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Two Morphotypes in Korean Striped Bitterling, *Acheilognathus yamatsutae* Mori (Cyprinidae, Pisces)

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In the course of an investigation on the morphological variation of Korean striped bittering, *Acheilognathus yamatsutae* Mori, two kinds of morphological types were found. Some morphological characters were compared between them and multivariate analysis was conducted. Since the difference of the barbel length between them was very significant ($p < 0.01$, t-test), they should be designated as L- and S-type fishes: fishes with long barbels and those with short barbels, respectively. Lateral line scales, snout length and prepectoral length showed a tendency that the two types could be distinguished from each other ($p < 0.05$, Duncan's multiple range test). There were no individuals over 70 mm BL in S-type and so S-type fishes were somewhat dwarf than L-type fishes. The two types were also clearly distinguished by multivariate analyses using cluster and discriminant analysis. According to the observation on the four populations of the Naktong River, the blue-green stripe on the body side and the white band on the margin of anal fin in males of S-type fishes were well developed through the year but those of males of L-type fishes completely disappeared or became slender during nonbreeding season as that of females. Of the seven localities surveyed, there were no places that the two types cohabit. S-type fishes are limited only in the Kumho and Wichon River of the Naktong River system but L-type fishes are distributed more widely in the Hongchon, Mangyong, Somjin, Miryang and Panbyon River.

KEY WORDS: *Acheilognathus yamatsutae*, Intraspecific variation, Morphometric, Multivariate analysis

Korean striped bitterling, *Acheilognathus yamatsutae* Mori, was described as a new species by Mori (1928) based on the specimens from the Yalu River. This species is very close to Japanese striped bitterling *A. cyanostigma* Jordan et Fowler, but the former is distinguished from the latter by smaller head, larger eye and longer barbels than those of the latter (Mori, 1928; Uchida, 1939). The differences of other morphological characters except barbel length, however, were not clear. It has been known that the shape and size of eggs are very different between Korean and Japanese striped bitterlings (Miyadi *et al.*, 1976; Kim, 1991). So it seems that there is no problem in discrimination between the two species.

There were some reports on the presence of Japanese striped bitterling in the Korean Peninsula (Mori, 1935, 1952; Jeon, 1982; Kim, 1982, 1988). This misreading results from using barbel length only as key character. This fact suggests that there may be some morphological variation in Korean striped bittering, so an investigation on the morphological variation of the Korean striped bitterling is necessary. In the course of investigation on the geographic variation of

Korean striped bitterling, we found the presence of two types in this species. This paper presents a comparison of some morphological characters between the two types, with a brief discussion on their taxonomic relationship and zoogeography.

Materials and Methods

Population samples of *A. yamatsutae* were taken from 7 localities in the southern Korean Peninsula (Fig. 1). The sample numbers, collection sites and sample size are shown in Table 1.

The following 7 meristic and 20 morphometric characters were counted and measured by a conventional method described by Hubbs and Lagler (1964): anal fin rays (AF), dorsal fin rays (DF), pectoral fin rays (PF), ventral fin rays (VF), upper caudal fin rays (UC), lower caudal fin rays (LC), lateral line scales (LLSC), standard body length (BL), head length (HL), snout length (SNL), eye diameter (ED), prepectoral length (PPL), predorsal length (PDL), preventral length (PVL), preanal length (PAL), head depth (HD), body depth (BD), body depth at anus (BDA), depth of caudal peduncle (DCP), length of caudal peduncle (LCP), interorbital width (IOW), dorsal fin length (DFL), anal fin length (AFL), ventral fin length (VFL), dorsal fin base length (DFBL), anal fin base length (AFBL) and barbel length (BBL). All measurements were taken with vernier calipers or with an ocular micrometer under a binocular dissecting microscope and measured to the nearest 0.1 mm.

