Bull. Inst. Zool., Academia Sinica **25**(1): 67-77 (1986)

SYSTEMATIC REVISION OF FOUR FORMOSAN *LAGOCEPHALUS* SWELL-FISHES WITH PARTICULAR REFERENCE TO ELECTROPHORETIC COMPARISON ON SOLUBLE MUSCLE PROTEINS[1]

MENG-HSIEN CHEN, KUN-HSIUNG CHANG

Department of Marine Resources, Sun-Yat Sen University,
Kaohsiung 800, Republic of China

and

SIN-CHE LEE[2]

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

(Accepted December 4, 1985)

Meng-Hsien Chen, Kun-Hsiung Chang and Sin-Che Lee (1986) Systematic revision of four Formosan *Lagocephalus* swell-fishes with particular reference to electrophoretic comparison on soluble muscle proteins. *Bull. Inst. Zool., Academia Sinica* **25**(1): 67-77. This paper deals with the electropherograms of soluble muscle proteins of four *Lagocephalus* species (*L. inermis, L. lunaris, L. wheeleri* and *L. gloveri*) and the results are described and discussed in relation to the morphological data to demonstrate the phylogenetic relationships among them. All these species are very similar with one another in external appearance, however, a minor difference in color patterns, occurrence of tilly bones, number of caudal vertebrae and spinulose patterns on the back are suitable for use in identification of species. From the dendrogram constructed using UPGMA clustering procedure and the phylogenetic tree using Fitch-Margoliash procedure, it is suggested that *L. wheeleri* and *L. gloveri* are the most closely related pairing with similar spinulose pattern on the back and same caudal vertebrae of 11. *L. inermis* is considerably more distant from all other species by its completely naked predorsal area. *L. lunaris* though with spinulose back, is closer to *L. inermis* than to other twos. The relationships among the three other than *L. inermis, L. lunaris* is slightly closer to *L. wheeleri* than *L. gloveri* which has different body shape from the rest of species. The systematic position of the *Lagocephalus* species essentially agrees with the pattern of relationships established using conventional taxonomic approaches stated in the key.

The swellfish of the genus *Lagocephalus* is commonly known as food fish in Taiwan, which is usually sold to local consumers as fresh or dried-seasomed meat and is exported to Japan as frozen raw meat. In recent years, study of swellfish has been receiving renewed attention since there has been occasionally food-intoxicated cases occurring in Taiwan and Japan when eating them. It is suggested that there must be some taxonomic problems among *Lagocephalus* species to confuse fish dealers or consumers since the toxicity is species-specific and which may vary with

1. Paper No. 269 of the Journal Series of the Institute of Zoology, Academia Sinica.
2. To whom reprint request should be sent.

seasons and geographical distributions. In this sense, it is aimed at this report to clarify the validity of these species morphologically and biochemically in order to infer the phylogenetic relationship among species. It is expected to provide a key to species, specific diagnostic characters with color illustrations and electrophoretic patterns on muscle proteins. We believe this will be of great help for fishermen and consumers to identify these fishes properly.

In the Taiwan area, a comprehensive account of *Lagocephalus* species was made by Yang (1970) who stated three species namely, *L. laevigatus inermis* (=*L. inermis*, not toxic except liver and gonads), *L. lunaris lunaris* (=*L. lunaris*, strong toxic from South China Sea while not toxic from Taiwan) and *L. lunaris spadiceus* (=*L. gloveri*, not toxic). A fourth form believed to be the hybrid between *L. inermis* and *L. lunaris* (Harada, 1979) is now treated as a valid species *L. wheeleri* (Abe, Tabeta and Kitahama, 1984) which is a common food fish in Southern Japan.

MATERIALS AND METHODS

A total of 1,774 frozen specimens including 88 *Lagocephalus inermis*, 548 *L. lunaris*, 957 *L. gloveri* and 181 *L. wheeleri* were collected from the coastal waters off Shimen, Tashi, Kaohsiung, Tungkang and Pescadores. They were remained at steadily frozen condition on the way to the laboratory. A piece of shoulder muscle below the dorsal origin was removed immediately after the arrival of specimens and then deep-freezed at −20°C until further electrophoretic procedure. Liver and gonads were removed for the purpose of a subsequent project on toxicity experiment. The remaining body was made on meristic counts and preserved in 10% formalin thereafter.

Point five gram of muscle tissue was used for electrophoresis with the same method follow Lee and Chang (1983) except the electric current was set at 35 mA and the time of running was extended to 3 hours.

