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INTERSPECIFIC VARIATIONS OF MORPHOLOGICAL CHARACTERS AND MUSCLE PROTEINS IN THE FORMOSAN *KYPHOSUS* FISHES[1]

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Sin-Che Lee and Jung-Ti Chang (1983) Interspecific variations of morphological characters and muscle proteins in the Formosan *Kyphosus* fishes. *Bull. Inst. Zool., Academia Sinica* 22(1): 83-89. The genus *Kyphosus* is represented by two valid species, *Kyphosus lembus* and *K. cincerascens* in Taiwan. Comparisons on some morphological characters and electrophoretic patterns of soluble muscle proteins between these species were made. *K. cincerascens* is distinguishable from *K. lembus* in having the soft dorsal rays higher than the spinuous portion of the dorsal, fewer fin rays and an extra major electrophoretic band. The biochemical dendrogram of genetic relationship shows that *Kyphosus* species are more closely resemble than to the *Girella* spp. Three out of 28 *K. lembus* specimens with the same protein patterns had fewer fin rays (dorsal soft rays 12-13, anal soft rays 11-12), a character state similar to that of *K. biggibus*. It is not certain whether these 3 specimens represent a meristic variation of *K. lembus* or are conspecific of *K. biggibus*.

The genus *Kyphosus* is readily recognizable from the closely related genus *Girella* in having exposed maxillae and teeth on vomer, palatines and tongue. Only two species of *Kyphosus* (*K. lembus* and *K. cincerascens*) has been recorded from the waters of Taiwan (Chen, 1969). *K. lembus* (Fig. 1) can be distinguished from *K. cincerascens* (Fig. 2) by morphological character such as the relative length of the soft dorsal rays and spines and meristic characters such as scale and fin ray counts. However, the above differential characters are somewhat overlapped among individuals of these species. The purpose of this paper are: 1) to determine the species-specific electrophoretic patterns of soluble proteins extracted from the white skeletal muscle of *Kyphosus* spp. and 2) to compare the results with those of morphological examinations. The electrophoretic pattern of *Girella melanichthys* is compared with that of *Kyphosus* spp. for a more comprehensive view of the overall phylogenetic relationships among the members of Kyphosidae.

MATERIALS AND METHODS

Twenty eight *Kyphosus lembus*, 32 *K. cincerascens and* 27 *Girella melanichthys* used in this study were collected from the waters around Keelung and Hengchun located at the northern and southern coasts of Taiwan, respectively, during March and June 1981. A piece of white skeletal muscle removed from the shoulder was homogenized with phosphate buffer (KH_2PO_4 -K_2HPO_4, I=0.05, PH=7.5) (1:2 W/V). The homogenate was centrifuged (6,000 rpm, 15 minutes, 4°C) and the creamy upper layer of the extracts was applied to the thin slab gel (acrylamide 7.5%), with a proportion of 100 μl extracts, 20 μl 40% sucrose and 5 μl 0.5% bromophenol blue as an indicator. The gel preparation included the upper stacking gel and the lower separating gel. Trisglycine buffer

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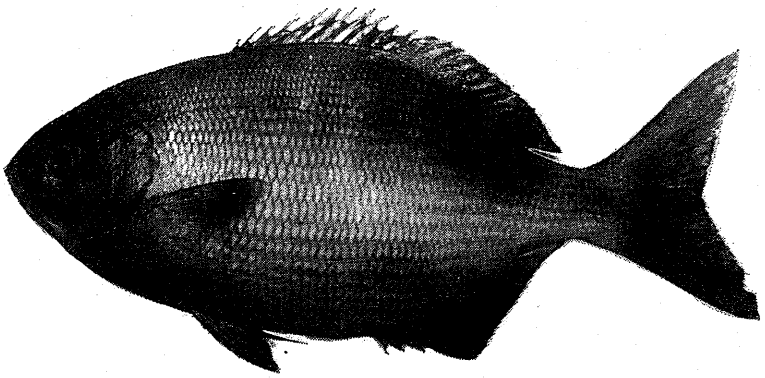

Fig. 1. *Kyphosus lembus*, 202 mm SL.

