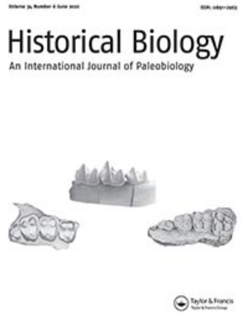

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A new Chinese perch (Perciformes, Sinipercidae) from the early Miocene of South Korea

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ABSTRACT
A new species of Chinese perch (Perciformes, Sinipercidae), †*Coreoperca chosun*, sp. nov., is described based on four specimens (mostly fragmentary and disarticulated) found in the freshwater Lower Miocene Geumgwangdong Formation in the vicinity of Pohang City, South Korea (N35°57′30.5, E129°26′57.3). Such characters of this fossil sinipercid as the serrated ventral margin of the preopercle, the third dorsal-fin spine being shorter than the fourth and fifth spines, the third to fifth neural spines inserted shallowly rather than deeply between the proximal dorsal-fin pterygiophores, the relatively strong supraneurals and relatively large scales indicate its attribution to the genus *Coreoperca*. However, its unique combination of characters clearly distinguishes †*C. chosun*, sp. nov. from both the extinct and extant members of the genus *Coreoperca*. This is the first fossil record of the family Sinipercidae in the Korean Peninsula, one of the earliest representatives of *Coreoperca* known to date, and the first described Neogene freshwater fish from South Korea.

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Sinipercidae; Lower Miocene; †*Coreoperca chosun*; sp. nov; freshwater; South Korea

Introduction

Records of Neogene freshwater fishes in the Korean Peninsula are still extremely scarce. Actually, they are known only from the Geumgwangdong Formation outcropped in the vicinity of Pohang City on the eastern coast of South Korea. To date, the skeletons of as yet undescribed cyprinids were discovered there and deposited in both scientific institutions and in private collections. Recently, four specimens of a percoid fish were discovered in the Geumgwangdong Formation deposits. These belong to the new species of Chinese perches of the extant genus *Coreoperca* (Herzenstein 1896) described below in detail. This is the first fossil record of the family Sinipercidae in the Korean Peninsula, one of the earliest representatives of its genus, and the first described Neogene freshwater fish from South Korea (Lee 2004).

Chinese perches (Perciformes, Sinipercidae) is a group of freshwater fish distributed exclusively in eastern Asia (China, Korea, Japan, Russia, and Vietnam), mostly in China. Sinipercids have variously been considered as Centropomidae, Percichthyidae (see Nelson 2006), or *incertae sedis* among the Percoidei (Johnson 1984). However, since the paper by Roberts (1993), the family Sinipercidae of the Percoidei *sensu lato* is always recognised (e.g., Nelson et al. 2016). A total of twelve to fourteen extant species have been described in this family, which were sometimes assigned to only one genus, *Siniperca* Gill 1862 (Johnson 1984; Zheng 1989). However, usually one more genus, *Coreoperca* Herzenstein 1896 is recognised within the Sinipercidae. The genus *Coreosiniperca* Fang and Chong 1932 sometimes distinguished for *C. roulei* (e.g., Zhou et al. 1988) is actually a synonym of *Siniperca* (Liu and Chen 1994; Song et al. 2017).

The fossil records of sinipercids are also restricted to Eastern Asia. They were previously known from China and Japan. In Japan, a new genus and species †*Inabaperca taniurai* was described from the marine middle Miocene Iwami Formation, Tottori Prefecture (Yabumoto and Uyeno 2000); it still remains the sole marine sinipercid. Two early Miocene species of the extant genus *Coreoperca* were described from the freshwater deposits of Kani, Gifu – †*C. fushimiensis*, Nakamura Formation (Ohe and Ono 1975) and †*C. kaniensis*, Hiramaki Formation (Ohe and Hayata 1984). Later, two more sinipercids were described from the early to middle Miocene freshwater Chojabaru Formation, Iki Island, Nagasaki – †*C. maruoi* (Yabumoto and Uyeno 2009), and †*Siniperca ikikoku* (Yabumoto 2020).

In China, the fossil species †*Coreoperca shandongensis* was described from the early-middle Miocene Shanwang Formation, Shandong, eastern China (Chen et al. 1999), whereas †*Siniperca wusiangensis* was recorded from the Pliocene of Shanxi based on an incomplete specimen (Liu and Su 1962). The Eocene Chinese genus †*Tungtingichthys* Liu, Liu et Tang, 1962 should be regarded as a basal perciform of uncertain relationships (Chang and Liu 1998).

