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A New Species of Cyprinid Fish, *Zacco koreanus* with Redescription of *Z. temminckii* (Cyprinidae) from Korea

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A new chub, *Zacco koreanus* sp. nov., is described on the basis of 104 specimens from six localities in Korea. The new species is distinguished from other *Zacco* species by the following characteristics: 9~10 scales above lateral line to dorsal fin origin, yellowish anterolateral side of body, no hemicircular red blotch on the upper margin of the eyes, reddish anterior margin of pectoral fin, larger orbit diameter and narrow interorbital width. The new species is widely distributed in the most streams of Korea, except the Yeongsan R., while *Zacco temminckii* is restricted in the Dongjin R., Yeongsan R., Seomjin R., Tamjin R. and Nakdong R. in Korea. When the two species occurred sympatrically in the same stream, *Z. koreanus* sp. nov. prefered mostly rapid lotic environments while *Z. temminckii* inhabited lentic ones. The Korean *Z. temminckii* was redescribed herein. A key to the *Zacco* species of Korea and Japan is provided.

Key words : Cyprinidae, dark chub, *Zacco temminckii*, *Zacco koreanus* sp. nov., Korea

Introduction

Since the dark chub *Zacco temminckii* was described for the first time as *Leuciscus temminckii* by Temminck and Schlegel (1846) from Japan, it has been known as the most common species in the freshwaters of Japan, Korea and China mainland. Jordan and Starks (1905) first reported *Z. temminckii* based on several specimens from Busan, Korea, and reported that the Korean specimens seemed to differ from those of Japan in having a little darker coloration and a more diffused lateral band. Uchida (1939) provided informations on morphometric characters, ecology, life history, and distributions of the species under the scientific name "*Zacco temmincki*" based on specimens from several populations in Korea. Subsequently, *Z. temminkii* specimens from Korea have been reported to have some variations in lateral line scales and coloration of the anterolateral sides of the body (Choi *et al*., 1990; Kim, 1997). Yang and Min (1987, 1989) recognized two different enzyme types, MM(A) and MS(B), of *Zacco temminckii*.

Recently, *Z. temminckii* of Japan has been divided into two types, A and B, based on the number of branched anal rays and lateral line scales (Hosoya, 2002). Thereafter Hosoya *et al*. (2003) identified type A and type B as *Z. sieboldii* and *Z. temminckii*, respectively, and redescribed the two species in detail with diagnostic characters. Based on such information on the delimitation of *Z. temminckii*, we discovered that *Z. temminckii* specimens from Korea included an undescribed species. Herein, we describe it as a distinct new species and compare it with *Z. temminckii* and *Z. sieboldii*.

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Materials and Methods

Most specimens investigated in this study were

collected by the Korean authors in several Korean streams and deposited at the Faculty of Biological Sciences, Chonbuk National University, Chonju, Korea (CNUC). Some paratypes are deposited in the Department of Fisheries, Kinki University, Nara, Japan (FKUN) and the California Academy of Sciences, San Francisco, USA (CAS). Methods of counting and measuring followed Hubbs and Lagler (1964). The nuptial coloration in the breeding season were observed from color photographs of the samples collected using cast nets. Counts of fin rays and total vertebrae including Weberian apparatus were carried out using soft X-ray.

Fig. 1. *Zacco koreanus* sp. nov. Holotype from the Han River, Hongcheon, Korea. CNUC 36074, male, 106.6 mm SL.

Zacco koreanus sp. nov.

(English name: korean chub)
(New Korean name: cham-gal-gyeo-ni)
(Table 1, Fig. 1 and Fig. 2A)

Holotype. CNUC 36074, male, 106.6 mm SL (standard length), Han River, Haoan-ri, Hongcheon-eup, Hongcheon-gun, Gangwon-do, Korea, Aug. 8, 2003, M.K. Oh.

Paratypes. CNUC 36064~36068, 3 males and 2 females, 92.0~108.4 mm SL, same collection data of holotype; FKUN 33764~33768, 3 males and 2 females, 89.5~105.5 mm SL, Geum River, Daebul-ri, Jucheon-myeon, Jinan-gun, Jeollabuk-do, Korea, Aug. 9, 2003, M.K. Oh; CNUC 36114~36118, 3 males and 2 females, 95.7~100.7 mm SL, Mangyong River, Sincheon-ri, Soyang-myeon, Jeollabuk-do, Korea, Aug. 9, 2003, M.K. Oh; CNUC 36179~36183, 2 males and 3 females, 85.2~102.1 mm SL, Nakdong River, Sannae-myeon, Namwon-si, Jeollabuk-do, Korea, Aug. 5, 2003, M.K. Oh; CAS 221356, 3 males and 2 females, 106.6~113.8 mm SL, Seomjin River, Maryeong-myeon, Jinan-gun, Jeollabuk-do, Korea, Aug. 11, 2003, M.K. Oh.