For all the analyses, the size factor was removed from all morphometric characters in each individual. A size correcting method was used for morphometric characters: the measurements were

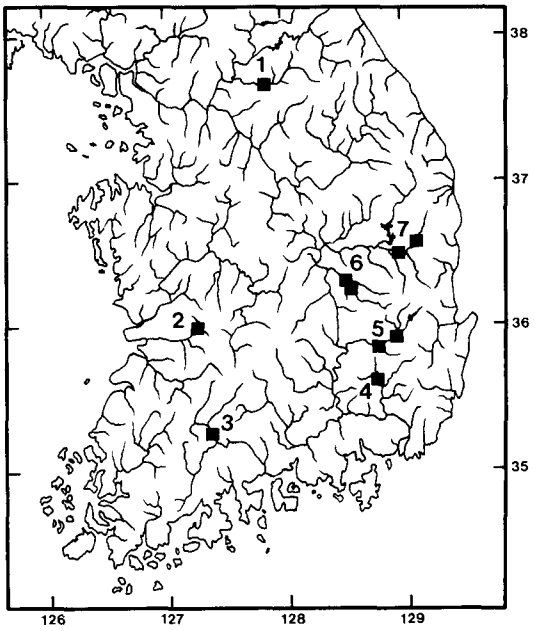

Fig. 1. Sampling localities of *Acheilognathus yamatsutae* in the southern Korean Peninsula. See Table 1 for locality data.

Table 1. Collection localities, dates and number of individuals of *Acheilognathus yamatsutae* collected for morphological analysis

No.	Collection Locality	River	Collection date	No. of Individuals
1	Somaegok-ri, Pukpang-myon, Hongchon-gun, Kangwon-do	Hongchon R.	Nov.15,1990	18
2	Upnae-ri, Kosan-myon, Wanju-gun, Chollabuk-do	Mangyong R.	Oct.13,1990	17
3	Hogok-ri, Kodal-myon, Koksong-gun, Chollanam-do	Somjin R.	Nov.12,1989	16
4	Shindo-ri, Chongdo-up, Chongdo-gun, Kyongsangbuk-do	Miryang R.	May. 3,1992	11
			Aug.18,1992	19
5	Koejon-dong, Tong-gu, Taegu-jikalshi	Kumho R.	May.29,1991	30
	Kwanjong-ri, Kumho-up, Yongchon-gun, Kyongsangbuk-do	Kumho R.	Apr.14,1991	17
6	Ssanggye-ri, Pian-myon, Uisong-gun, Kyongsangbuk-do	Wichon R.	Jun.16,1991	20
	Pongso-ri, Sobo-myon, Kunwi-gun, Kyongsangbuk-do	Wichon R.	Jun. 6,1992	11
7	Hupyong-dong, Chinbo-myon, Chongsong-gun,	Panbyon R.	Aug. 7,1985	14
	Kyongsangbuk-do		Jul.24,1992	2
	Hunggu-ri, Ibam-myon, Yongyang-gun, Kyongsangbuk-do	Panbyon R.	Aug.10,1992	2

divided by body length (BL) and the resulting ratio values were used as size-independent variables. Descriptive statistics, Duncan's multiple range test, discriminant function analysis and cluster analysis were performed using SPSS programs (Nie *et al.*, 1975; Norušis, 1985a, b). All computations were made with HYUNDAI SUPER-386C personal computer system.

Results

Morphological characters

The data on the morphological characters are presented in Table 2. The barbel length of the individuals from the Kumho and the Wichon River were shorter than the other populations ($p < 0.01$, t-test), and their range of length did not overlap at all with that of the other populations.

Table 2. Meristic counts and morphometric measurements of *Acheilognathus yamatsutae* obtained from several rivers. Figures are mean ± standard deviation and parenthesis represent ranges. N is the number of individuals used in the analysis