Geological settings

The Geumgwangdong Formation is well known due to its rich complex of plant leaf fossils, accounting 64 taxa belonging to 43 genera of 27 families (Paik et al. 2012; Lee and Nam 2021). The remains of fishes and terrestrial insects were also recorded there, but in smaller amount (Sohn et al. 2018). The beds of this formation consist of paper shale, shale, shaly mudstone, laminated silty mudstone, and tuffaceous mudstone. The deposition of this formation occurred in a relatively deep lake in calm and disaerobic conditions and a cool-temperate climate (Paik et al. 2012). The Geumgwangdong Formation is a member of the sedimental Janggi Group whose age were estimated by the Ar-Ar dating of basalts as early Miocene within Burdigalian (Paik et al. 2012).

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Materials and methods

The four specimens available were examined using a Leica ES2 stereomicroscope. Some details of the specimens examined were best seen when the specimens were moistened with alcohol. The specimens were prepared by needles. Measurements were taken with a dial caliper, to the nearest 0.1 mm. The photographs of the specimens were made using a Digital Single Lens Reflex Canon EOS 6D equipped with a Canon EF 100 mm F2.8 L Macro lens.

Interneural and interhaemal spaces are numbered based on the vertebra whose neural or haemal spine forms the anterior border of the space, with the first space being between the first and second neural or haemal spines (following Baldwin and Johnson 1993; Bannikov and Tyler 1995; Tyler and Bannikov 1997; etc.). The diurnal terminology is used for the caudal skeleton: Schultze and Arratia (2013) have shown that the two ural centra are not homologous in different Teleostei.

The dagger symbol (†) indicates extinct taxa.

Institutional abbreviations. **GNUE**, Gongju National University of Education, Gongju, Korea; **ZIN**, Zoological Institute RAS, Saint-Petersburg, Russia.

Anatomical abbreviations. **aar**, anguloarticular; **bo**, basioccipital; **br**, branchiostegals; **ch**, ceratohyal; **cl**, cleithrum; **cor**, coracoid; **d**, dentary; **ecp**, ectopterygoid; **eh**, epihyal; **fr**, frontals;

hh, hypohyals; **HL**, head length; **hm**, hyomandibular; **ih**, interhyal; **iop**, interopercle; **lac**, lachrymal; **let**, lateral ethmoid; **ll**, lateral line scales; **mx**, maxilla; **op**, opercle; **pal**, palatine; **pcl**, postcleithra; **pel**, pelvic; **pop**, preopercle; **pr**, pectoral-fin rays; **prs**, parasphenoid; **PU**, preural vertebrae; **q**, qudrate; **SL**, standard length; **smx**, supramaxilla; **sn**, supraneurals; **sy**, symplectic; **U**, ural vertebrae; **uh**, urohyal; **v**, vomer.

Comparative materials examined. *Siniperca chuatsi* (Basilewsky 1855), ZIN 19731, 1 specimen, SL 141 mm; ZIN 19732, 1 specimen, SL 106 mm; *S. knerii* Garman 1912, ZIN 6758, 2 specimens, SL 155–185 mm; *S. scherzeri* Steindachner 1892, ZIN 44328, 1 specimen, SL 93 mm; ZIN 46739, 1 specimen, SL 120 mm; *Coreoperca herzi* Herzenstein 1896, ZIN 10550 n syntypes, 2 specimens, SL 47–70 mm.

Systematic palaeontology

Order Perciformes *sensu* Nelson 2006
Suborder Percoidei *sensu* Nelson 2006
Family Sinipercidae Jordan et Richardson, 1910
Genus *Coreoperca* Herzenstein 1896
†*Coreoperca chosun*, sp. nov.
(Figures 1–5)

Diagnosis

A species of the genus *Coreoperca* which differs from its congeners in having the following combination of characters: relatively large mouth; preopercle finely serrated posteriorly and strongly serrated ventrally; ventral edges of both interopercle and subopercle weakly serrated; opercular spines almost equal; 30 (12 + 18) vertebrae; dorsal fin consists of 12 spines (middle of them longest) and 12 soft rays; anal-fin with three spines (second strongest) and eight soft rays; lateral line scales less than 50.

Etymology

The species is named after the ancient name of Korea, as the country of morning freshness. The Korean word ‘fresh morning’ can be pronounced as ‘chosun’.

Holotype

GNUE321001, complete skeleton somewhat disarticulated anteriorly, with incomplete counterpart, 105 mm SL (Figure 1).

Paratype

GNUE321008, part and counterpart, incomplete skeleton, preserved portion length 45 mm (Figure 2).

Referred Specimens

GNUE321006 (Figure 3) and GNUE321007, incomplete disarticulated skeletons.

Type Locality and Horizon

South Korea, Geumgwangdong area, Pohang City, Gyeongsangbukdo (GPS coordinates: N35°57′30.5, E129°26′57.3); Lower Miocene Geumgwangdong Formation.