The genetic distance (D) was obtained from $D=-\log_e I$, where I, the genetic identity, deriving from $I=\sum X_iY_i/\sqrt{\sum X_i^2\sum Y_i^2}$ (Nei, 1972) based on the data in Fig. 4 and Table 5, and were subsequently employed for dendrogram construction using UPGMA procedure (Sneath and Sokal, 1973) and Fitch-Margoliash procedure (1967). These are normal procedure to make quantitative assessment of the similarities and differences between species.

The morphological features described in this report include coloration, shape of fins, distributional pattern of predorsal cutaneous spinules, fin formulae, number of vertebrae and occurrence of tilly bones (or osteophyma-like swelling) on caudal vertebrae.

RESULTS

Morphological comparisons

Coloration: Fig. 1A–D shows that the coloration on the upper surface of body is quite different among species. *Lagocephalus gloveri* is the only species with black or blackish green back. *L. inermis* has pale-brown back in young, which is darkened in adult. Both *L. lunaris* and *L. wheeleri* have yellowish green back but distinguishable by having irregular dark cross bands in the latter. Gill-opening is black in *L. inermis* and *L. wheeleri*, greyish in *L. gloveri* and whitish in *L. lunaris*. Dorsal fin is uniformly yellow in *L. lunaris* and *L. wheeleri*, black in *L. gloveri* and pale-brown with black distal margin in *L. inermis*. As for the caudal fin coloration in *L. inermis*, it is grey with very small whitish tips on both lobes at young, the range of whitish tips almost extends to distal half of upper and ventral margins of rounded caudal fin at adult. In the case of *L. lunaris*, caudal fin in yellow on upper two third with very small whitish tip and is whitish on lower one third. In *L. wheeleri*, caudal fin is entirely yellow except the very small whitish posterior tips. In *L. gloveri*, caudal is black or greenish black with much broader whitish tips than those in *L. wheeleri*.

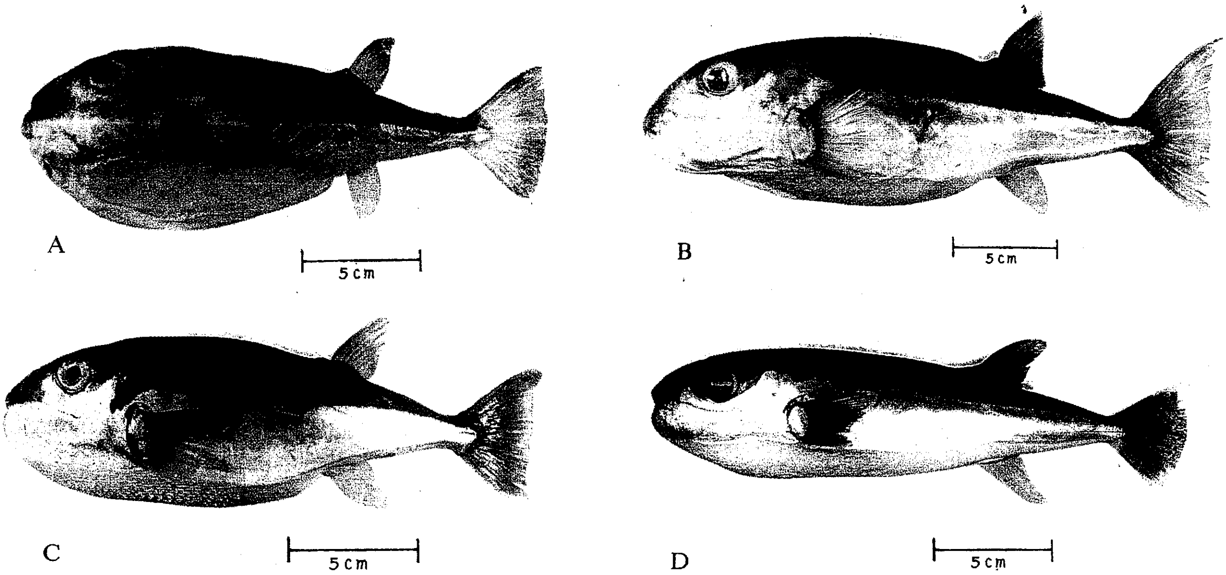

Fig. 1. Lateral view of *Lagocephalus inermis* (A), *L. lunaris* (B), *L. wheeleri* (C), and *L. gloveri* (D).

Predorsal cutaneous spinules: Six types of dorsal spinulose patterns (Fig. 2, Table 1) among specimens are designated according to the following criteria.

Type 0: The whole back naked.

Type I: Spinulose area on the back rhombic in shape extending from upper edge of orbit to above the middle of pectoral.

Type II: Spinulose area of same shape as Type I, but its rear end extends beyond half the length of pectoral or to the tip of pectoral.