Characters	Hongchon R. (N=18)	Mangyong R. (N=17)	Somjin R. (N=16)	Miryang R. (N=30)	Kumho R. (N=47)	Wichon R. (N=31)	Panbyon R. (N=18)
DF	8.0 ± 0.0 (8)	8.1 ± 0.4 (7~9)	8.3 ± 0.5 (8~9)	8.0 ± 0.0 (8)	8.0 ± 0.2 (8~9)	8.1 ± 0.3 (8~9)	8.0 ± 0.0 (8)
AF	7.9 ± 0.4 (7~8)	8.1 ± 0.8 (7~10)	8.0 ± 0.0 (8)	8.0 ± 0.2 (7~8)	7.9 ± 0.3 (7~8)	8.0 ± 0.2 (7~8)	7.9 ± 0.2 (7~8)
PF	14.4 ± 1.1 (13~16)	13.4 ± 0.5 (13~14)	14.3 ± 0.5 (14~15)	13.6 ± 0.6 (13~15)	13.4 ± 0.5 (13~15)	13.4 ± 0.6 (13~15)	14.6 ± 0.7 (13~15)
VF	7.0 ± 0.0 (7)	6.9 ± 0.3 (6~7)	7.0 ± 0.0 (7)	7.0 ± 0.2 (6~7)	7.0 ± 0.0 (7)	7.0 ± 0.0 (7)	6.9 ± 0.2 (6~7)
LLSC	37.8 ± 0.7 (37~39)	38.3 ± 0.6 (37~39)	39.7 ± 1.8 (38~43)	38.4 ± 0.7 (37~40)	37.1 ± 0.7 (36~38)	36.9 ± 0.6 (36~38)	39.2 ± 0.9 (37~41)
HL/BL	23.8 ± 0.6 (22.9~24.7)	22.7 ± 0.4 (21.9~23.2)	23.3 ± 0.5 (22.5~24.1)	24.0 ± 1.1 (21.6~25.7)	24.7 ± 1.1 (22.6~26.8)	24.7 ± 1.1 (23.1~27.7)	22.5 ± 1.0 (21.0~24.2)
SNL/BL	7.3 ± 0.4 (6.7~7.8)	7.1 ± 0.3 (6.6~7.6)	7.4 ± 0.5 (6.5~7.9)	7.3 ± 0.4 (6.6~8.4)	6.7 ± 0.4 (5.9~7.8)	6.8 ± 0.4 (5.9~7.5)	7.2 ± 0.3 (6.6~8.0)
ED/BL	7.5 ± 0.3 (7.0~8.1)	7.0 ± 0.2 (6.7~7.4)	6.9 ± 0.3 (6.5~7.5)	7.0 ± 0.3 (6.4~7.6)	7.2 ± 0.4 (6.4~8.1)	7.8 ± 0.5 (6.8~8.8)	6.1 ± 0.4 (5.3~6.8)
BD/BL	33.6 ± 1.0 (32.2~35.6)	32.6 ± 1.2 (31.3~34.7)	31.5 ± 0.6 (31.0~32.5)	31.3 ± 1.7 (28.0~34.8)	31.9 ± 1.2 (28.9~34.1)	31.8 ± 1.9 (28.9~36.0)	36.1 ± 2.6 (30.2~39.4)
PPL/BL	21.9 ± 0.7 (21.0~22.9)	21.6 ± 0.8 (20.1~23.1)	22.1 ± 0.5 (21.5~22.7)	22.6 ± 1.1 (20.0~24.9)	23.7 ± 1.2 (21.3~25.8)	23.6 ± 1.1 (21.7~26.1)	21.1 ± 1.3 (19.4~24.0)
PDL/BL	49.0 ± 0.9 (47.7~50.2)	50.7 ± 1.6 (49.1~56.3)	50.1 ± 1.1 (48.4~51.6)	50.2 ± 1.0 (47.4~52.0)	49.8 ± 1.0 (47.2~52.0)	49.4 ± 0.9 (47.6~51.5)	48.8 ± 0.9 (47.3~50.3)
DCP/BL	11.8 ± 0.5 (11.2~12.4)	12.4 ± 0.3 (11.9~13.1)	12.0 ± 0.2 (11.7~12.3)	12.3 ± 0.6 (11.1~13.4)	11.6 ± 0.6 (10.4~12.7)	11.4 ± 0.8 (9.9~13.1)	12.6 ± 0.7 (11.5~13.9)
LCP/BL	22.3 ± 1.1 (20.6~23.6)	21.2 ± 0.8 (19.9~22.7)	22.6 ± 1.3 (20.7~24.3)	21.4 ± 1.2 (19.2~23.4)	22.6 ± 1.0 (20.0~25.0)	22.5 ± 1.0 (20.2~24.0)	22.3 ± 1.0 (20.4~24.0)
IOW/BL	9.0 ± 0.2 (8.8~9.4)	9.1 ± 0.4 (8.2~9.7)	8.8 ± 0.5 (8.4~9.6)	8.9 ± 0.4 (7.4~9.6)	9.2 ± 0.4 (8.4~10.3)	9.7 ± 0.5 (9.7~10.7)	8.5 ± 0.3 (7.9~9.2)
BBL/BL	3.2 ± 0.4 (2.5~3.9)	3.6 ± 0.6 (2.8~4.7)	4.0 ± 0.4 (3.5~4.5)	3.8 ± 0.6 (2.6~5.3)	1.3 ± 0.3 (0.8~1.7)	1.4 ± 0.3 (0.6~1.9)	4.4 ± 0.8 (2.3~5.6)
DCP/LCP	53.1 ± 3.2 (47.8~58.3)	58.4 ± 2.9 (55.1~65.9)	53.2 ± 3.4 (49.6~58.2)	57.7 ± 4.8 (50.0~69.1)	51.5 ± 3.7 (43.7~57.8)	50.7 ± 4.1 (44.6~60.0)	56.8 ± 4.3 (49.0~63.2)