Description

Most of the material is either incomplete (paratype) or disarticulated (referred specimens). The holotype represents the complete skeleton, which is somewhat disarticulated anteriorly. Restoration of the skeleton (Figure 4) is based mostly on the holotype. The body is moderately elongate, with a rather deep, relatively short caudal peduncle (Figures 1, 4). The caudal peduncle depth is about 0.37 of the body depth. The head is relatively large; its length (tip of snout to posterior edge of the opercle) exceeds the body depth. The head length is contained approximately 2.5–2.6 times in SL. The dorsal profile of the body seems to be slightly more convex than the ventral profile.

Head. The head is moderately deep, conical, with its depth much less than its length. The orbit seems to be relatively small, and the snout is longer than the orbit. The mouth is very large and terminal. The lower jaw articulation is situated either under the posterior border of the orbit or behind it. The lachrymal is moderately large and relatively shallow, with a gently rounded and not serrated ventral margin and traces of several pores of the seismosensory system (Figure 5); the other infraorbital bones are difficult to recognise. The neurocranium is incompletely preserved and moderately deep, with the supraoccipital crest evidently low. The frontals are extended, forming an almost straight dorsal margin of the cranium in lateral view. Anteriorly, the frontals overhang the ethmoids. The bones of the otic region are poorly preserved. The lateral ethmoid forms most of the anterior wall of the orbit; it is massive and somewhat trapezoid in lateral view. The parasphenoid is not preserved; its vague imprint in the matrix of the holotype indicates that the bone was probably almost straight. The nasals and mesethmoid are only partially preserved in the paratype. The premaxilla has distinct and moderately long ascending and articular processes, as evidenced by the paratype, the only specimen in which the bone is partially preserved. No premaxillary teeth are preserved. The maxilla is long and almost straight, being only slightly curved near its head; it is somewhat expanded distally. The supramaxilla is very small and narrow. The lower jaw is large and relatively deep; its length is about 64% HL. The dentary is notched posteriorly and does not project ventrally near the low symphysis. The lower jaw teeth are minute and hardly recognisable. The angulo-articular is inserted deeply into the dentary notch. There seems to be a narrow space between the anterodorsal border of the angulo-articular and the posterodorsal process of the dentary. The angulo-articular is deep below the articular facet, but its retroarticular process

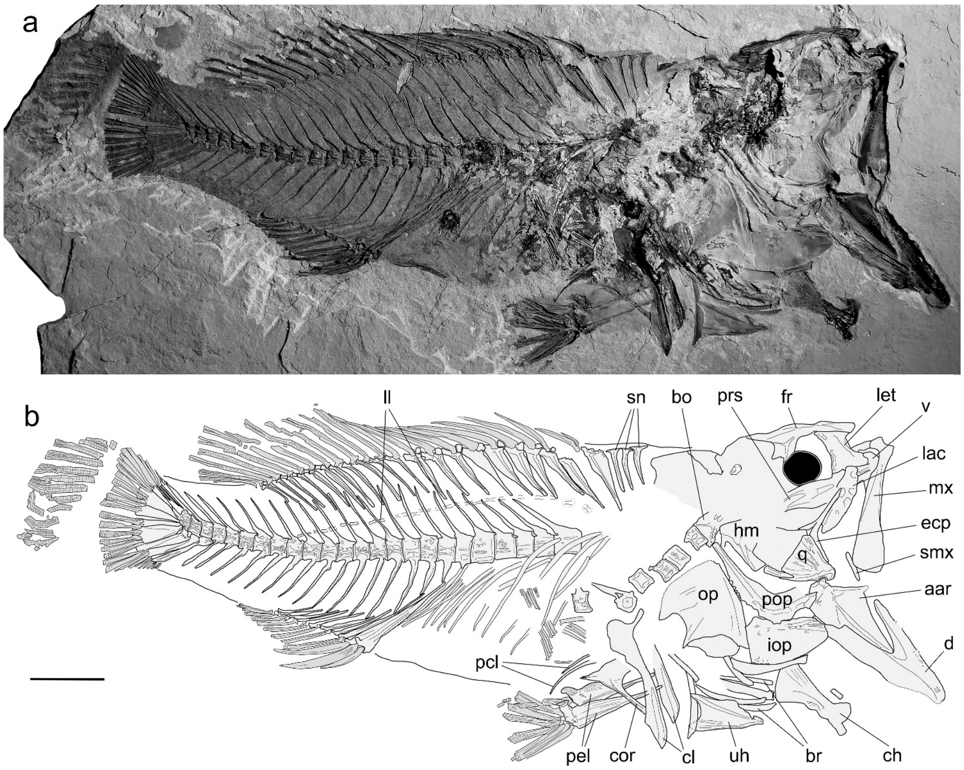

Figure 1. †*Coreoperca chosun*, sp. nov. from the Lower Miocene Geumgwangdong Formation of Pohang City, South Korea; holotype GNUE321001, 105 mm SL. (a) general view. (b) interpretative drawing. Scale bar equals 10 mm. [Planned for the page width].