Type III: The spinulose area of similar pattern to that in the above two types except few interrupted spinules in between posterior tip of rhombic area and dorsal origin.

Type IV: Rhombic spinulose area slender posteriorly, extending continuously toward the dorsal origin.

Type V: The spinulose area broad ovoid in shape coveiing the whole predorsal area.

Table 1 shows that *L. inermis* belongs to Type 0 with the whole back naked which is ieadily distinct from the rest of species. *L. lunaris* belongs to Type V with broad ovoid shape of spinulose pattern. The spinulose pattern in *L. wheeleri* and *L. gloveri* include widely from Type I to Type IV, with the highest frequencies of Type II which occurs 64% and 98% of the present specimens examined respectively. Type III and Type IV

TABLE 1

Occurrence of spinulose patterns on the back in four *Lagocephalus* species. Explanations refer to p. 91

Species	Types						Total fish
	0	I	II	III	IV	V	
LI	88	0	0	0	0	0	88
LL	0	0	0	0	0	548	548
LW	0	1	105	10	50	0	166
LG	0	52	761	0	19	0	835

LI, *Lagocephalus inermis;* LL, *L. lunaris;* LW, *L. wheeleri;* LG, *L. gloveri*

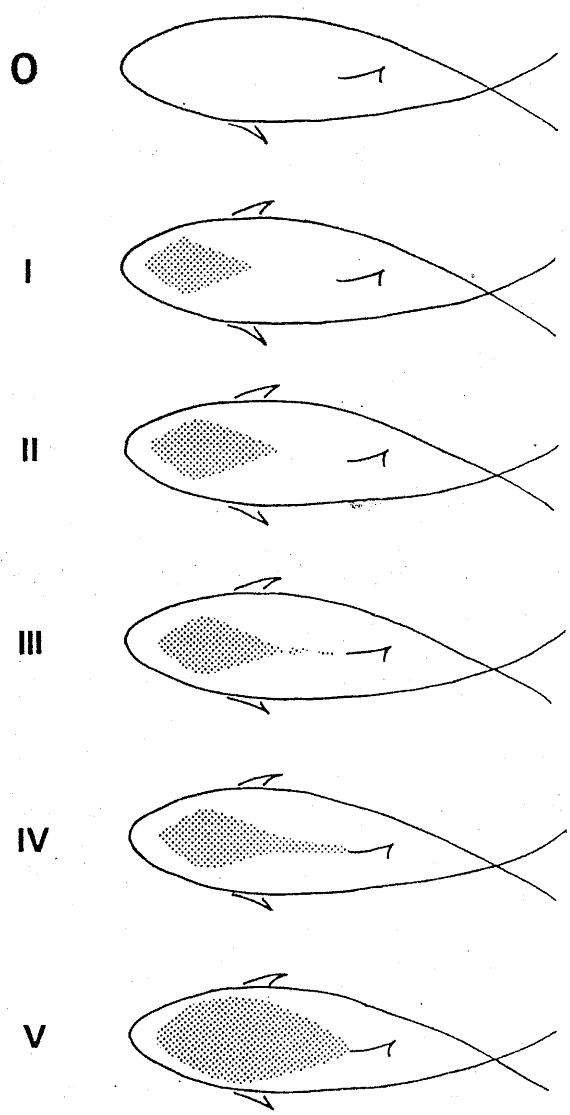

Fig. 2. The spinulose area on the back of four *Lagocephalus* species. Explanations refer to p. 91.

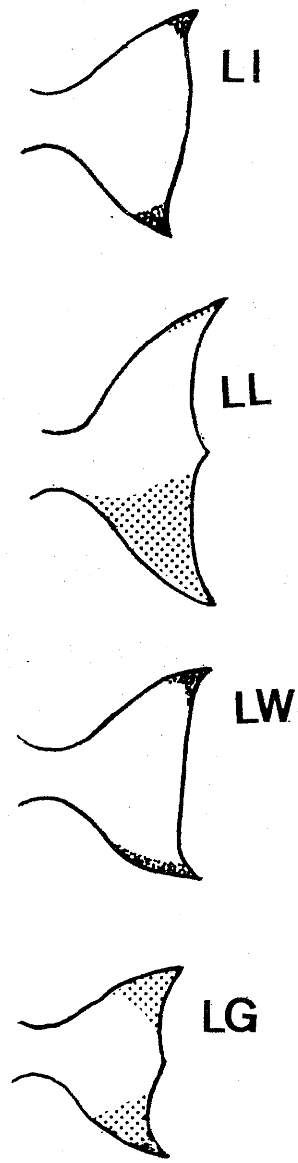

Fig. 3. Shape of caudal fin tips in *Lagocephalus inermis* (LI), *L. lunearis* (LL), *L. wheeleri* (LW) and *L. gloveri* (LG). Shading area indicates the range of white caudal tips.

seems to be the intermediated form between Types I or II and Type V.