Thus we call them as S-type (short barbel type) and L-type (long barbel type) fishes to distinguish each other. Lateral line scales, snout length and prepectoral length also showed a tendency that L-type fishes could be distinguished from S-type fishes ($p < 0.05$, Duncan's multiple range test). Most of the other characters except above ones were overlapped largely in the range of the value.

Fig. 2 shows a relationship between barbel length and body length. In the juveniles (up to 30 mm BL) there was no difference between the two types. But in 60 mm BL, barbel length of L-type fishes were longer about two-times than that of S-type fishes. Judging from the pattern of distribution of body length (abscissa of Fig. 2), body length of S-type fishes were shorter than that of L-type fishes. Most S-type fishes were concentrated in the range of 50-60 mm BL and there were no individuals over 70 mm BL. Most L-type fishes were between 60 mm and 80 mm BL, and moreover there were some large individuals exceeding 110 mm BL in the Panbyon River (population 7).

Multivariate analyses

Two multivariate analyses, cluster analysis and stepwise discriminant function analysis, were performed to summarize all the morphological data. A UPGMA cluster analysis (Fig. 3) expressing phenetic similarities of the all individuals was conducted on 7 meristic and 19 morphometric characters. All used individuals were divided into two major groups at the level of 25; one group was composed of the individuals belonging to S-type (populations 5 and 6) and the other group was composed of the individuals of L-type (populations 1, 2, 3, 4, and 7). The two groups were subdivided at level 10 and 5 respectively. But in these subgroups or the lower

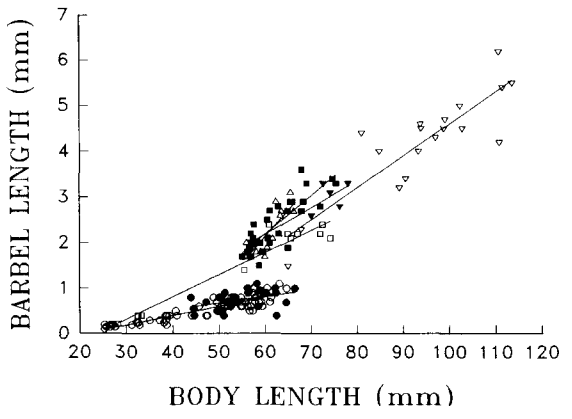

Fig. 2. Relationship between barbel length and body length. Open squares; Hongchon River, solid squares; Miryang River, open triangles; Mangyong River, open reverse triangles; Panbyon River, solid reverse triangles; Somjin River, open circles; Kumho River, solid circles; Wichon River.

