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COMPARATIVE STUDIES OF THE FISHES OF THE GENUS *GIRELLA* FROM TAIWAN[1]

SIN-CHE LEE and JUNG-TI CHANG

Institute of Zoology, Academia Sinica
Taipei, Taiwan 115,
Republic of China

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Sin-Che Lee and Jung-Ti Chang (1981). Comparative studies of the fishes of the genus *Girella* from Taiwan. *Bull. Inst. Zool., Academia Sinica* **20**(1): 9-16. The comparison of three *Girella* species based on morphological and biochemical characters was studied. There are little differences in body proportions and fin ray counts among them. The gill rakers of the left first arch are 32-41 (mostly 35) in *Girella melanichthys*, 40-49 (mostly 43) in G. *punctata* and 36-40 (mostly 40) in *G. mezina*. The operculum is scaled only on its ⅓ upper part in *G. melanichthys* while scaled on its ½ upper part in *G. punctata* and scaled completely in *G. mezina*. Body scales in *G. melanichthys* are slightly smaller than those in *G. punctata* and *G. mezina*. Tips of caudal fin are rounded in *G. mezina* and otherwise pointed in other two species. *G. melanichthys* has a black opercular margin to separate from the other two species. Electrophoretic patterns of proteins from skeletal muscle are similar. However, the genetic distances estimated from the proteins show somewhat differences. On the basis of some morphological characters and the phylogenetic tree obtained from the soluble muscle proteins electrophoresis, the Taiwan *Girella* can be grouped into two groups: *G. melanichthys* in one group and the other with *G. mezina* and *G. punctata*.

The fishes of the nibblers of the genus *Girella* are tropical or subtropical fishes, feeding on sea algae and occasionally on small animals including copepods, amphipods and decapod larvae. Their distributions are confined to an area from Japan, southwards to the East China Sea, Taiwan and Hongkong. The range of *G. punctata* extended as far as the Batan Island, Philippines. The three species, *G. mezina*, *G. punctata* and *G. melanichthys*, frequently occur in the northern coast of Taiwan. They are of considerable commercial value, especially *G. punctata*. They are frequently taken in the gill net or angled by fishermen and game-fish anglers.

All three species of *Girella* (*G. mezina*, *G. punctata* and *G. melanichthys*) were once placed in the family Girellidae which was distinguished from the closely allied family Kyphosidae by having cusps on teeth and no tooth on vomer, palatines and tongue. However, Greenwood *et al.*[5] combined both families into a single family Kyphosidae.

The synoptic key for identifying Taiwanese *Girella* was prepared by Chen[1], however, some meristic characters used to distinguish species from one another were, to some extent, overlapped. It is therefore, attemped to make a more extensive comparative study on their morphometric, meristic and electrophoretic characters and discuss the relationships among them.

MATERIALS AND METHODS

Thirty one specimens of *Girella melanichthys* and 55 *G. punctata* from the northern coast and

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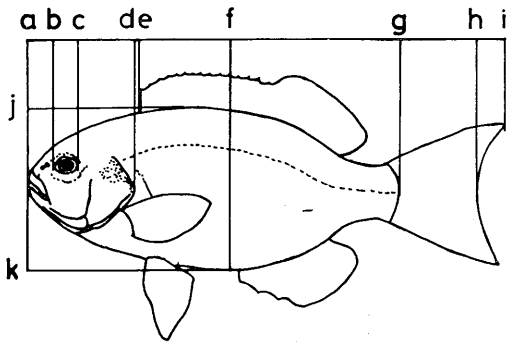

Fig. 1. Methods of measuring in the fishes of *Girella*.
a-i, total length; a-h, fork length; a-g, standard length; j-k, body depth; a-e, predorsal length; a-f, preanal length; a-d, head length; a-b, snout length; b-c, eye diameter.

5 *G. mezina* from the southern coast of Taiwan were used in this study. With the aid of vernier caliper, the measurements including total length, fork length, standard length, predorsal length, preanal length, body depth, head length, snout length, mouth cleft length and eye diameter (see Fig. 1) were made.

Meristic counts on dorsal and anal fin rays and vertebrae were based on radiographs. Count of gill-rakers was only done for the left first arch.