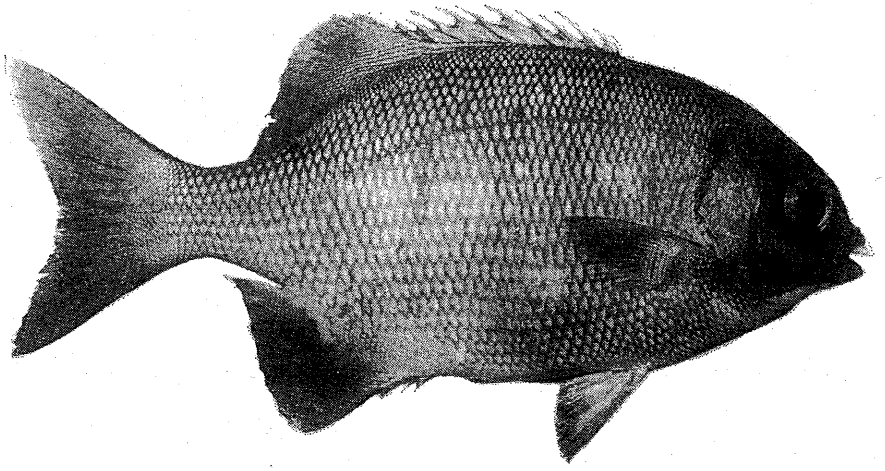

Fig. 2. *Kyphosus cincerascens*, 193 mm SL.

was used as tray buffer system. After about two hours of electrophoretic running with a current of 25 mA at 4°C, the gels were then stained with 1% amido black in 7% acetic acid.

Based on the data in Fig. 8 and Table 4, the genetic distance (D) was calculated from $D = -\log_e I$ (Nei, 1975), where I is the genetic identity derived from the formula $I = \sum X_i Y_i / \sqrt{\sum X_i^2 \sum Y_i^2}$. The biochemical dendrogram was drawn according to the data derived from the above equation.

The measurements taken were fork length, standard length, head length, body depth, snout length, eye diameter, scale length and the lengths of longest dorsal spine and soft ray. Average scale length for each fish was obtained from measurement of 10 scales removed from the area under the pectoral fin. Counts of dorsal and anal fin rays and vertebrae were based on radiographs. Number of gill-rakers was obtained from the left first gill arch.

Test of differences between pairs of regression lines were performed by covariance analysis. Single and double asterisks in the figures indicate the significant level of 0.05 and 0.01, respectively.

RESULTS

Body proportion

The regression lines of head length (Fig. 3) against standard length and both snout length (Fig. 4) and eye diameter (Fig. 5) against head length have shown longer head and snout, and larger eye in *Kyphosus cincerascens* than those in *K. lembus*. The ratio between the length of

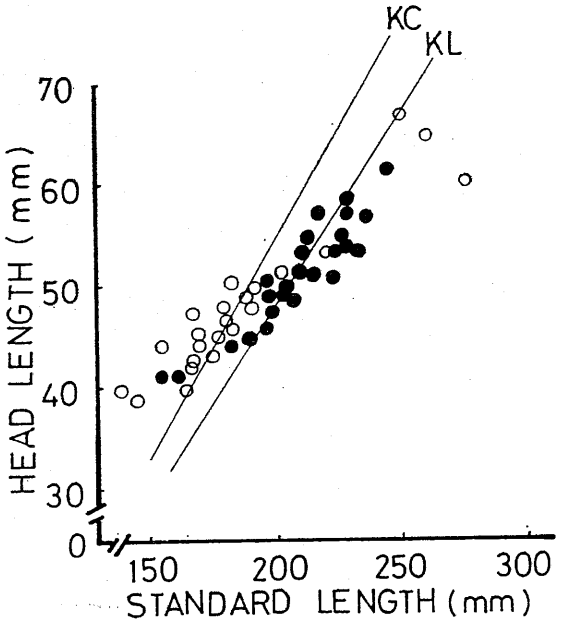

Fig. 3. Head length *vs* standard length of *Kyphosus lembus* (•) and *K. cincerascens* (◦).
KC: $Y=7.14+0.22X$ ($r=0.92$)
KL: $Y=5.92+0.22X$ ($r=0.96$)
Comparison of slopes: Fb=0.00 NS.
Comparison of elevation: Fa=6.63*, significant at 5% level.