Diagnosis. *Zacco koreanus* is distinguished by its color pattern with yellowish anterolateral body side and no hemicircular red blotch on the upper margin of the eyes. It can be distinguished by having 9~10 scales above lateral line to the dorsal fin origin.

Description. Dorsal fin rays iii 7, anal fin rays iii 10, pectoral fin rays i 14(15), pelvic fin rays ii 8, caudal fin rays i 9,8 i, lateral line scales 44~49, scale above lateral line 9~10, scales below lateral line 4, vertebrae 42~44, gill rakers 9~10, pharyngeal teeth 1, 3, 5-5, 3, 1. Proportional measurements and meristic counts are shown in Table 1.

Body elongated, well compressed outline from occiput to nuchal region gradually ascending upward. Head moderately compressed, its length slightly short. No maxillary barbel. Maxillary extending backward reaching near vertical line through front margin of the eyes. Posterior margin of operculum slightly roundish. Anterior tip of snout slightly pointed forming a triangle. Eyes moderately large, 28.4 (23.2~33.6)% in head length, located at a midlateral position or slightly higher. Interorbital width nearly 1.2 times orbit diameter. Dorsal fin moderate, its origin somewhat behind ventral insertion and nearer to caudal fin base than tip of snout. Anal fin prolonged, triangular in shape and reaching backward to caudal fin base when squeezed. Posterior margin of caudal fin slightly forked. Lateral line scales complete and curved ventrally.

Dorsal half bluish brown, ventral half grayish, with a bluish brown longitudinal band along body sides from shoulder to base of caudal fin, anteriorly narrow and posteriorly wide. Largest recorded size 139.5 mm (CNUC 34552).

Coloration in life. Body color of the young and adults in the non-breeding season are dark grayish on the back and gradually lighter towards the abdomen, with a bluish black longitudinal band. They have no hemicircular red blotch on the upper margin of the eyes. Mature males are tinged with yellowish on the anterolateral sides of the body and reddish on ventral parts in the breeding season. The anterior margin of the pectoral fin is colored reddish with yellow ground ventrally. The anal and caudal fin are yellowish. The dorsal fin is tinged with yellowish on the upper half, blackish on the lower part, and reddish on the anterior margin (Fig. 2A).

Table 1. Proportional measurements and meristic counts of *Zacco koreanus* sp. nov., *Z. temminckii* and *Z. sieboldii* from Korea and Japan