Fresh skeletal muscle taken from a part of trunk under the tip of pectoral fin was frozen at −20°C for the electrophoretic analysis. The defrosted muscle with equal volume of Phosphate buffer (KH_2PO_4-K_2HPO_4) (I=0.05, PH=7.5) was homogenized. The homogenate was centrifuged at 3000 rpm for 15 minutes. The extracts from the upper layer of liquid in tube were applied directly on the gels. Gel was prepared according to the formula of Nagai[11]. Bisacryalmide in the contents at 5% of total concentration of acryalmide (T=5%) was the most satisfactory concentration. Tris-glycine buffer[14] was used as tray buffer system. After 3-4 hours of running polyacryalmide disc. gel electrophoresis under the current of 35 mA, the gel was then stained with 1% Amido Black 10B in 7% acetic acid and destained in 7% acetic acid.

The genetic distance (D) was obtained from $D=-\log_e I$[12], where I, the genetic identity derived from the formula $I=J_{xy}/\sqrt{J_xJ_y}=\sum X_iY_i/\sqrt{\sum X_i^2\sum Y_i^2}$[12], based on the data in Fig. 10 and Table 3, respectively.

RESULTS

Body proportion

The measurements of body proportions are given in Table 1. The regression correlation obtained from head length (Fig. 2), preanal

TABLE 1.
Body proportions of *Girella melanichthys*, *G. punctata* and *G. mezina*, values given are range, and mean±S. D. (in parentheses)

	G. melanichthys (n=31)	*G. punctata* (n=55)	*G. mezina* (n=5)
In standard lenth			
Head length	3.34-4.10(3.50±0.20)	3.63-4.13(3.91±0.13)	3.64-3.83(3.73±0.07)
Snout length	10.06-19.36(13.42±2.44)	10.88-19.77(14.44±1.73)	14.21-18.23(15.56±1.61)
Preanal length	1.64-1.89(1.77±0.05)	1.67-1.88(1.77±0.05)	1.79-1.98(1.84±0.08)
Predorsal length	2.57-3.57(3.10±0.36)	3.16-3.88(3.51±0.17)	2.99-3.43(3.19±0.17)
Body depth	2.07-2.47(2.22±0.08)	2.15-2.51(2.35±0.07)	2.08-2.23(2.14±0.07)
In head length			
Snout length	2.83-4.76(3.61±0.50)	2.79-4.88(3.68±0.39)	3.82-4.76(4.17±0.38)
Eye diameter	3.80-4.76(4.19±0.24)	3.66-4.92(4.26±0.32)	3.32-3.62(3.40±0.13)
Mouth cleft length	2.65-3.43(3.00±0.18)	2.60-3.27(2.88±0.17)	2.61-2.90(2.77±0.11)
Mouth breadth	2.72-3.72(3.14±0.24)	2.53-3.68(3.13±0.21)	2.43-2.72(2.52±0.12)

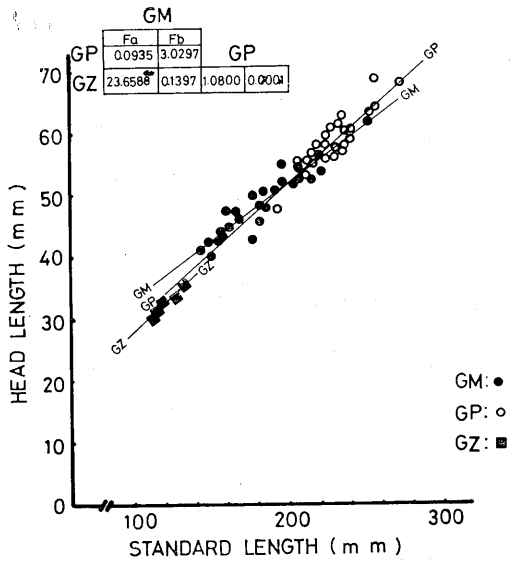

Fig. 2. Head length (mm) versus standard length (mm) of *Girella melanichthys* (GM), *G. punctata* (GP) and *G. mezina* (GZ), with significant test of regression lines among three species. **significant at 1% level.