Shape of caudal fin: As shown in Fig. 3, the posterior margin of caudal fin in *L. inermis* is slightly rounded with small protruding on upper and lower tips in young. The posterior margin of the caudal fin in *L. wheeleri* is nearly straight without medial protruding, the upper and lower tips of lobes being slightly protruded. The posterior margin of the caudal fin in *L. lunaris* and *L. gloveri* is commonly protruded medially and the upper and lower tips are more prolonged in *L. lunaris* than in *L. gloveri*.

Number of caudal vertebrae: Table 2 is the summary of vertebral counts of *Lagocephalus* species. The majority of examined *L. gloveri* (10–12) and *L. wheeleri* (10–12) commonly have modal number of 11, there is no significant difference between two species

TABLE 2
Frequency distribution of the number of vertebrae of *Lagocephalus inermis* (LI), *L. lunaris* (LL), *L. wheeleri* (LW) and *L. gloveri* (LG)

No. of vertebrae Total	= Abdominal	+ Caudal	LG S. Taiwan N=212	LG N. Taiwan N=161	LG Sum N=373	LW N=116	LL N=314	LI N=28
16	7	+ 9					2	
	8	+ 8					1	
17	8	+ 9					302	1
	7	+ 10					1	2
18	8	+ 10	7	1	8	2	7	25
	7	+ 11	2		2	4		
19	8	+ 11	195	156	351	101	1	
	7	+ 12	3	2	5			
20	8	+ 12	5	2	7	9		
Range			18–20	18–20	18–20	18–20	16–19	17–18
(Mean±S. D.)			(18.98 ±0.26)	(19.0 ±0.14)	(18.99 ±0.21)	(19.03 ±0.36)	(17.02 ±0.21)	(17.89 ±0.31)

according to the result of *t* test. *L. lunaris* (8–11) has modal number of 9 and *L. inermis* of 10. The number of caudal vertebrae could be used to help the identification of *Lagocephalus* species.

Tilly bones: Number of osteophyma-like swelling in posterior caudal vertebrae is present in Table 3. *Lagocephalus wheeleri* is the only one species without such bone. On the contrary, *L. gloveri* has shown the most frequent occurrence of tilly bones (mode at 3) with the mean of 4.23 in southern population and 2.83 in northern population. *L. lunaris* (1.23) and *L. inermis* (1.04) both have less number (mode at 1) than those of *L. glover*. Tilly bones situate mostly at 2nd–4th posterior caudal vertebrae in *L. gloveri* and at 2nd posterior caudal vertebra in *L. lunaris.*

TABLE 3
Frequency distribution of the number of tilly bones in posterior caudal vertebrae of *Lagocephalus gloveri* (LG), *L. wheeleri* (LW), *L. lunaris* (LL) and *L. inermis* (LI)

No. of tilly bones	LG S. Taiwan N=212	LG N. Taiwan N=161	LW N=116	LL N=314	LI N=28
0	4	23	116	104	15
1		4		112	1
2	18	24		52	8
3	69	67		20	4
4	27	23		19	
5	45	12		7	
6	28	6			
7	14	2			
8	7				
Range	0–8	0–7	0	0–5	0–3
(Mean±S. D.)	(4.23±1.67)	(2.83±1.57)		(1.23±1.26)	(1.04±1.18)

Electrophoretic patterns

The muscle protein patterns of 161 specimens of four *Lagocephalus* species shown in Fig. 4 are classified into 4 types based on the differences of mobility of electrophoretic bands. Each type is specific to a valid species. There are 9 component bands designated from 1 to 9 by their position from cathodal to anodal side. *L. inermis* has strong-staining bands 1, 2, 4, 7, and moderate-staining bands 6, 8. *L. lunaris* has strong-staining bands 1, 2, 4, 5, 6, 7, and weak-staining bands 8, 9. *L. wheeleri* has strong-staining bands 1, 2, 3, moderate-staining bands 4, 5, 8, 9 and weak-staining band 7. *L. gloveri* has strong-staining bands 1, 2, 3, 4 and moderate-staining band 5. Band 4 commonly appears in each of four species. Band 3 occurs only in *L. wheeleri* and *L. gloveri*. Both bands 4 and 7 occur in *L. inermis* and *L. lunaris*. Band 5 occurs only in *L. lunaris*, *L. wheeleri* and *L. gloveri*. Bands 1 and 2 appear in all species examined.