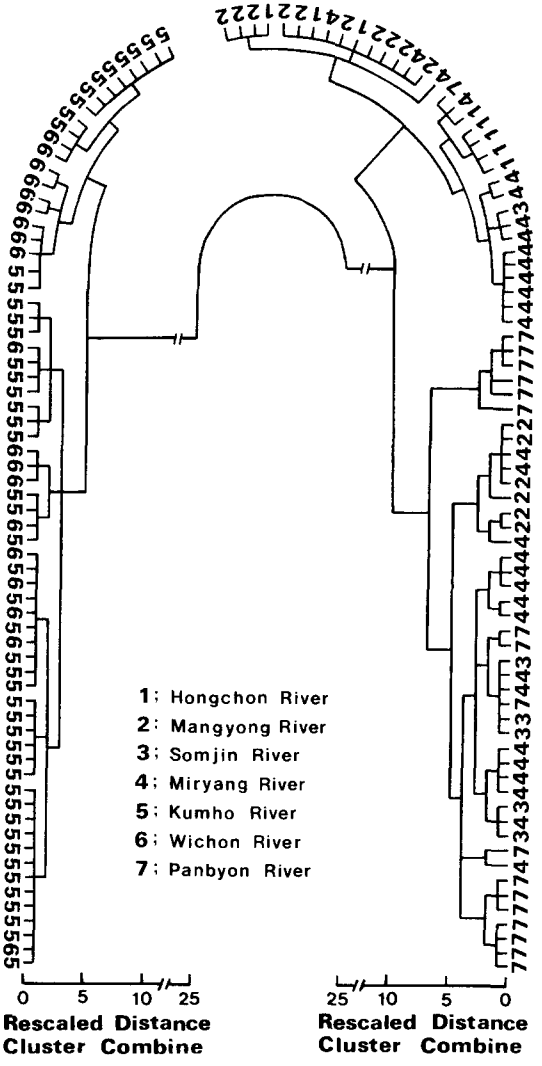

Fig. 3. Dendrogram for the relations among each individuals from seven populations of *Acheilognathus yamatsutae* based on the UPGMA clustering procedure of 26 morphological characters.

levels no populations were assigned to specific groups. Therefore only the first two groups were meaningful.

The result of the stepwise discriminant function analysis were basically same with that of the cluster analysis. Six significant canonical discriminant functions were formed in this analysis, but the first two canonical discriminant functions accounted for 84.64% of the total dispersion among populations (first function, 71.78%; second function, 12.85%). The standardized discriminant coefficients and the percentage of variance are given in Table 3. When the sign is ignored, the size of the coefficient represents the relative contribution of that character to the function. The first function was roaded mainly by such characters BBL/BL, BD/BL and PPL/BL. The second function was roaded heavily by such characters BD/BL and DCP/BL.

Table 3. Standardized coefficients for the first two canonical discriminant functions from analysis of morphological characters of geographic populations of *Acheilognathus yamatsutae*

Character	Function 1	Function 2
DF	-0.00254	0.16924
AF	-0.01889	-0.07174
PF	0.04915	-0.29156
VF	-0.21494	0.14161
UC	-0.03773	-0.19013
LLSC	0.26148	-0.10031
SNL/BL	0.39808	0.14978
ED/BL	-0.13242	0.31133
PPL/BL	-0.51555	0.14420
PDL/BL	0.26208	-0.00766
PVL/BL	0.39662	0.22410
PAL/BL	-0.01397	0.26748
HD/BL	-0.02279	0.36906
BD/BL	-0.53964	-1.14741
BDA/BL	-0.19950	-0.18735
DCP/BL	0.31006	0.85053
LCP/BL	0.12675	0.19409
IOW/BL	-0.01752	-0.53152
DFL/BL	-0.09737	0.10426
AFL/BL	0.03773	-0.14371
VFL/BL	0.03497	0.04915
DFBL/BL	0.01418	-0.32878
AFBL/BL	0.15167	0.41997
BBL/BL	1.03756	0.11068
% of variance	71.78%	12.85%
Cumulative %	71.78%	84.64%

In the two-dimensional plots of function 2 against function 1 (Fig. 4), the two types were clearly recognized; populations 5 and 6 (S-type) were separated into one group from the other populations (L-type) by function 1 and their distribution ranges did not overlap at all. In the grouping of L-type fishes, it seemed that subgrouping by function 2 was possible: groups 1-3-7 and 2-4. But such grouping is meaningless because their distribution ranges overlap each other and variance of function 2 is very low.