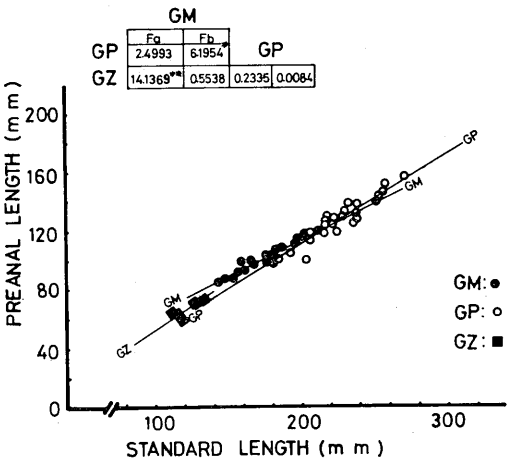

Fig. 3. Preanal length (mm) versus standard length (mm) of *Girella melanichthys* (GM), *G. punctata* (GP) and *G. mezina* (GZ) with significant test of regression lines among three species. *significant at 5% level; **significant at 1% level.

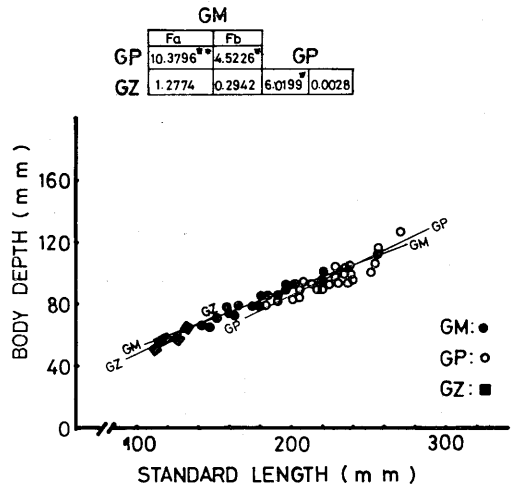

Fig. 4. Body depth (mm) versus standard length (mm) of *Girella melanichthys* (GM), *G. punctata* (GP) and *G. mezina* (GZ), with significant test of regression lines among three species. *significant at 5% level; **significant at 1% level.

length (Fig. 3) and body depth (Fig. 4) against standard lengths of three species are apparently close to each other.

Meristic characters

Fin rays: In Table 2, dorsal spines ranged 14–15 in number, mostly 15 in *Girella melanichthys* and *G. punctata* and 14 in *G. mezina;* soft rays ranged 13–16 (mode at 14 and 15) in number for *G. melanichthys*, 12–15 (mode at 13) for *G. punctata* and 13–14 (mode at 14) for *G. mezina*. The anal soft rays ranged 12–13 (mode at 13) in number for *G. melanichthys*, 11–13 (mode at 12) for *G. punctata* and 11 for *G. mezina*.

Vertebrae: The number of vertebrae including urostyle, is very consistant, the great majority of examined individuals of these species has 27, with exception of one specimen of *G. melanichthys* which has 28 vertebrae.

Scales: The relative size of scales in *Girella punctata* and *G. mezina* are slightly larger than that of *G. melanichthys* (Fig. 5). Number of scales in lateral line series are 48–60

TABLE 2.
Frequency distributions for dorsal and anal fin rays of *Girella melanichthys*, *G. punctata* and *G. mezina*

Species	No. exam.	Standard lengths (mm)	Spinuous dorsal rays			Soft dorsal rays						Anal soft rays			
			14	15	mean	12	13	14	15	16	mean	11	12	13	mean
G. melanichthys	31	142.8-251.3	3	28	14.9	0	2	14	14	1	14.45	0	3	28	12.9
G. punctata	55	185.1-271.7	12	43	14.78	4	33	17	1	0	13.27	2	49	4	12.04
G. mezina	5	115.1-133.6	5	0	14.0	0	1	4	0	0	13.8	5	0	0	11.0

(mean 53.08) in *G. punctata*, 56-59 (mean 57.2) in *G. mezina* and 54-62 (mean 58.99) in *G. melanichthys*

Gill rakers: As shown in Fig. 6, gill rakers on left first arch range 32-41 (mean 35.87) in *G. melanichthys*, 40-49 (mean 43.32) in *G. punctata* and 36-40 (mean 38.4) in *G. mezina*.