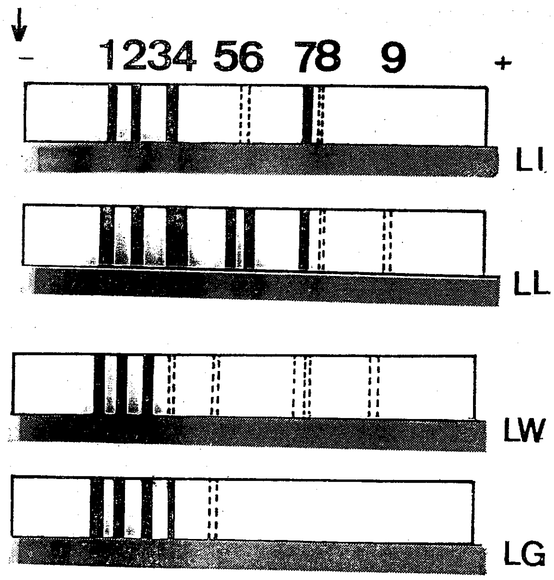

Fig. 4. Electropherograms of soluble muscle proteins of *Lagocephalus inermis* (LI), *L. lunaris* (LL), *L. wheeleri* (LW) and *L. gloveri* (LG). Arrow indicates the origin. Black and dash-line indicate deep and moderate or weak-staining bands respe ctively.

Genetic distance values and dendrograms

By adopting the formulae of Nei (1972), the genetic distance (*D*) in Table 5 is gained *via* the conversion from genetic identity data (*I*) which was in turn derived from the frequency occurrence of protein bands (or loci) appeared in Table 4. The dendrogram of *Lagocephalus* species (Fig. 5) is then constructed by applying UPGMA clustering method on the basis of genetic distance data. Species on the dendrogram are divided into two main stems: the one with *L. inermis* and the other with *L. lunaris* and its dichotomous component comprising *L. wheeleri* and *L. gloveri*. The last two species are the most closely-related pairs. Fig. 6 is a phylogenetic tree derived according to Fitch-Margoliash method which clearly shows that the *L. wheeleri* and *L. gloveri* pairing is far apart from the remaining two.

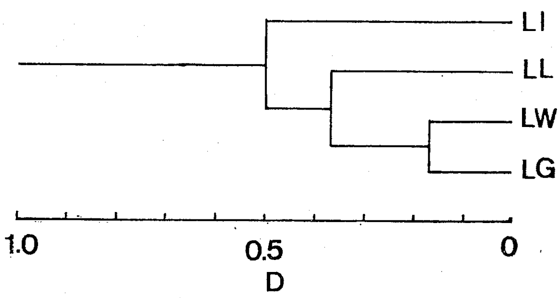

Fig. 5. UPGMA dendrogram of *Lagocephalus inermis* (LI), *L. lunaris* (LL), *L. wheeleri* (LW) and *L. gloveri* (LG), based on the genetic distance data in Table 5.

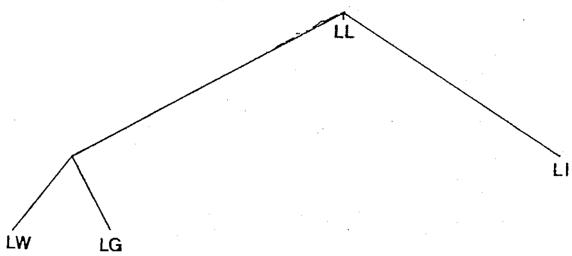

Fig. 6. Unrooted phylogenetic tree constructed using Fitch-Margoliash procedure based on the matrix of density values given in Table 5.

TABLE 4
Frequencies of protein bands on the gels of *Lagocephalus inermis* (LI), *L. lunaris* (LL), *L. wheeleri* (LW) and *L. gloveri* (LG) appeared in Fig. 4

Protein variants	LI (n=14)	LL (n=44)	LW (n=38)	LG (n=58)
1	0.9286	1.0000	1.0000	1.0000
null	0.0714	0	0	0
2	1.0000	1.0000	1.0000	1.0000
null	0	0	0	0
3	0	0	1.0000	1.0000
null	1.0000	1.0000	0	0
4	1.0000	1.0000	0.8421	1.0000
null	0	0	0.1579	0
5	0	1.0000	1.0000	1.0000
null	1.0000	0	0	0
6	0.5714	0.9773	0	0
null	0.4286	0.0227	1.0000	1.0000
7	1.0000	0.4318	0.2632	0
null	0	0.5682	0.7368	1.0000
8	0.5714	0.5909	0.5263	0
null	0.4286	0.4091	0.4767	1.0000
9	0	0.4091	0.9737	0
null	1.0000	0.5909	0.0263	1.0000