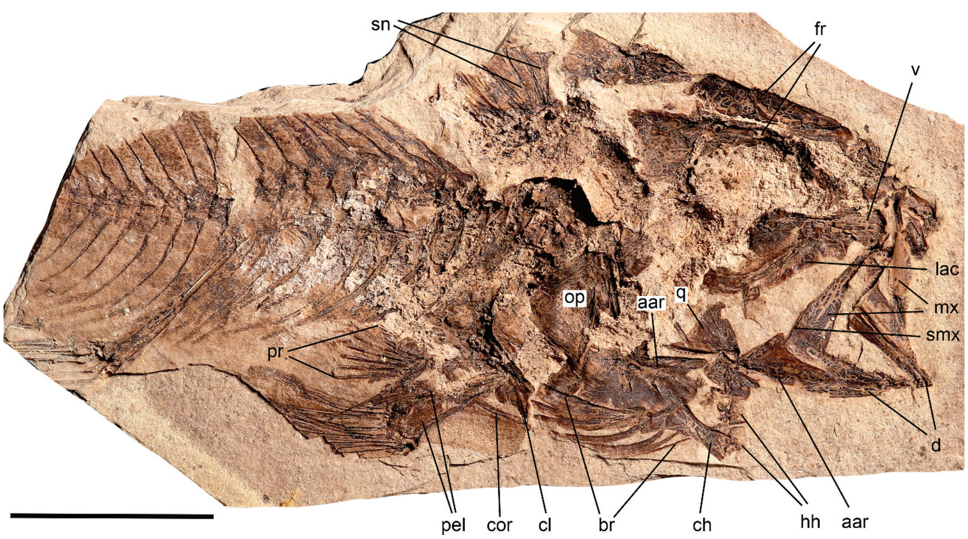

Figure 2. †*Coreoperca chosun*, sp. nov. from the Lower Miocene Geumgwangdong Formation of Pohang City, South Korea; paratype GNUE321008, general view. Scale bar equals 10 mm. [Planned for the page width].

is short (Figure 5). The hyomandibular shaft seems to be oriented close to vertically. The quadrate is moderately large, triangular in shape, and with a robust articulating condyle (Figure 5). There is a process on the posterior margin of the quadrate divided by a notch from the dorsal margin of the bone. The symplectic is small and rod-like e (Figure 5). The metapterygoid is poorly recognisable, whereas the entopterygoid is moderately wide and lamellar. The ectopterygoid is narrow, consisting of a ventral arm and a longer anterior shank, with an angle of ca. 115° between them. The dorsal arm of the ectopterygoid is rudimentary. The palatine is preserved in specimen GNUE321006; it has a moderate main body with an indication of small dentition, and a strong anterior process for the articulation with the maxilla (Figure 5). The preopercle is relatively large and moderately curved, broadest at the lower posterior angle; its posterior border is rather finely serrated, at least in its lower portion. The lower border of the preopercle is more strongly serrated – it has four

Figure 3. †*Coreoperca chosun*, sp. nov. from the Lower Miocene Geumgwangdong Formation of Pohang City, South Korea, referred specimen GNUE321006. Scale bar equals 10 mm. [Planned for two-third of the page width].

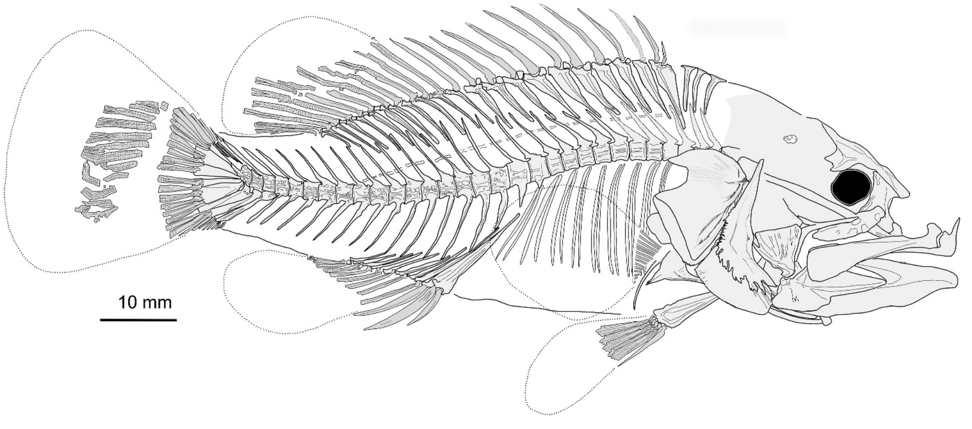

Figure 4. †*Coreoperca chosun*, sp. nov. from the Lower Miocene Geumgwangdong Formation of Pohang City, South Korea; reconstruction of the skeleton based mostly on the holotype GNUE321001. [Planned for the page width].