Characters	Korea				Japan	
	Z. koreanus sp. nov.			*Z. temminckii*	*Z. temminckii*	*Z. sieboldii*
	Holotype	Paratypes	Non-types	Non-types	Non-types	Non-types
Number of specimens	1	25	78	77	10	10
Standard length (mm)	106.6	85.2～113.8	67.4～121.3	75～173.0	63.0～112.0	66.1～102.2
Measurements in SL*(%)						
Head length	26.6	25.3～28.3 (26.9±0.7)	25.9～30.6 (27.1±0.8)	23.0～31.4 (28.4±1.2)	28.0～30.6 (29.4±0.9)	23.6～30.7 (28.2±1.9)
Body depth	24.9	21.8～26.5 (24.3±1.3)	20.1～28.8 (24.1±1.5)	20.6～27.0 (23.9±1.3)	11.9～25.7 (22.8±3.9)	21.9～24.8 (23.7±1.1)
Length of caudal peduncle	16.6	14.6～18.6 (16.7±1.1)	15.4～19.2 (17.3±0.9)	12.2～25.6 (17.6±1.6)	16.8～20.0 (18.2±1.1)	16.8～20.2 (18.8±0.9)
Depth of caudal peduncle	9.9	9.5～12.6 (10.2±0.6)	8.9～11.7 (10.2±0.5)	7.3～15.6 (10.1±0.8)	10.5～11.4 (10.8±0.3)	10.3～11.5 (10.8±0.3)
Predorsal length	52.9	50.5～56.3 (52.8±1.4)	48.6～60.9 (53.2±1.4)	49.3～55.4 (53.1±1.2)	51.1～54.2 (52.7±1.1)	50.0～55.1 (52.7±1.5)
Preanal length	67.3	66.8～73.6 (69.5±2.0)	62.8～80.6 (70.3±2.1)	66.5～74.0 (70.9±1.7)	68.6～74.8 (71.3±2.1)	68.8～72.0 (70.4±1.1)
Preventral length	48.8	48.4～52.8 (50.2±1.3)	48.1～58.3 (50.7±1.3)	48.3～53.9 (51.2±1.1)	49.2～54.0 (51.4±1.5)	49.7～52.1 (50.9±0.7)
Dorsal origin to caudal base	51.1	47.6～53.4 (50.8±1.5)	46.9～56.6 (50.3±1.4)	47.6～54.1 (50.2±1.3)	47.6～52.6 (50.0±1.4)	48.4～51.4 (50.0±0.9)
Length of dorsal fin base	14.7	10.8～14.1 (12.4±1.2)	10.0～13.6 (11.8±0.8)	10.1～13.7 (11.4±0.8)	10.2～12.4 (11.4±0.8)	9.9～11.7 (10.9±0.6)
Length of anal fin base	18.9	13.3～19.5 (15.9±1.9)	12.5～17.6 (14.5±1.0)	11.8～17.6 (13.9±1.3)	13.3～14.9 (13.8±0.5)	12.5～14.5 (13.2±0.6)
Measurements in HL*(%)						
Snout length	32.4	30.7～35.5 (33.8±1.2)	29.9～36.3 (33.6±1.1)	24.1～41.0 (33.8±2.2)	31.1～36.0 (33.0±1.6)	31.1～41.4 (33.6±2.9)
Interorbital width	34.5	32.2～38.3 (34.9±1.5)	29.8～38.0 (33.9±1.6)	31.8～43.3 (36.9±2.7)	33.3～36.7 (35.0±1.2)	34.7～47.0 (38.8±3.5)
Orbit diameter	27.5	23.2～30.0 (27.1±1.8)	24.7～33.6 (28.9±1.9)	19.0～31.9 (24.3±2.9)	23.4～29.0 (25.9±2.0)	21.0～27.6 (24.1±2.0)
IW*/OD*	1.3	1.1～1.6 (1.3±0.1)	1.0～1.5 (1.2±0.1)	1.2～2.2 (1.6±0.3)	1.2～1.5 (1.4±0.1)	1.4～1.9 (1.6±0.2)
Counts						
Dorsal fin rays	iii 7	iii 7	iii 7	iii 7	iii 7	iii 7
Anal fin rays	iii 10	iii 10	iii 10	iii 10	iii 10	iii 9
Pectoral fin rays	i 14	i 14(15)	i 14(15)	i 14(15)	i 14	i 13
Pelvic fin rays	ii 8	ii 8	ii 8	ii 8	ii 8	ii 7
Principal caudal fin rays	i 9,8 i	i 9,8 i	i 9,8 i	i 9,8 i	i 9,8 i	i 9,8 i
Lateral line scales	46	44～49	43～52	46～53	47～53	54～61
Gill raker	–	(8)9～10	(8)9～10	11～12	(10)11	(10)11
Scales above lateral line	9	9～10	9～10	11～12	11(12)	13～15
Scales below lateral line	4	4	4(3)	4(5)	4～5	4～5
Vertebrae	43	42～44	41～45	42～45	42～44	42

*SL: standard length, HL: head length, IW: interorbital width, OD: orbit diameter, ( ): mean±SD

Sexual dimorphisms. In breeding season, males have nuptial tubercles with two rows from the tip of snout to the front margin of the eyes, with one row on the suborbital, mandible, lower part of cheek and on rays of the anal fin. Females have a weakly developed tubercles and an un-