TABLE 5
Mean genetic distance (D) (below diagonal) and genetic identity (I) (above diagonal) calculated from the frequencies of the soluble muscle protein electrophoretic bands of *Lagocephalus inermis* (LI), *L. lunaris* (LL), *L. wheeleri* (LW) and *L. gloveri* (LG)

	LI	LL	LW	LG
LI		0.7845	0.5088	0.5675
LL	0.2427		0.6953	0.6806
LW	0.6756	0.3634		0.8453
LG	0.5665	0.3848	0.1681	

Systematic accounts

Key to species of *Lagocephalus*

1. The back before dorsal fin completely naked........................*L. inermis*
   The predorsal area with spinules 2
2. Predorsal spinulose area large broad ovoid in shape, reaching to dorsal origin; vertebrae mostly 17..............*L. lunaris*
   The spinulose area small rhombic in shape with maximum width of about the interorbital, its end not reaching to dorsal origin, or if extended to the dorsal origin, the width at the posterior part is very narrow; vertebrae mostly 19..........3
3. The posterior margin of caudal fin almost straight without medial protrusion; upper and lower corners of caudal lobes protruded slightly; tilly bones on vertebrae absent; color when fresh yellowish brown on the back with 2–3 dark irregular cross bands; whitish area on caudal tips very small; pectoral fin membrane without melanophores ....*L. wheeleri*
   The posterior margin of caudal fin with rounded protrusion medially; upper and

lower corners of caudal fin slightly protruded; tilly bones present (67%); dorsal part of body dark green or blackish; the white area on caudal tips larger than the former species; pectoral fin membrane with dark melanophores.......*L. gloveri*

Lagocephalus inermis (Temminck and Schlegel)

滑背河魨

Fig. 1A

Tetraodon inermis Temminck and Schlegel, 1850: 278 (Shimahara Bay, Japan).

Lagocephalus inermis, Smith, 1965: 417; Masuda *et al.*, 1984: 364.

Lagocephalus laevigatus inermis, Yang, 1970: 143.

Diagnosis: D. 13–14 (mostly 14); A. 12; P. 17–18 (mostly 18, with 10 caudal vertebrae). Body deeper, whole back smooth. Tilly bones on vertebrae present with mean number of 1.04. Caudal fin slightly protruded in each corner in young and rounded in adult. Color when fresh brown on back and golden yellow on lateral side. Gill-openings black. Dorsal fin black with white or brown color at base. Anal fin nearly colorless. Pectoral fin grey in young and brown with yellowish lower one third and black posterior margin in adult. Caudal grey with small whitish tips in young and brownish with whitish outer margins in adult.

Distributions: Widely distributed from Southern Japan, East China Sea, Taiwan, South China Sea to tropical Australia and Indian Ocean.

Lagocephalus lunaris (Bloch and Schneider)

毒鯖河魨

Fig. 1B

Tetraodon lunaris Bloch and Schneider, 1801: 505 (Malbar).

Gastrophysus lunaris, Smith, 1965: 418.

Lagocephalus lunaris lunaris, Yang, 1970: 144; Kyushin *et al.*, 1982: 300.

Lagocephalus lunaris, Kuronuma and Abe, 1972: 112; Abe *et al.*, 1984: 2; Masuda *et al.*, 1984: 364.

Diagnosis: D. 10–13 (mostly 12): A. 8–12 (mostly 11); P. 14–17 (mostly 16): vertebrae 16–19 (mostly 17, with 9 caudal vertebrae). Body higher than *L. gloveri* but less deeper than *L. inermis*. The ovoid dorsal spinulose area large and broad, extending broadly to dorsal origin. Two-hundred and ten out of 314 examined fish (67%) have occurred tilly bones on vertebrae with the mean of 1.23. Color when fresh variable: yellowish green to brownish green on back, golden-yellow, light-yellow or silvery white on lateral side. Gill-openings white. Dorsal fin yellow. Pectoral with upper two third yellow and lower one third white. Anal fin colorless. Caudal with upper two third yellow and lower one third white. This is a very poisonous species.

Distributions: Widely ranged from Southern Japan, East China Sea, Taiwan, Philippines, South China Sea to Indian Ocean and Arabian Gulf.

Lagocephalus wheeleri Abe, Tabeta and Kitahama

白鯖河魨

Fig. 1C

Tetraodon lunaris, Temminck and Schlegel, 1850: 277.

Lagocephalus spadiceus, Tanaka, 1916: 438; Gloerfelt-Tarp and Kailola, 1984: 297.

Lagocephalus wheeleri Abe, Tabeta and Kitahama, 1984: 4; Masuda *et al.*, 1984: 364.