to five protrusions, each of them being serrated (Fig. 5, 6). The opercle is broad and flat; it is thickened along its anterior margin. The posterior margin of the opercle forms two flat spines divided by a relatively deep rounded notch. The upper spine seems to be slightly shorter than the lower one (Figures 1, 4, 5). The subopercle is a flat triangular-oval, with a prominent anterior projection; the ante-ventral corner of this bone bears weak serrations. The interopercle is wide and flat, with an almost straight lower margin which is slightly, almost indistinctly, serrated. The hyoid bar bones are partly visible in three specimens, with the natural articulation of branchiostegal rays only on the paratype. The anterior ceratohyal is relatively long, broadest at the posterior end and with somewhat concave dorsal and ventral margins (Figure 5). The anterior ceratohyal seems to lack a 'beryciform foramen' (McAllister 1968), however, this may well be an artefact of preservation; the middle part of the anterior ceratohyal posteriorly interlocks with the triangular posterior ceratohyal (Figure 5) by means of odontoid processes issuing from both elements (ceratohyal-epihyal suture of McAllister 1968). The first branchiostegal is narrow, whereas the others are broader and sabre-like in shape; the anterior four branchiostegals are attached to the anterior ceratohyal, and posterior three to the posterior ceratohyal. Two small hypohyals are recognisable on the paratype, and the interhyal on specimen GNUE321006; the interhyal is an elongated rod constricted in the middle (Figure 5). The urohyal is a flattened laminar triangular bone thickened along its ventral margin; the bone is moderately

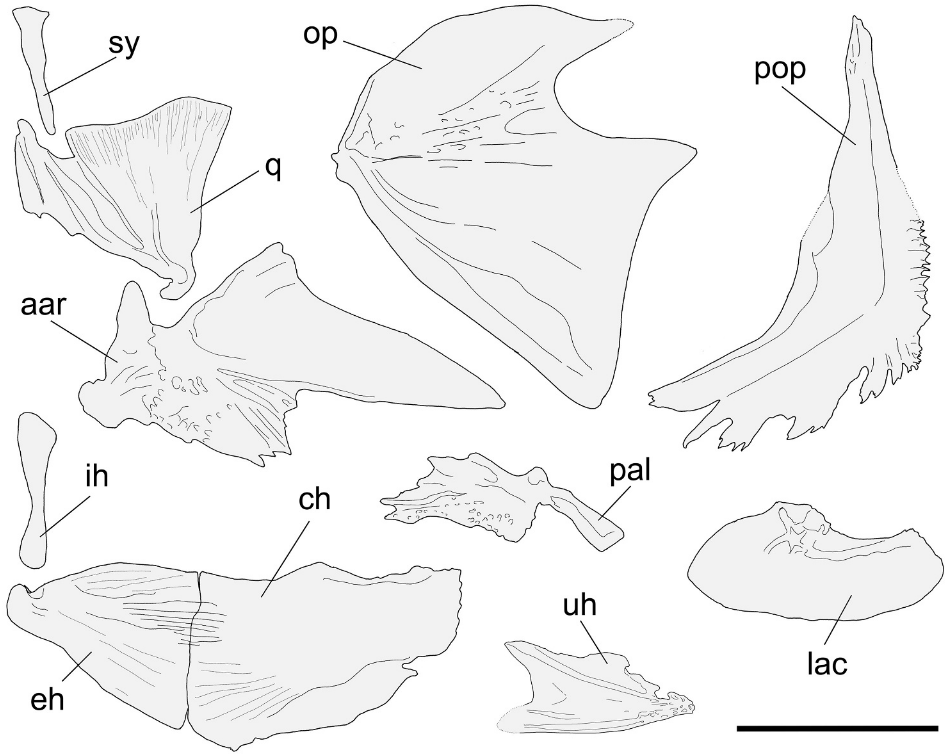

Figure 5. †*Coreoperca chosun*, sp. nov. from the Lower Miocene Geumgwangdong Formation of Pohang City, South Korea, individual bones of referred specimen GNUE321006, and urohyal of holotype GNUE321001. Scale bar equals 10 mm. [Planned for the column width].

deep and seems to be concave posteriorly (Figure 5). The branchial arch bones are not preserved completely enough to be described; and pharyngeal teeth are not recognisable.

Axial skeleton. The holotype is the only specimen with the whole vertebral column preserved. However, only its middle and posterior portions (caudal vertebrae plus six posteriormost abdominal vertebrae) are articulated in their natural position. We interpreted the six anteriormost vertebrae as displaced and partly disarticulated. There are 18 caudal vertebrae, including the urostyle. The number of abdominal vertebrae is restored as 12 (the abdominal portion of the vertebral column is also damaged in the paratype). The axis of the vertebral column seems to be very slightly sigmoid, being elevated anteriorly. The vertebral centra are rectangular (square to deeper than long) in lateral view. The length of the caudal portion of the vertebral column is restored as at least 1.7 times greater than the length of the abdominal portion of the vertebral column. The vertebral spines are relatively short and only slightly curved. The haemal spines of the two anterior caudal vertebrae are thicker and shorter than the other haemal spines. Most of the neural spines arise from the middle of the centra, whereas the anterior haemal spines arise from the anterior half of the centra. The haemal spines of the fourth and several succeeding caudal vertebrae are slightly longer than the opposite neural spines and less inclined. Short parapophyses are recognisable only on the posterior abdominal vertebra. The pleural ribs are moderately long and relatively stout; these are rather strongly inclined posteroventrally. Epineurals are hardly recognisable.