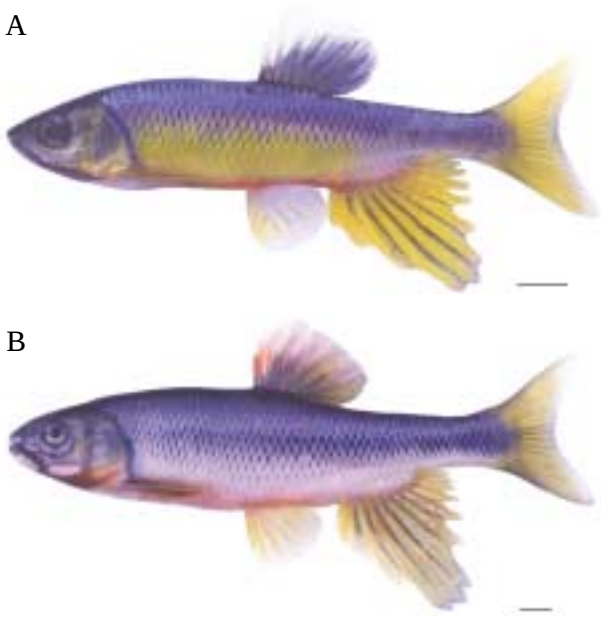

Fig. 2. Nuptial coloration of *Z. koreanus* sp. nov. (A), Han R., paratype (CNUC 36064), male and *Z. temminckii* (B), Tamjin R., non-type (CNUC 36189), male. Bar indicates 10 mm.

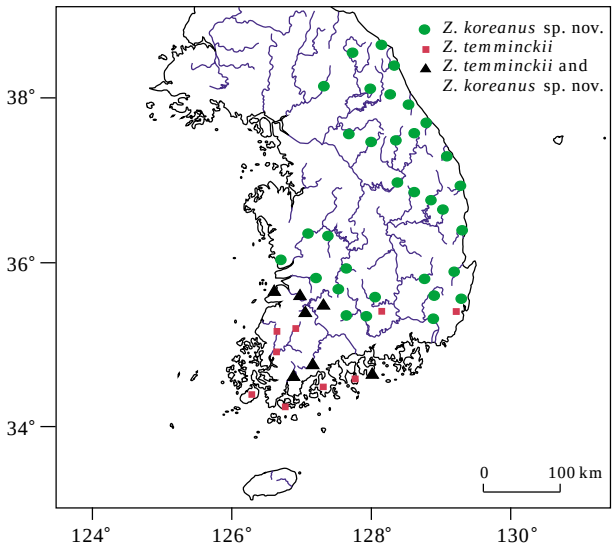

Fig. 3. The geographical distribution patterns of *Z. koreanus* sp. nov. and *Z. temminckii* from Korea.

clear nuptial coloration. The anal fin rays of males are prolonged and triangular.

Distribution and habitat. *Z. koreanus* sp. nov. is widely distributed in the following rivers of Korea : Han R., Geum R., Mangyong R., Dongjin R., Tamjin R., Seomjin R., Nakdong R. and most streams flowing into the eastern coast of Korea (Fig. 3). They commonly inhabit rapid lotic waters along the upper and middle courses of the streams.

Etymology. The name *koreanus* refers to the geographical occurrence of the species in Korea.

Remarks. Yang and Min (1989) reported two types of Mdh of *Z. temminckii* in Korea and gave a hint that the two types might each represent distinct species, but they did not provide any morphological characteristics. However, through morphological investigations of extensive collections on the Korean dark chub, the two types, MM and MS of Mdh-1, are recognized as *Z. temminckii* and *Z. koreanus* sp. nov., respectively. And the color plates of "*Z. temmincki*" (Choi *et al*., 1990; Kim, 1997) are also considered by those of *Zacco koreanus* sp. nov. The Korean form of dark chub (Hosoya *et al*., 2003) is described as *Z. koreanus* sp. nov., and is distinguished from *Z. temminckii* and *Z. sieboldii* of Japan based on the anterolateral body sides having a brilliant yellow color.

The new species is very similar to *Z. temminckii*, but it is distinguished from that species by the following characters: 9~10 scales above lateral line (vs. 11~12 in *Z. temminckii*), larger orbit diameter orbit (mean 28.4: 23.2~33.6% HL vs. mean 24.3: 19.0~31.9%), no hemicircular red blotch on the upper margin of the eyes (vs. present), yellowish anterolateral body sides in breeding season (vs. reddish) and reddish anterior margin of pectoral fin in mature males (vs. yellowish). Molecular biological studies are required for evaluating their relationships.