Squamation on operculum

Fig. 7 shows the differences in the occurrence of scales on operculum. The operculum of *Girella mezina* is entirely scaled while that of *G. melanichthys* and *G. punctata* are scaled only on the upper 1/8 and 1/2 portions of opercular bone, respectively.

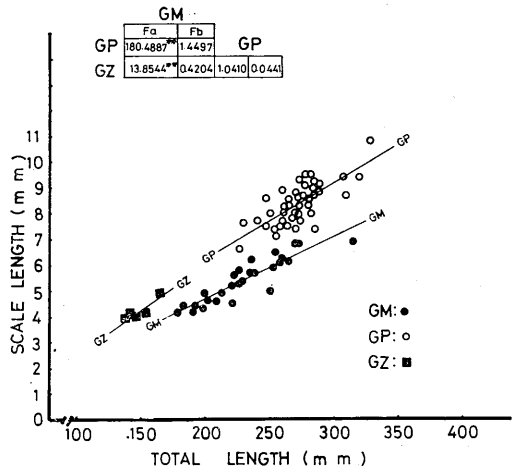

Fig. 5. Scale length (mm) versus total length (mm) of *Girella melanichthys* (GM), *G. punctata* (GP) and *G. mezina* (GZ), with significant test of regression lines among three species. **significant at 1% level.

Shape of caudal fin

As shown in Fig. 8, both upper and lower tips of caudal fin in *Girella melanichthys* and *G. puncta* are pointed while that of *G. mezina* is rounded.

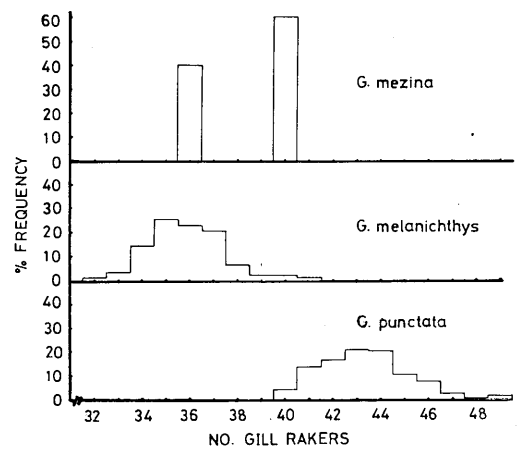

Fig. 6. Frequency distribution of the gill rakers on the left first arch of *Girella melanichthys*, *G. punctata* and *G. mezina*.

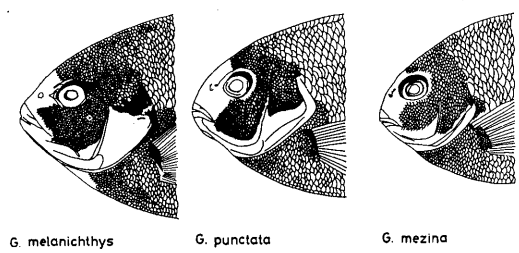

Fig. 7. Opercular scale patterns of *Girella melanichthys*, *G. punctata* and *G. mezina*.

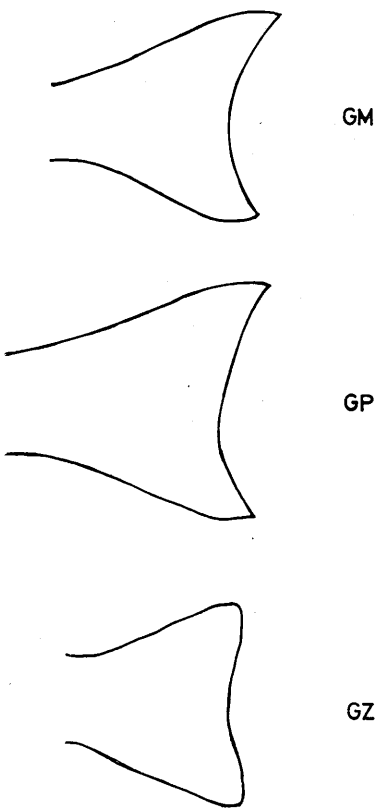

Fig. 8. The shape of caudal fin tips in *Girella melanichthys* (GM), *G. punctata* (GP) and *G. mezina*.