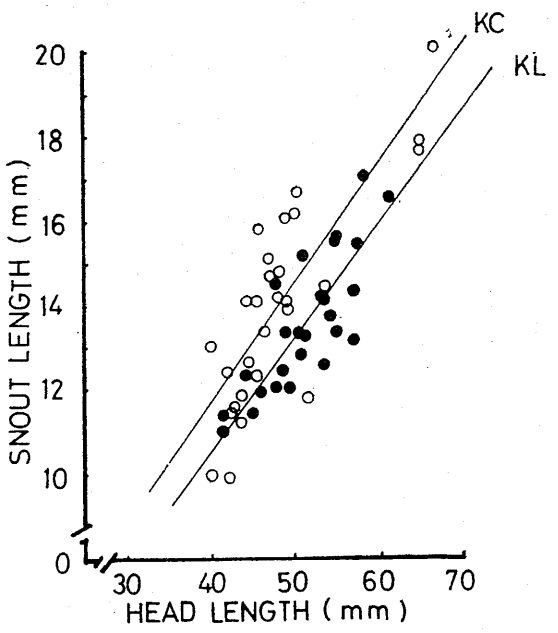

Fig. 4. Snout length *vs* head length of *Kyphosus lembus* (•) and *K. cincerascens* (◦).
KC: $Y=0.36+0.28X$ ($r=0.82$)
KL: $Y=-0.15+0.27X$ ($r=0.83$)
Comparison between slopes: Fb=0.07 NS.
Comparison between elevation: Fa=14.98**, significant at 1% level.

longest dorsal spine and that of the longest soft ray is 0.98–1.57 ($m=1.23$) in *K. lembus* (Fig. 1) and 0.60–0.90 ($m=0.78$) in *K. cincerascens* (Fig. 2).

Meristic counts

The number of soft dorsal rays (Table 1) ranged from 12 to 14 (mostly 14) in *Kyphosus lembus* and 12 in *K. cincerascens*. The anal soft rays ranged 11–14 (mostly 13) in *K. lembus* and 11 in *K. cincerascens*. Vertebral counts of both *K. lembus* and *K. cincerascens* were mostly 26 with the exception of 12.5% of the *K. cincerascens* specimens examined which were 25.

The frequency distribution of gill-raker counts (Table 2) indicated that *K. lembus* has slightly fewer gill-rakers (mean 26.26 ± 3.08, mode at 26) than *K. cincerascens* (mean 27.34 ± 1.56, mode at 28).

The average size of scales in *K. cincerascens* was slightly larger than that of *K. lembus* (Fig.

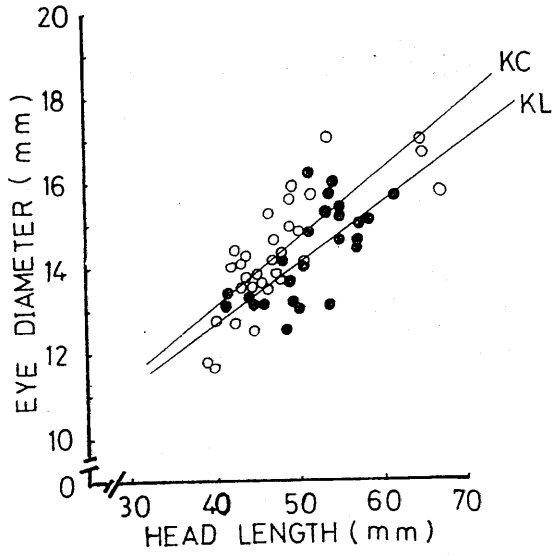

Fig. 5. Eye diameter *vs* head length of *Kyphosus lembus* (•) and *K. cincerascens* (◦).
KC: $Y=6.72+0.16X$ ($r=0.80$)
KL: $Y=6.96+0.14X$ ($r=0.70$)
Comparison between slopes: Fb=0.20 NS.
Comparison between elevation: Fa=6.99*, significant at 5% level.