Geographic distribution

S-type fishes were limited only in the Kumho and the Wichon River of the Naktong River system but L-type fishes were distributed more widely in the Hongchon, Mangyong, Somjin, Miryang and Panbyon River. There were no places that the two types cohabit. In the case of the Naktong River system, both types were found in the same river system but their habitats were clearly divided. That is, S-type fishes were distributed in tributaries of middle reach (the

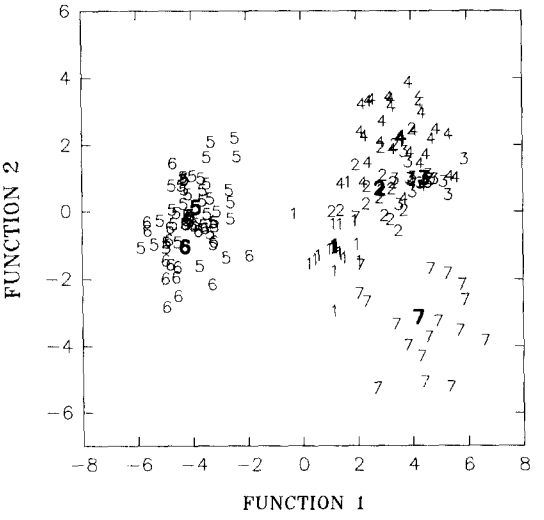

Fig. 4. Two-dimensional representation of discriminant function analysis of morphological characters for geographic populations of *Acheilognathus yamatsutae*. Bold numbers represent the population centroids. Symbols for the population samples are the same as in Table 1.

Kumho and Wichon River) and L-type fishes were distributed in tributaries of upper and lower reaches (the Panbyon and Miryang River).

Discussion

Korean striped bitterling is a small cyprinid fish (Acheilognathinae) and endemic in Korea. This fish was reported as a new species by Mori (1928). It has been known that Korean striped bitterling was distinguished from Japanese striped bitterling in some respects (Mori, 1928; Uchida, 1939), and the difference of barbel length was the most peculiar. It was recently found that some other characters are also different between the two species (Miyadi *et al.*, 1976; Kim, 1991).

There were some reports on the presence of Japanese striped bitterling in the Korean Peninsula. Mori (1935) reported that *A. cyanostigma* was collected at Changhung, Chollanam-do, but he removed this species in the Check List of the Fishes of Korea (1952). Kim (1982) and Jeon (1982) described the rare presence of *A. cyanostigma* in the Mangyong River (Wanju, Chollabuk-do) and in the Kumho River (Yongchon, Kyongsangbuk-do), but Kim removed this species in his later paper (1988). On the other hand, Kim (1991) denied the presence of *A. cyanostigma* in the Korean Peninsula based on the morphology of the eggs and exomorphology.

In present investigation, we found that there was a variation in the barbel length. Two types are present: one type with long barbels and the other with short barbels. Furthermore, the two types do not overlap geographically. The former was found in the Hongchon, Mangyong, Somjin, Miryang and Panbyon River and the latter in the Kumho and Wichon River. Thus we called them as L-type

Table 4. A comparison of some morphological characters between *Acheilognathus yamatsutae* and *Acheilognathus cyanostigma*