Diagnosis: D. 12–13 (mostly 13); A. 11–12 (mostly 11); P. 14–17 (mostly 16); vertebrae 18–20 (mostly 19, with 11 caudal vertebrae). Body deeper. The dorsal rhombic spinulose area smaller, not ending at dorsal origin (64%) or extended narrowly to dorsal origin (36%) or interrupted in a minority of cases. No tilly bones on vertebrae. Color when fresh greenish yellow on back with 2–3 irregular dark cross-bands. Gill-openings black. Dorsal fin yellow. Pectoral yellow, without melanophores on the membrane between fin rays. Anal fin white. Caudal fin yellow with very small whitish tips on each corners. This is the commonest non-toxic swell-fish inhabiting Japanese Waters.

Distributions: Ranging from Northern Japan, East China Sea, Taiwan, Indonesia and Red Sea.

Lagocephalus gloveri Abe and Tabeta
黑鯖河魨
Fig. 1D

Lagocephalus gloveri Abe and Tabeta, 1983: 2 (Shizuoka, Japan); Masuda *et al.*, 1984: 364.
Lagocephalus lunaris spadiceus, Yang, 1970: 145; Abe, 1978: 248.
Gastrophysus spadiceus, Smith, 1965: 418.

Diagnosis: D. 12–15 (mostly 13–14); A. 11–13 (mostly 12): P. 15–17 (mostly 16); vertebrae 18–20 (mostly 19, with 11 caudal vertebrae). Body less deep. The spinulose area of most fish (98%) does not extend to the dorsal origin, only 2% of them extend with very narrow posterior part to dorsal origin. Tilly bones present with the mean of 2.83 in northern population and 4.23 in southern population. Both dorsal and anal fins falcate in shape. Color when fresh black or black-green on the back and silvery white below. Gill-openings grey. Dorsal fin black or black-green. Pectoral fin grey-yellow with narrow white ventral edge and with melanophores between fin rays. Anal fin pale yellow. Caudal fin black or black-green with broader triangular whitish area on each of caudal fin corners.

Distributions: Ranged from Pacific coast of Japan, Taiwan to South China Sea.

DISCUSSION

As stated earlier in the text, the four nominal *Lagocephalus* species are very much alike in external appearance when at the first glance. However, the completely naked predorsal area enables the *L. inermis* to separate widely from other three species: *L. lunaris*, *L. wheeleri and L. gloveri*. In which, *L. lunaris* is distinct from the *L. wheeleri* and *L. gloveri* in having continuous broad extension of ovoid-shaped spinulose area to dorsal origin (Fig. 2). On the contrary, the majority of the specimens of the latter two species remain a naked area in between end of spinulose area and dorsal origin, or if extended continuously in some cases, the posteriormost extension of the spinulose area is always narrow or even interrupted. As for *L. wheeleri* and *L. gloveri* alone, there is no clear-cut difference of dorsal spinulose pattern, however, the paler back with dark cross-bands in *L. wheeleri* could separate from that of black or blackish-green back in *L. gloveri*. In addition, *L. wheeleri* has never occurred any tilly bones. We are not sure if its occurrence is species specific or merely a geographical variation. A more widely ranged specimens should be studied. Since dorsal spinulose pattern does not change greatly with growth, a young fish of more or less 9 cm with 4–5 irregular dark cross bands on back, previously identified as *L. lunaris lunaris* by Yang (1970) is now recognized as young *L. wheeleri*. Young fishes of other species have never shown such color patterns on back. *L. lunaris spadiceus* (not of Richardson, 1845) used by Yang (1970) and Abe (1978) is in fact *L. gloveri* (Abe and Tabeta, 1983; Abe, Tabeta and Kitahama, 1984).

In the course of examining *Lagocephalus* materials from Taiwan by Harada (1979), a different form, *Lagocephalus* sp. was found and was provisionally treated as a hybrid between *L. laevigatus inermis* (=*L. inermis*) and *L. lunaris lunaris* (=*L. lunaris*) by their resemblances in body shape. It is now newly named as *L. wheeleri* (Abe, Tabeta and Kitahama, 1984) which is close to *L. gloveri* with similar dorsal spinulose pattern and same caudal vertebral number. *L. gloveri* is distinct from the closest allied *L. spadiceus* (Richardson) that the latter has black peritoneum and deeper forked caudal fin with less extensive whitish pattern at tips.

The highly poisonous *L. lunaris* is easily confused with non-poisonous *L. inermis* and *L. wheeleri* by their similar body shape, and their systematic relationships may be advisably clarified by electrophoretic procedure on muscle proteins which had successfully demonstrated phylogenetic relationships among closely-related fish species groups in Taiwan such as *Girella* (Lee and Chang, 1981), *Kyphosus* (Lee and Chang, 1982) and Priacanthidae (Lee, 1984).