TABLE 1
Frequency distribution of the meristic counts of *Kyphosus*

Soft rays	*K. lembus* (*N*=28)	*K. cincerascens* (*N*=32)
Dorsal		
12	2	32
13	1	0
14	25	0
Anal		
11	2	32
12	1	0
13	24	0
14	1	0

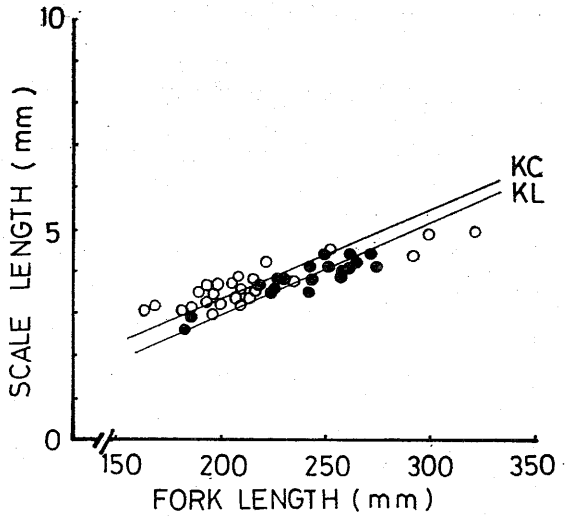

Fig. 6. Scale length *vs.* fork length of *Kyphosus lembus* (•) and *K. cincerascens* (◦).
KC: $Y=0.84+0.01X$ ($r=0.90$)
KL: $Y=0.34+0.01X$ ($r=0.87$)
Comparison between slopes: Fb=0.65 NS.
Comparison between elevation: Fa=4.50*, significant at 5% level.

6). *K. lembus* has more rows of scales between the middle of the base of spinuous dorsal and lateral line (10-12, $m=10.59$) than *K. cincerascens* (8-10, $m=9.09$; Table 3). The vernacular names for these *Kyphosus* spp. at Hengchun are given according to scale size; *K. lembus* is called the small-scaled sea chub, while *K. cincerascens* the large-scaled sea chub.

TABLE 2
Frequency distribution of the gill-raker counts of the *Kyphosus* of Taiwan

Gill rakers	*K. lembus* (*N*=27)	*K. cincerascens* (*N*=32)
18	1	0
19	0	0
20	0	0
21	1	0
22	0	0
23	1	0
24	2	2
25	4	2
26	7	4
27	4	8
28	3	10
29	1	3
30	1	3
31	0	0
32	0	0
33	2	0
Mean ± S.E.	26.26±3.08	27.34±1.56

TABLE 3
Frequency distribution of the numbers of scales between the middle of spinuous dorsal base and lateral line

No. of scales	*K. lembus* (*N*=27)	*K. cincerascens* (*N*=32)
8	0	4
9	0	21
10	13	7
11	12	0
12	2	0
Mean ± S.E.	10.59±0.64	9.09±0.59

Electrophoretic patterns

The patterns of muscle proteins of 60 specimens of *Kyphosus* spp. were grouped into two types based on the number, density and mobility of their component bands. In *Kyphosus*, there were 4 component bands designated as 1, 2, 4 and 5 by their positions from the cathodal side to anodal side. All twenty-eight specimens of *K. lembus* had bands 1, 4 and 5, and all 32 specimens of *K. cincerascens* had

TABLE 4
Frequencies of protein bands on the gels of *Kyphosus lembus* (KL), *K. cincerascens* (KC) and *Girella melanichthys* (GM) appeared in Fig. 7

Protein variants	KL (N=28)		KC (N=32)		GM (N=27)	
1	28	1.0000	19	0.5938	0	0
1′	0	0	0	0	27	1.0000
null	0	0	13	0.4063	0	0
2	0	0	31	0.9688	0	0
2′	0	0	0	0	13	0.4815
null	28	1.0000	1	0.0312	14	0.5185
3	0	0	0	0	22	0.8148
null	28	1.0000	32	1.0000	5	0.1852
4	26	0.9286	32	1.0000	26	0.9630
null	2	0.0714	0	0	1	0.0370
5	28	1.0000	32	1.0000	26	0.9630
null	0	0	0	0	1	0.0370
6	0	0	0	0	27	1.0000
null	28	1.0000	32	1.0000	0	0
		1.0000		1.0000		1.0000