Char-	*A. yamatsutae*			*A. cyanostigma*	
	Present specimens		Uchida (1939)	Uchida (1939)	Nakamura (1969)
acters	S-type	L-type	(N=12)*	(N=5)	(N=5)
DF	8.0 ± 0.2 (8~9)	8.0 ± 0.3 (7~9)	8.0 ± 0.0 (8)	8.0 ± 0.0 (8)	8.0 0.0 (8)
AF	8.0 ± 0.2 (7~8)	8.0 ± 0.4 (7~10)	8.0 ± 0.0 (8)	7.8 ± 0.4 (7~8)	8.0 ± 0.0 (8)
LLSC	37.1 ± 0.7 (36~38)	38.6 ± 1.0 (37~43)	37.3 ± 1.1 (36~39)	39.0 ± 0.0 (39)	39.1 ± 1.0 (38~41)
HL/BL	24.7 ± 1.1 (22.6~27.7)	23.3 ± 1.1 (21.0~25.7)	24.2 ± 1.5 (22.7~26.3)	25.6 ± 0.5 (25.0~26.3)	25.7 ± 1.0 (24.4~27.0)
SNL/BL	6.7 ± 0.4 (5.9~7.8)	7.2 ± 0.4 (6.5~8.4)	7.4 ± 0.4 (6.6~8.1)	8.5 ± 0.3 (8.0~8.8)	8.3 ± 0.6 (7.3~9.5)
ED/BL	7.4 ± 0.5 (6.4~8.8)	6.8 ± 0.6 (5.3~8.1)	7.5 ± 1.0 (6.0~9.2)	7.4 ± 0.5 (6.6~8.0)	7.6 ± 0.7 (6.3~8.4)
BD/BL	31.9 ± 1.5 (28.9~36.0)	32.9 ± 2.6 (28.0~39.4)	33.9 ± 2.2 (31.3~37.0)	30.7 ± 1.3 (29.4~32.3)	32.4 ± 0.9 (30.3~33.3)
DCP/BL	11.5 ± 0.7 (9.9~13.1)	12.3 ± 0.6 (11.1~13.9)	12.9 ± 0.9 (11.4~13.9)	12.0 ± 0.5 (11.7~12.8)	12.0 ± 0.3 (11.4~12.3)
LCP/BL	22.5 ± 1.0 (20.0~25.0)	21.8 ± 1.1 (19.2~24.3)	20.2 ± 1.9 (17.5~23.8)	24.7 ± 1.6 (22.7~26.3)	
IOW/BL	9.4 ± 0.5 (8.4~10.7)	8.9 ± 0.4 (7.4~9.8)	9.4 ± 0.7 (8.0~10.4)	10.6 ± 0.5 (9.9~11.0)	

*: All individuals were thought as L-type fishes.

(long barbel type) and S-type (short barbel type) respectively.

A morphological comparison among the two types of *A. yamatsutae* from Korea and *A. cyanostigma* from Japan was performed on the basis of the literatures and the present result (Table 4 and 5). S-type fishes and *A. cyanostigma* are similar each other in barbel length and maximum body length. The head length, length of caudal peduncle, intestinal convolutions and intestine-body length ratio of S-type fishes are intermediate between L-type fishes and *A. cyanostigma*. S-type fishes has lower caudal peduncle, shorter snout and lesser lateral line scales than L-type fishes and *A. cyanostigma*. Interorbital width of S- and L-type fishes is similar each other but narrower than that of *A. cyanostigma*. In the shape and size of eggs and nuptial color, however, L-type and S-type fishes are very similar each other (Uchida, 1939; Nakamura, 1969; Miyadi *et al.*, 1976; Kim, 1982; Kawanabe and Mizuno, 1989). According to the observation on the four populations of the Naktong River, the blue-green stripe on the body side and the white band on the margin of anal fin in males of S-type fishes were well developed through the year but in males of L-type fishes the white band on anal fin completely disappeared and the blue-green stripe became slender as that of female during nonbreeding season.

Classifying on the basis of the barbel length only, S-type fishes may be identified as *A. cyanostigma*. But it seems that S-type fishes are rather closer to *A. yamatsutae* morphologically as described above. It is a question, however, whether S-type fishes can be identified as *A. yamatsutae* because L-type and S-type fishes are different

Table 5. Comparisons among types of *Acheilognathus yamatsutae* and *Acheilognathus cyanostigma* for some characters

Species	*A. yamatsutae*		*A. cyanostigma*
Characters	L-type	S-type	
Maximum total length	ca.150 mm[a]	ca.90 mm	ca. 80 mm[b,f]
Length of barbel (BAL/ED %)	long[a,d] (32.6~105.1)	short (8.7~24.4)	short[a,c] (less than 25%[c])
Intestinal convolutions (Mean ± SD)	11~14 (12.1 ± 0.7)	6~13 (10.5 ± 1.6)	7[c]
Intestine L./Body L. (Mean ± SD)	3.4~7.1 (4.9 ± 0.9)	2.6~6.1 (4.4 ± 0.9)	2.3[c]
Ripe eggs			
Shape	egg-shaped	egg-shaped	capsule-shaped[c]
Size(mm): long axis	1.6~1.8[a]	1.5~1.8	2.4~3.4[b]
short axis	1.5~1.7[a]	1.3~1.6	0.8~1.0[b]
Nuptial color of male			
Margin of ventral fin	white[d]	white	pale pink[b,c]
Margin of anal fin	white[d]	white	red pink[b,c]
Development of blue green stripe in male*			
Spawning season	well	well	—
Nonspawning season	poor	well	—
Distribution	Korea[e]	Korea	Japan

Literatures cited: a, Uchida(1939); b, Nakamura (1969); c, Miyadi *et al.* (1976); d, Kim(1982); e, Choi *et al.* (1989); f, Kawanabe and Mizuno (1989).