Coloration

The body color of all three species is generally greyish brown. However, *Girella melanichthys* has a black opercular margin to separate it from the other two species. *G. mezina* and *G. punctata* are recognized each other by that *G. mezina* has a yellowish vertical band on body side.

Electrophoresis

Based on the myogens extracted from the skeletal muscle of the genus *Girella*, the electrophoretic patterns of the three species (Fig. 9) are very close to except minor differences in mobility. However, the genetic distances among the three species estimated are 0.1438; 0.2772 and 0.7020 for *Girella punctata* vs *G. mezina*; *G. punctata* vs *G. melanichthys* and *G. melanichthys* vs *G. mezina* respectively (Figs. 10-11) based on the data in Table 3.

TABLE 3.

Frequencies of protein bands on the gels of *Girella melanichthys* (GM), *G. punctata* (GP) and *G. mezina* (GZ) appeared in Fig. 9

Protein variants	GM N=23*		GP N=29		GZ N=3	
1	22	0.9565	0	0	0	0
1′	0	0	29	1.0000	0	0
1″	0	0	0	0	2	0.6667
null	1	0.0435	0	0	1	0.3333
2	8	0.3478	12	0.4138	0	0
2′	0	0	0	0	2	0.6667
null	15	0.6522	17	0.5862	1	0.3333
3	23	1.0000	29	1.0000	0	0
null	0	0	0	0	3	1.0000
4	0	0	25	0.8621	0	0
4′	0	0	0	0	3	1.0000
null	23	1.0000	4	0.1379	0	0
5	23	1.0000	0	0	3	1.0000
5′	0	0	29	1.0000	0	0
null	0	0	0	0	0	0
6	23	1.0000	0	0	0	0
6′	0	0	29	1.0000	3	1.0000
null	0	0	0	0	0	0
7	7	0.3043	0	0	0	0
null	16	0.6957	29	1.0000	3	1.0000
		1.0000		1.0000		1.0000

* N=Number of individuals examined.

$I=\sum X_i Y_i / \sqrt{\sum X_i^2 Y_i^2}$ $\quad D=-\log_e I$

Species accounts

Key to the species of the genus *Girella* of Taiwan

1. Scales smaller (Fig. 5), upper ⅓ of operculum scaled; dorsal spines XIV-XV (mostly XV), soft dorsal rays 13-16 (mostly 14-15); anal soft rays 12-13 (mostly 13); gill rakers 32-41 (mostly 35); with black opercular margin ..... *G. melanichthys*

   Scales larger (Fig. 5), at least ½ of operculum scaled; dorsal spines XIV-XV; without black opercular margin 2