Pectoral fin and girdle. The pectoral girdle is only poorly preserved. The posttemporal and supracleithrum are not recognisable in the articulated specimens. The cleithrum is strong and slightly sigmoid, with its upper part curved anteriorly. The cleithrum has a prominent posterodorsal projection and is somewhat thickened ventrally. The ventral postcleithrum is moderately long and rib-like. The coracoid is moderately broad dorsally where it connects with the cleithrum, and narrow postero-ventrally; there is a prominent interosseous space between the cleithrum and most of the coracoid. The scapula and pectoral radials are not recognisable. The pectoral fins are incompletely preserved; their length and total complement of their rays are unknown. The ventral portion of the pectoral fin, with its six lowermost rays, is preserved in the holotype; the pectoral-fin base is situated relatively low, below the midpoint between the vertebral column and the ventral body margin.

Pelvic fin and girdle. The pelvic bones are strong and wedge-shaped, each with a short postpelvic process (Figure 1). The pelvic fins have a moderately long spine and five soft, branched rays each. The pelvic fin is inserted under the pectoral-fin base. The pelvic fin is relatively long, as evidenced by the paratype; the pelvic-fin spine is longer than the first anal-fin spine but shorter than the two other anal-fin spines.

Supraneurals and dorsal fin. There are three relatively strong supraneurals; these touch each other by their apical projections directed rostral and caudal. The predorsal formula (Ahlstrom et al. 1976; Johnson 1984) is not precisely recognisable because of taphonomic reasons; we restore it as typical for *Coreoperca*, i.e., 0/0/0 + 2/1 + 1/. There is a single dorsal fin, with its pterygiophores forming a continuous series. The dorsal fin is relatively long-based; it terminates over the twelfth or thirteenth vertebra. The dorsal fin is almost completely preserved in the holotype; however, it is slightly distorted in its anterior portion, with the second pterygiophore displaced and one spine missing. Originally there were obviously 12 smooth spines and 12 soft rays in the dorsal fin. Although the spines are inclined posteriorly in the holotype and partly cover each other from above, it is evident that the third dorsal-fin spine is shorter than the fourth and fifth spines. The middle dorsal-fin spines are the longest but definitely shorter than the soft rays. The first two dorsal-fin spines are supernumerary on the first dorsal-fin pterygiophore. The first spine is the shortest, almost twice shorter than the second spine. The soft portion of the dorsal fin originates over the fifth caudal vertebra. The soft dorsal-fin rays are more closeset than the dorsal-fin spines; therefore, the length of the base of the soft portion of the dorsal fin is ca. 1.5–1.6 times shorter than the base length of the spiny portion of the dorsal fin. The dorsal-fin soft rays are segmented and branched; although these are incomplete distally, it is evident that the soft portion of the dorsal fin forms a rounded lobe. There are a total of 22 dorsal-fin pterygiophores. The anterior dorsal-fin pterygiophores are expanded anteroposteriorly, wedge-shaped and bear a longitudinal strengthening ridge; the succeeding pterygiophores gradually become narrower. The first dorsal-fin pterygiophore is longest; the pterygiophores gradually decrease in length posteriorly in the series. The dorsal-fin pterygiophores slightly penetrate down into the interneural spaces, with the interneural spaces below the dorsal fin having the ventral shafts of one (usually) or two (in three cases below the soft portion) pterygiophores present. The holotype has a single vacant interneural space below the posterior portion of the spiny dorsal fin. The medial pterygiophores seem not to be fused with the proximal pterygiophores.

Anal fin. The anal fin originates under the fifth caudal vertebra and terminates anterior to the end of the dorsal fin. The length of the base of the anal fin is rather short, approximately corresponding to the length of five opposite vertebrae. There are three strong spines and eight soft segmented and probably branched rays (all the rays are incomplete distally) in the anal fin. The first two anal-fin spines are supernumerary on the first anal pterygiophore. The second anal-fin spine is evidently longest, although shorter than the longest dorsal-fin spines. The first anal-fin spine is the shortest, slightly shorter than the pelvic-fin spine and seems to be approximately as long as the second dorsal-fin spine. The first anal-fin pterygiophore is strong, wedge-shaped and longest; it is strongly inclined to the body axis (at an angle of about 45 degrees). The succeeding pterygiophores are narrow and decrease in length posteriorly in the series, and also strongly inclined; these pterygiophores only slightly enter up into the interhaemal spaces. The posterior pterygiophore is almost horizontally oriented.