*: Observed in the 4 populations of the Naktong River System.

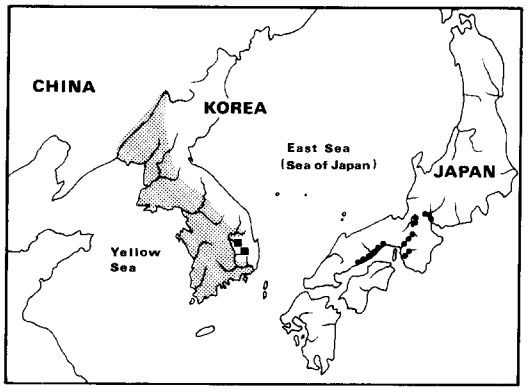

Fig. 5. Map showing the distribution pattern of L- (shaded area) and S-type (solid squares) of *Acheilognathus yamatsutae* and *Acheilognathus cyanostigma* (solid circles). L-type after Uchida (1939), Mori (1952), Jeon (1980) and Choi *et al.* (1989). *A. cyanostigma* after Miyadi *et al.* (1976) and Kawanabe and Mizuno (1989).

each other in several respects. According to the coefficient of difference (Mayr, 1969) of barbel length among populations, it is considered that the two types are in subspecific level at least (CD > 2.44). Comprehensive investigation is, therefore, needed to solve the problem on the taxonomic relationship of them.

The distribution pattern of L- and S-type fishes of *A. yamatsutae* and *A. cyanostigma* was presented in Fig. 5. There was no individuals with the characteristics of *A. cyanostigma* in the surveyed area. It seems, therefore, that *A. cyanostigma* inhabits only in Japan. In *A. yamatsutae*, S-type fishes were found only in the Kumho and Wichon River of the Naktong River system but L-type fishes distribute widely in the rivers drained into Yellow and South Sea (Uchida, 1939; Mori, 1952; Chyung, 1977; Jeon, 1980; Choi *et al.*, 1989) except the Kumho and Wichon River. There are no places that both types of *A. yamatsutae* cohabit. It will be very interesting to investigate and to discuss the distribution, reproductive isolation and speciation between these two types because both types are found in the same river system.

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줄납자루 ***Acheilognathus yamatsutae*** Mori(잉어과, 어강)의 두 type

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한국산 줄납자루 *Acheilognathus yamatsutae* Mori의 형태적 변이를 조사하던 중 형태의 차이가 있는 두 type을 발견하여 이들에 대한 형태적 형질을 비교하고 다변량분석을 실시하였다. 이들 두 type 사이의 입수염길이는 매우 유의하게 다르기 때문에($p < 0.01$, t-test), 입수염의 길이가 긴 개체는 L-type 그리고 입수염이 짧은 개체는 S-type으로 하였다. 측선린수, 문장 및 가슴지느러미 기점거리의 3형질에서도 두 type사이에 차이를 나타내는 경향이 있었다($p > 0.05$, multiple range test). 체장분포에서도 S-type은 체장이 70mm 이상인 개체는 전혀 발견되지 않아 L-type보다 왜소하였다. 또한 집괴분석과 판별분석의 다변량분석에서도 이들 두 type이 명확하게 구분되었다. 한편 낙동강의 4개체군에서 조사된 바로는 체측의 청녹색 종대와 뒷지느러미 가장자리의 흰띠가 S-type의 수컷에서는 연중 잘 발달되어 있는데 반하여 L-type의 수컷에서는 산란시기에는 잘 발달되나 그 외의 시기에는 거의 소실된다. 조사된 7하천에서 두 type이 혼서하는 곳은 없었으며, S-type은 낙동강 수계의 금호강과 위천에만 국한되어 있었고 L-type은 홍천강, 만경강, 섬진강 그리고 낙동강의 밀양강과 반변천에 분포하고 있었다.