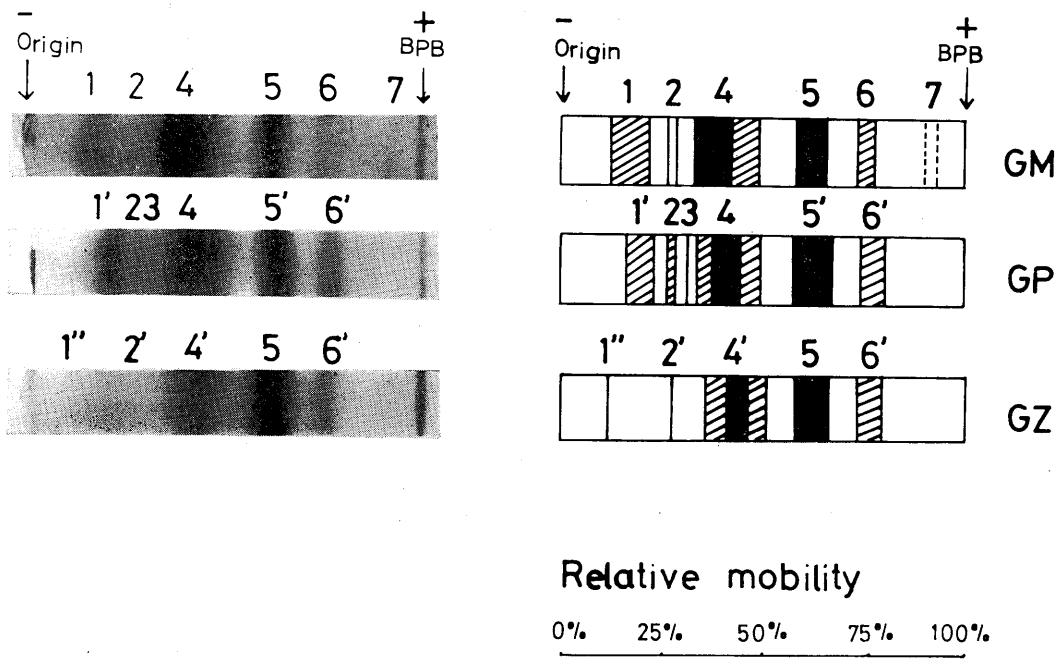

Fig. 9. Electrophoretic patterns of soluble proteins (skeletal muscle) of *Girella melanichthys* (GM), *G. punctata* (GP) and *G. mezina* (GZ). Each zone was numbered 1-7 from cathode side. Black, hatched and white bands indicate strongly, moderately and weakly stained band on the gels, respectively.

Genetic identity

	GM	GP	GZ
GM		0.4380 ±0.5009	0.3330 ±0.4508
GP	0.2772 ±0.6922		0.3379 ±0.4716
GZ	0.7020 ±1.4494	0.1438 ±0.3805	

Genetic distance

Fig. 10. Genetic identity (I) and genetic distance (D) produced from the formula $I=\sum X_i Y_i / \sqrt{\sum X_i^2 Y_i^2}$ and $D=-\log_e I$, respectively, on the basis of the data in Table 3.

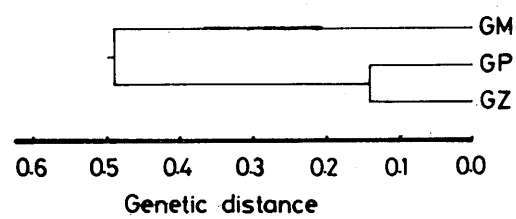

Fig. 11. Phylogenetic tree for the three species of *Girella*, which was produced from the genetic distance data in Fig. 10.

2. Operculum entirely scaled; tips of caudal fin rounded; gill rakers 36-40 (mostly 40); dorsal soft rays 13-14 (mostly 14); anal rays 11; yellowish vertical band present on body side ..... *G. mezina*

Operculum partly scaled; tips of caudal fin sharp; gill rakers 40-49 (mostly 43); dorsal soft rays 12-15 (mostly 13); anal soft rays 11-13 (mostly 12); no yellowish band on body side..... *G. punctata*

***Girella melanichthys* (Richardson)**

Crenidens melanichthys Richardson, 1846: 243 (on *Melanychthys* Temminck and Schlegel, 1842: 75, type locality: Nagasaki Bay, Kyushu, Japan).
Crenidens leoninus Richardson, 1846: 242 (Canton).
Girella melanichthys; Fowler, 1940: 522; Chu, 1957: 18; Matsubara 1955: 647; Chen, 1969: 375; Masuda *et al.*, 1975: 227.

Diagnosis: Head length 3.34–4.10, body depth 2.07–2.47 in standard length. Snout 2.83–4.76 and eye 3.80–4.76 in head length. D. XIV–XV (mostly XV), 13–16 (mostly 14 or 15); A. III, 12–13 (mostly 13); vertebrae 27–28 (mostly 27); Ll. 54–62; gill rakers 32–41. Tips of caudal fin sharp; a black margin on operculum.

***Girella mezina* Jordan and Starks**

Girella mezina Jordan and Starks, 1907: 196 (type locality: Riukiu, Japan); Jordan and Richardson, 1909: 190; Matsubara, 1955: 647; Chen, 1969: 375; Masuda *et al.*, 1975: 227.

Diagnosis: Head length 3.64–3.83, body depth 2.08–2.23 in standard length. Snout 3.82–4.76 and eye 3.32–3.62 in head length. D. XIV, 13–14 (mostly 14); A. III, 11; vertebrae 27; Ll. 56–59; gill rakers 36–40. A distinct yellowish vertical band on body side; completely scaled operculum; round-tipped caudal fin.