Zacco temminckii
(Temminck and Schlegel, 1846)

(English name: dark chub)
(Korean name: gal-gyeo-ni)
(Table 1 and Fig. 2B)

Materials examined. CNUC 36144~36163, 75.0~127.5 mm SL, Seomjin River, Jeongsan-ri, Bokheung-myeon, Sunchang-gun, Jeollabuk-do, Korea, Aug. 10, 2003, M.K. Oh; CNUC 36188~36204, 79.6~168.4 mm SL, Tamjin River, Gidong-ri, Busan-myeon, Jangheung-gun, Jeollanam-do, Korea, Aug. 6, 2003, M.K. Oh; CNUC 36205~36224, 102.1~173.0 mm SL, Do-ngjin River, Yongsan-dong, Jeongeu-si, Jeollabuk-do, Korea, Aug. 10, 2003, M.K. Oh; CNUC 36225~36224, 84.5~160.7 mm SL, Yeongsan River,

Ssangwoon-ri, Bukha-myeon, Jangseong-gun, Jeollanam-do, Korea, Aug. 6, 2003, M.K. Oh.

Diagnosis. *Z. temminckii* is distinguished from *Z. koreanus* sp. nov. by the combination of the following characters: 11～12 scales above lateral line to dorsal fin origin; interorbital width nearly 1.6 times orbit diameter; conspicuous hemicircular red blotch on the upper margin of the eyes; anterolateral side of body reddish; anterior margin of pectoral fin yellowish when alive.

Description. Dorsal fin rays iii 7, anal fin rays iii 10, pectoral fin rays i 14(15), pelvic fin rays ii 8, caudal fin rays i 9,8 i, lateral line scales 46～53, scales above lateral line 11～12 and scales below lateral line 4(5), vertebrae 42～45, gill rakers 11～12, pharyngeal teeth 1, 3, 5-5, 3, 1. Proportional measurements and meristic counts are shown in Table 1.

Body elongated and moderately compressed, head moderately compressed. No maxillary barbel. Maxillary extending backward reaching near vertical line through front margin of the eyes. Outline from chin to nape somewhat convex. Posterior margin of operculum roundish. Anterior tip of snout roundish. Deep bluish longitudinal band extending from shoulder to base of caudal fin. Largest recorded size 173.0 mm (CNUC 36208).

Coloration in life. Anterolateral side of body and ventral region reddish, overall head region yellowish. Dorsal part grayish. Lower part of mandible reddish black. Conspicuous hemicircular red blotch on the upper margin of the eyes. Anterior margin of pectoral fin yellowish. Paired fins and caudal fin yellowish. Black bands present on anal fin membrane. Upper half of dorsal fin yellowish red; lower half blackish and anterior margin reddish (Fig. 2B).

Sexual dimorphisms. In breeding season, males have nuptial tubercles in two rows from tip of snout to front margin of the eyes. In the region of the suborbital, mandible, and lower part of cheek, nuptial tubercles are also arranged in one row. In females, the nuptial tubercles of head region are weakly developed. On the anal fin rays and caudal peduncle, nuptial tubercles are distinctive in males but absent in females. In males, the anal fin ray is prolonged reaching the base of the caudal fin.

Distribution and habitat. *Z. temminckii* is restricted in the southern part of Korea to the Yeongsan, Seomjin, Tamjin and Nakdong River (Fig. 3). It is also distributed in Japan. The species inhabits upper and middle courses of streams and prefers lentic waters.

Remarks. *Z. temminckii* of Japan was classified into type A and B (Hosoya, 2002), but was subsequently redescribed as two valid species, *Z. sieboldii* for the specimens with 9 branched anal fin rays and lateral scales more than 53, and *Z. temminckii* for the specimens with 10 branched anal fin rays and lateral scales less than 52 (Hosoya *et al*., 2003). Because *Z. temminckii* was clearly redefined from *Z. sieboldii* by the number of lateral line scales, branched anal fin rays, and color patterns on sides of the body, the Korean *Z. temminckii* had to be checked for its meristic characters. During investigations on alive specimens of the Korean *Z. temminckii*, the two color types of red and yellow were recognized. Subsequently, we realized that the red type was well in accord with *Z. temminckii*, however the yellow type was distinguished from the red type in the number of scales above lateral line. As described above, all specimens of the yellow type investigated were distinguished as a valid new species, *Z. koreanus*, which was known to be widely distributed throughout the country except in the Yeongsan River. As shown in Table 1, the specimens of *Z. temminckii* from Korea are well in accord with those of Japan in the investigated characteristics, however it is distinguished from *Z. sieboldii* in the number of anal fin rays, lateral line scales, and scales above the lateral line.

