 6 branchiostegal rays (7 in sinipercids) and serrated

ventral margin of lachrymal (smooth in sinipercids) (also see Liu and Chen, 1994; Chang and Liu 1998).

All together, the present study proposes that the ancestor of sinipercids probably arose in the shallow seas of eastern Asia before Miocene or in Early Miocene, because the oldest fossil record of *Coreoperca* is known from the late Early Miocene, the marine sinipercid genus †*Inabaperca* comes from the Middle Miocene Iwami Formation in Tottori, Japan (Yabumoto and Uyeno, 2000), and that sinipercids do not seem to have a close relationship with the Eocene †*Tungtingichthys*.

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