Caudal fin and skeleton. The terminal centrum is composed of the fusion of PU1, U1 and U2. The hypurals, parhypural, and thickened haemal spines of PU2 and PU3 are autogenous (Figure 1). There is a deep and very narrow hypural diastema between the epaxial and hypaxial hypurals. The neural and spine of PU3 is somewhat longer than that of the preceding vertebra. The neural spine of PU2 is evidently a short crest. There are three very slender epurals; the first is longest. The uroneurals are poorly recognisable. The caudal fin seems to be rounded; it is incompletely preserved in the holotype. There are 17 principal rays in the caudal fin (I,8–7,I), with seven or eight procurrent rays below and not less than five rays above.

Squamation. The scales are very thin and evidently cycloid, covering the entire body and bases of the unpaired fins. The limits of individual scales are scarcely recognisable; therefore, the number of scale rows on the body is unknown, although the scales seem to be relatively small. The lateral line is poorly traceable; it is very gently arched anteriorly and descends to the level of the vertebral column near the 11th caudal vertebra. There are at least 27 perforated scales observed in the holotype, which suggest that the total number of lateral line scales is much less than 50.

Colouration. No pigmentation is unambiguously traceable.

Discussion

Such characters of the new taxon as the vertebral formula (12 + 18 = 30), dorsal fin consisting of 12 spines and 12 soft rays, anal fin with three spines and eight soft rays, serrated preopercle, two opercular spines, three supraneurals, 17 principal caudal-fin rays, and cycloid scales indicate its belonging to the percoid fish family Sinipercidae (Berg 1949; Liu and Chen 1994; Yabumoto and Uyeno 2000). This family includes two freshwater extant genera, *Siniperca* Gill and *Coreoperca* Herzenstein, and an extinct marine Miocene genus †*Inabaperca* Yabumoto et Uyeno from Japan.

The new Korean Miocene species can be attributed to the genus *Coreoperca* based on the serrated ventral margin of the preopercle (vs. ventral margin of the preopercle with four strong spines in *Siniperca* and †*Inabaperca*; Figure 6), the third dorsal-fin spine being shorter than the fourth and fifth spines (vs. third dorsal-fin spine almost equal in length with the fourth and fifth spines in *Siniperca* and †*Inabaperca*). The new fossil species is similar to *Coreoperca*, and differs from *Siniperca*, because its third to fifth neural spines are inserted apparently shallowly rather than deeply between the proximal dorsal-fin pterygiophores (see Fang and Chong 1932; Yabumoto and Uyeno 2000, 2009; Yabumoto 2020), and its supraneurals are stronger than in *Siniperca*. The study of comparative materials and descriptions available shows that the length of the longest supraneural is 52.3–62.6% of the length of the anterior dorsal-fin proximal pterygiophore in the species of *Siniperca*, whereas it is 69.8–76.4% in *Coreoperca herzi*, 67.7% in †*C. shandongensis* (Chen et al. 1999), 77.4% in †*C. maruoi* (Yabumoto and Uyeno 2000, 2009), and 66.0% in †*C. chosun*, sp. nov. Moreower, *Siniperca* spp. possesses a longer neurocranium with an almost flat dorsal outline and its height is 2.9–3.1 in its length. The neurocranium of *Coreoperca* spp. has a slightly convex dorsal outline, and it is relatively shorter, with its height 2.4–2.6 in its length (2.4 in †*C. chosun*). Like other *Coreoperca* spp., the new species possesses comparatively large scales that separate them from both †*Inabaperca* and *Siniperca*, which usually have more than 90 scales in the lateral line.

Both extant and extinct species of *Coreoperca* are quite similar in their main proportions and meristics. Nevertheless, the new species can be separated from the congeners by its unique combination of characters (Table 1). Its high number of vertebrae distinguishes it from most of the extinct species except for †*C. maruoi*, and brings it together with the extant *C. herzi* and *C. whiteheadi* (Boulenger 1900). The low numbers of anal-fin rays and lateral-line scales fall in the range of only one congener, *C. kawamebari* (Temminck and Schlegel, 1843), from which it differs by a higher number of the caudal vertebrae and serrated edge of the subopercle. The structure of