Key to the species of the genus *Zacco* in Korea and Japan

A1 A series of irregular vertical bands present on both sides of the body; scales above lateral line not more than 9 ····· *Z. platypus*

A2 A dark brown longitudinal band present along midline on both sides of the body; scales above lateral line not less than 9 ····· B

B1 Longitudinal band anteriorly narrow and posteriorly wide from vertical line through dorsal fin origin; anal fin rays iii 9, number of lateral line scales not less than 54; scales above lateral line not less than 13 ····· *Z. sieboldii*

B2 Longitudinal band equally wide from the shoulder to caudal fin base; anal fin ray, iii 10; number of lateral line scales not more than 53; scales above lateral line not more than 12 ····· C

C1 Scales above lateral line 11～12; conspicuous hemicircular red blotch on the upper margin of the eyes; anterolateral body sides reddish

in alive specimens; anterior margin of pectoral fin yellow ····· *Z. temminckii*

C2 Scales above lateral line 9～10; no hemicircular red blotch on the upper margin of the eyes; anterolateral sides of body yellowish in alive specimens; anterior margin of pectoral fin red ····· *Z. koreanus* sp. nov.

Comparative materials

Zacco koreanus CNUC 36069～36073, 36075～36083, 14 specimens, 70.0～108.5 mm SL, Han River, Haoan-ri, Hongcheon-eup, Hongche-on-gun, Kangwon-do, Korea, Aug. 8, 2003, M.K. Oh; CNUC 36084～36087, 36093～36103, 15 specimens, 76.0～103.6 mm SL, Geum River, Daebul-ri, Jucheon-myeon, Jinan-gun, Jeolla-buk-do, Korea, Aug. 9, 2003, M.K. Oh; CNUC 36104～36113, 36119～36123, 15 specimens, 79.5～101.1 mm SL, Mangyong River, Sinchon-ri, Soyang-myeon, Jeollabuk-do, Korea, Aug. 9, 2003, M.K. Oh; CNUC 36164～36178, 15 specimens, 73.0～92.5 mm SL, Nakdong River, Sannae-myeon, Namwon-shi, Jeollabuk-do, Korea, Aug. 5, 2003, M.K. Oh; CNUC 36124～36126, 36132～36143, 15 specimens, 96.0～70.8 mm SL, Seomjin River, Maryong-myeon, Jinnan-gun, Jeollabuk-do, Korea, Aug. 11, 2003, M.K. Oh; CNUC 36184～36187, 76.1～121.3 mm SL, 4 specimens, Tamjin River, Gidong-ri, Busan-myeon, Jangheung-gun, Jeollanam-do, Korea, Aug. 6, 2003, M.K. Oh.

***Zacco temminckii* of Japan** CNUC 36391～36395, 5 specimens, 93.3～106.6 mm, The tributary of Seobang-cheon Stream, Japan, Aug. 22, 2003, K. Hosoya; CNUC 36396～36400, 5 specimens, 63.0～97.2 mm, Bojeseon-cheon Stream, Japan, Sep. 28, 2003, K. Hosoya.

***Zacco sieboldii* of Japan** CNUC 36401～36407, 7 specimens, 66.1～102.2 mm, Bohyunsa-cheon Stream, Japan, Sep. 19, 2003, K. Hosoya; CNUC 364081～36410, 3 specimens, 87.0～96.0 mm, Bohyunsa-cheon Stream, Japan, Oct. 23, 2003, K. Hosoya.

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한국산 피라미속 어류 1 신종 *Zacco koreanus* 기재와 갈겨니 *Z. temminckii*의 재기재

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우리나라 영산강을 제외한 남부의 여러 하천에서 채집된 갈겨니로 알려진 표본 가운데 체측상부비늘 수가 9~10개이고, 체측 전반부가 노란색을 띠고, 동공상단에 붉은색 반점이 없으며, 가슴지느러미 앞쪽 가장자리는 붉은색을 띤 104개의 개체들은 전형적인 갈겨니 *Zacco temminckii*와 잘 구별되어, 신종 *Zacco koreanus*로 기재하고 새로운 국명을 "참갈겨니"로 지칭하여 갈겨니 *Z. temminckii*와 비교하였다. 갈겨니는 영산강, 동진강, 섬진강, 탐진강, 낙동강의 우리나라 남부에서만 분포하지만, 참갈겨니는 영산강을 제외한 대부분의 하천에 분포한다. 이 두 종이 혼서하는 수역에서는 갈겨니는 주로 정수역에 서식하지만 참갈겨니는 비교적 빠른 유수역을 선호하였다. 한국과 일본의 피라미속 어류의 종 검색표를 제시하였다.