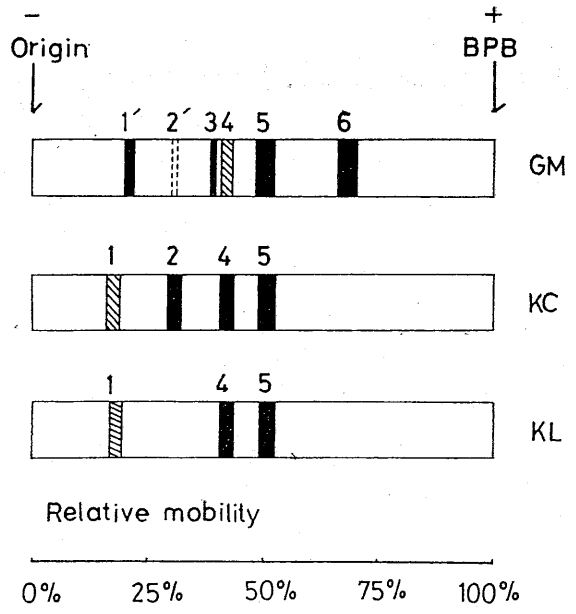

Fig. 7. Electrophoretic patterns of soluble proteins (skeletal muscle) of *Kyphosus lembus* (KL), *K. cincerascens* (KC) and *Girella melanichthys* (GM). Each zone was numbered 1-6 from cathode side. Black, hatched and white bands indicate strongly, moderately and weakly stained band on the gels, respectively. BPB, the indicating mark stained by Bromophenol blue.

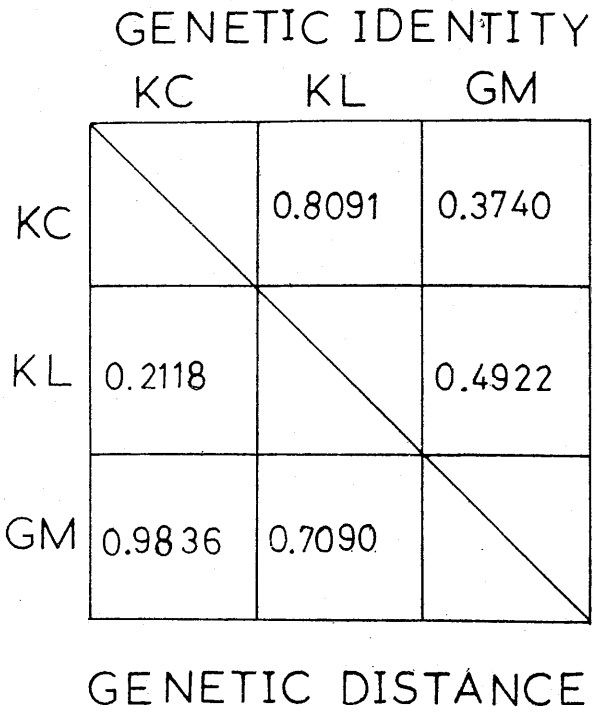

Fig. 8. Mean genetic identity (I) and genetic distance (D) calculated from the frequencies of the soluble protein electrophoretic bands of each species.

bands 1, 2, 4 and 5. The twenty-seven *Girella melanichthys* specimens analyzed had bands 1′, 2′, 3, 4, 5 and 6 (Fig. 7; Table 4).

From the formula of Nei, 1975, the genetic distance (D) were 0.2118, 0.7090 and 0.9836, respectively for *K. lembus vs K. cincerascens; K. lembus vs Girella melanichthys;* and *K. cincerascens vs G. melanichthys* (Fig. 8).