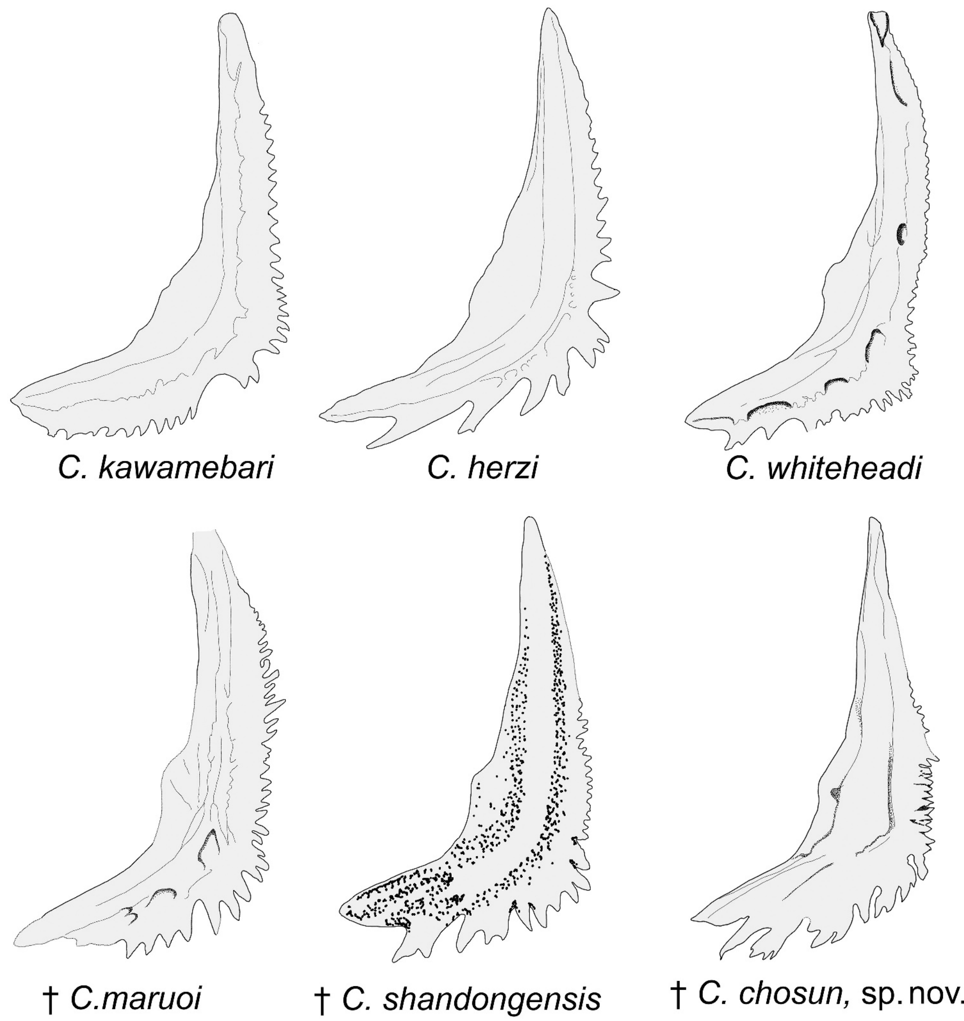

Figure 6. Left preopercles of some extant (upper row) and extinct (lower row) species of *Coreoperca*. Redrawn from Yabumoto and Uyeno (2009), with additions, and specimen GNUE321006. Out of scale. [Planned for the column width].

Table 1. Some distinctive characters of *Coreoperca* spp. Data from: (Ohe and Hayata 1984; Chen et al. 1999; Yabumoto and Uyeno 2009; Zhang et al. 2009); and comparative materials studied here.

	vertebrae			dorsal-fin		anal-fin	opercle	lateral	sop	iop	pop
	abdominal	caudal	total	spines	rays	rays	spines	line	edge	edge	edge
†*C. chosun* sp. nov.	12	18	30	12	12	8	equal	<50	serrated	serrated	4 protrusions
†*C. maruoi*	13	18	31	13	13	9	equal	?	?	serrated	serrated
†*C. kaniensis*	12	16	28	12	13	9	?	?	?	?	?
†*C. fushimiensis*	>9	17	>26	?	?	?	?	?	?	?	?
†*C. shandongensis*	13	17	30	12	13	9 – 10	equal	?	?	?	4 protrusions
C. herzi	12 – 13	18 – 20	30 – 32	13 – 14	12 – 13	9	upper shorter	53	smooth	smooth	4 spines
C. kawamebari	13	16 – 17	28 – 30	11 – 13	11 – 13	8 – 10	equal	<50	smooth	serrated	serrated
C. whiteheadi	15	18	28 – 33	12 – 15	12 – 16	10 – 12	equal	<60	serrated	serrated	serrated
C. loona	?	?	?	?	?	?	?	64 – 70	?	?	4 spines
C. liui	?	?	?	?	?	>10	?	>50	serrated	?	?

the preopercle of the new species is most similar with that of †*C. shandongensis* from China (Figure 6). This can be interpreted as a sign of a closer relationship between these Miocene species. At the same time, other characters, including the shape of opercle (Table 1; Figures 1, 4, 5); (Chen et al. 1999: Figure 5D), well separate the new species from its coeval Chinese relative.

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