***Girella punctata* Gray**

Girella punctata Gray, 1833: pl. 98, Figs. 3 & 4 (type locality: China); Gunther, 1859: 427; Herre, 1927: 434; Fowler, 1940: 521; Matsubara, 1955: 647; Chen, 1969: 375; Masuda *et al.*, 1975: 226.
Crenidens punctatus; Richardson, 1846: 242.

Diagnosis: Head length 3.63–4.13, body depth 2.15–2.51 in standard length. Snout 2.79–4.88 and eye 3.66–4.92 in head length. D. XIV–XV (mostly XV), 12–15 (mostly 13); A. III, 11–13 (mostly 12); vertebrae 27; Ll. 48–60; gill rakers 40–49. Tips of caudal fin sharp; without black opercular margin.

DISCUSSION

The genus *Girella* was described by Gray[4] in 1833. The genera *Melanichthys* of Temminck and Schlegel, 1844[16] and *Crenidens* of Richardson, 1846[15] were the synonyms of genus *Girella*. In 1859, Gunther[6] evidently included *G. melanichthys* under *G. punctata*, however, these two species were distinct[7] due to the possession of uniserial outer jaw teeth in *G. punctata* and 2–4 rows of such teeth in *G. melanichthys*[3]. *G. mezina* was added as third *Girella* species according to Jordan and Richardson[8].

The application of the electrophoretic technique for the taxonomical study of various fish groups reveals that the electrophoregram of protein represents species specific characters[17]. The result of the present investigation shows that the examination of electrophoretic patterns of muscle protein is useful to compare closely related species and to estimate the phylogenetic relationships among *Girella* species. The soluble protein extracted from skeletal muscle shows species specificity. The numbers of bands are considered as a criterion to evaluate the relationship; the more closely related species have more bands in common[17]. Comparison with the genetic distance estimated from the electrophoretic patterns among the three species (Figs. 10–11), it seems that *Girella melanichthys* is well separated from the other two species.

As to the morphological characters, the possession of a distinct black opercular margin, smaller sized scales, wider naked area on operculum, larger head in *G. melanichthys* are easily distinguished from the other two species. The phylogenetic tree in Fig. 11 evidently supports the data of morphological analysis. Thus, the Taiwan *Girella* can be grouped into two groups: *G. melanichthys* in one and the other group with *G. mezina* and *G. punctata*.

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臺灣產瓜子鱲 (*Girella*) 屬魚類之比較研究

李 信 徽　　張 戎 悌

本文記述黑瓜子鱲 (*Girella melanichthys*)、瓜子鱲 (*G. punctata*) 及黃帶瓜子鱲 (*G. mezina*) 等三種魚類之形態與生化特徵之比較研究。三種間之體部比例及各鰭條數之差異甚微。左側第一鰓弧之鰓耙數，黑瓜子鱲爲 32～41 (多爲 35)，瓜子鱲爲 40～49 (多爲 43)，而黃帶瓜子鱲爲 36～40 (多爲 40)。黑瓜子鱲之鰓蓋僅其上方 1/3 部份被鱗，瓜子鱲則約 1/2 被鱗，而黃帶瓜子鱲則全部被鱗。黑瓜子鱲之體鱗一般較其他二種魚爲細小。黃帶瓜子鱲之尾鰭上下葉均鈍圓，其他二種則較爲尖銳。黑瓜子鱲之鰓蓋具黑色後緣，可與其他二種輕易區分。三種魚類骨肌之水溶性肌蛋白之電泳圖極爲相似，然據以估算之遺傳距離則顯示出極有趣之差異。綜合若干形態特徵及由電泳圖推判之系統樹，臺灣產之瓜子鱲屬 (*Girella*) 魚類大致可分成二個種羣：即黑瓜子鱲與另一種羣包括瓜子鱲及黃帶瓜子鱲。在類緣關係上黑瓜子鱲與黃帶瓜子鱲較爲疏遠，與瓜子鱲之關係則次之；瓜子鱲與黃帶瓜子鱲則最爲接近。