DISCUSSION

In the north western Pacific region, only *Kyphosus lembus* and *K. cincerascens* were previously reported (Matsubara, 1955). However, a third species, *K. biggibus* from southern Japan has been added recently by Zama (1976). The distinctive characters among the above three species are the proportion of the height of the longest soft dorsal ray and longest dorsal spine, and fin ray counts. *K. cincerascens* is clearily distinguishable from the other two species in having the soft dorsal rays higher than the

TABLE 5
Some meristic and morphometric data of *Kyphosus biggibus*, *K. lembus* and *K. vaigiensis* done by several authors

Species	Authors	Soft dorsal rays	Soft anal rays	Scales above lateral line	Head L. / Eye D.
K. biggibus	Smith, 1965	12-14	11-13	12	—
	Masuda *et al.*, 1980	10-12	10-12	—	—
	Zama, 1976	11-13	10-12	11-14	—
K. lembus	Fowler, 1928	14	13	11-13	3.7-4.0
	Weber and de Beaufort, 1936	14	12-13	11	3.5-4.0
	Munro, 1967	14	12-13	11-13	3.5-4.0
	Masuda *et al.*, 1980	14	12-13	—	—
	Zama, 1976	14	13	11-12	—
	Present author	12-13	11-12	11-12	3.10-3.92
		14	13-14	10-12	3.17-4.08
K. vaigiensis	Fowler, 1928	14	13	12	3.6
	Weber and de Beaufort, 1936	14-15	12-13	11	2.0?
	Schultz, 1953	14	13	10	3.8
	Smith, 1965	13-15	13-14	11	—
	Munro, 1967	14-15	12-13	11-12	3.0-3.6
	Jones and Kumaran, 1980	14	12-13	11	3.5-3.7

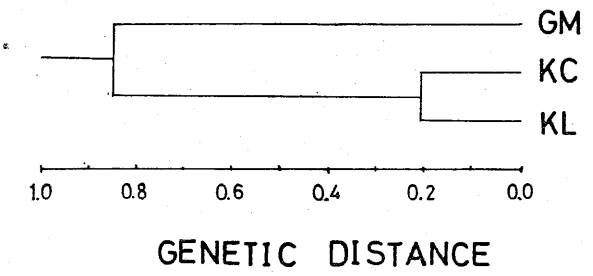

Fig. 9. Phyletic relationships of *Kyphosus lembus* (KL), *K. cincerascens* (KC) and *Girella melanichthys* (GM).

dorsal spinuous portion. In comparison with other kyphosids, *K. biggibus*, *K. lembus*, and *K. vaigiensis* have shorter soft dorsal rays (Table 5). Among them, *K. biggibus* has fewer dorsal rays, while *K. vaigiensis* has slightly more dorsal rays (Table 5). Three out of the twenty-eight specimens of *K. lembus* with the same electrophoregram had 12-13 soft dorsal rays and 4 with 11-12 soft anal rays. Their ray counts agree quite well with the diagnostic characters of *biggibus*. However, external features of *K. biggibus*, *K. lembus* and *K. vaigiensis* are closely resemble each other. As such, they may be conspecific. Electrophoretic analysis of *K. biggibus* and *K. vaigiensis* may provide evidence to support this view. The genetic distance data demonstrated that *Girella* species is widely separated from the *Kyphosus* species (Fig. 9). This phyletic relationship is well supported by morphological characters, *i.e.*, the tooth patterns.

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臺灣產舵魚屬魚類形態特徵及肌肉蛋白之種間差異

李 信 徽　張 戩 悌

臺灣海域產之舵魚屬（*Kyphosus*）魚類現已知道者有蘭勃舵魚（*Kyphosus lembus*）及天竺舵魚（*K. cincerascens*）二種。本文將兼用形態特徵及肌肉蛋白之電泳分析比較此二種舵魚。典型之天竺舵魚背鰭軟條部一般較硬棘部爲高、背鰭及臀鰭軟條數均較少、電泳譜帶則多出第二帶、而與蘭勃舵魚有別。由遺傳距離之資料顯示二種舵魚間之關係較爲接近、與瓜子鱸屬（*Girella*）之關係則較爲疏遠、似乎可應證形態特徵與生化特徵之一致性。28尾具有相同電泳譜帶之蘭勃舵魚中、有3尾具有較少之背鰭軟條（12～13）及臀鰭軟條（11～12）與另一種舵魚 *K. biggibus* 之特徵符合。殊不知此3尾標本爲蘭勃舵魚之形態變異，抑或應隸屬於 *K. biggibus*，將有待進一步之探討。