As it is known that a shift of genetic identity values (I) from a high to a low class with decrease in systematic similarity. The values for subspecies level is estimated in the range of 0.85–0.95, for congeneric species 0.40–0.85, and for related non-congenerics 0.15–0.45 (Avise, 1977; Wallis and Beardmore, 1984). The values obtained in our study (Table 5) fit in well with those mentioned above. The *L. wheeleri* and *L. gloveri* have the highest I values of 0.8453 against the remaining twos, which is almost close to the subspecies or conspecific population level. It is not supprising that some closely-related but morphologically, behaviourly and ecologically quite distinct species *eg*., several North American *Cyprindon* species have genetically as similar (I=0.894) as conspecific populations (Turner, 1974). Accordingly, *L. wheeleri* and *L. gloveri* are entitled to be the closest pairs. The table of I values also suggest that *L. lunaris* is the next nearest relative to *L. wheeleri* (I=0.6953) which is in turn the farthermost relative to *L. inermis* (I=0.5088). The *L. wheeleri* and *L. gloveri* pairing is closer to *L. lunaris* than to *L. inermis*. *L. lunaris* is slightly closer to *L. inermis* than the other two species. All the above available identity values fall entirely into the range of so-called congeneric species level.

Comparing morphologicaly taxonomy of four *Lagocephalus* species with their dendrograms constructed from electrophoretic data on muscle proteins, *L. inermis*, however, is considerably more distantly from the remaining three by its completely naked back. Among the rest of three with spinulose area on the back, *L. wheeleri* and *L. gloveri* are the closest relative with similar spinulose pattern and with same caudal vertebral number. It is interesting that the above two species have the highest identity values among all *Lagocephalus* species. *L. lunaris* has more extensive spinulose area and fewer caudal vertebrae than the above two species. This again reflect the difference in identity values which show that *L. lunaris* is far apart from the most-closely-related *L. wheeleri* and *L. gloveri* pairing. The result of Fitch-Margoliash phylogenetic tree furtherly prove the same assumption.

The systematic position of *L. wheeleri* or the former *Lagocephalus* sp. was previously known to hybridize between *L. inermis* and *L. gloveri* (Harada, 1979). Although the body shape of *L. wheeleri* resembles *L.* inermis, however, the electrophoretic data does not show closer similarity between them. Their distant divergency on the dendrograms corresponds primarily to different spinulose pattern on the back. Since the spinulose pattern does not change with the state of growth, it is considered as a stable key character for the comparison with biochemical result. Other characters such as occurrence of tilly bones and the number of caudal vertebrae may vary with geographical distributions, and they are of little value here. It is now concluded that there is a close similarity of *Lagocephalus* classifications based on morphological data and that derived from biochemical studies. Thus the electrophoretically determined protein variants form useful markers for species verification in *Lagoce phalus*.

REFERENCES

ABE, T. (1978) *Keys to the Japanese fishes fully illustrated in colors* (7th rev. ed.). Hokuryukan, Tokyo. 358pp.

ABE, T. and O. TABETA (1983) Description of a new swellfish of the genus *Lagocephalus* (Tetraodontidae, Teleostei) from Japanese waters and the East China Sea. *U. O.* **32**: 1-8.

ABE, T., O. TABETA and K. KITAHAMA (1984) Notes on some swellfishes of the genus *Lagocephalus* (Tetraodontidae, Teleostei) with description of a new species from Japan. *U. O.* **34**: 1-10.

AVISE, J. G. (1974) Systematic value of electrophoretic data. *Syst. Zool.* **23**: 465-481.

BLOCH, M. E. and J. G. SCHNEIDER (1801) *Systema ichthyologiae iconibus cx illustratum.* Sanderiano Commisum, Berlin (reprinted 1967). 584pp.

FITCH, W. M. and E. MARGOLIASH (1967) Construction of phylogenetic trees. *Science* **155**: 279-284.

GLOERFELT-TARP, T. and P. J. KAILOLA (1984) *Trawled fishes of southern Indonesia and Northwestern Australia.* ADAB, DGF and GTZ. 406pp.

HARADA, Y. (1979) Classification and toxicological examination of "Fugu" imported from Formosa. *J. Food. Hygen. Soc. Jap.* **20**(6): 437-441.

KURONUMA, K. and Y. ABE (1972) *Fishes of Kuwait.* Kuwait Inst. Scient. Res., Kuwait. 123pp.

KYUSHIN, K., K. AMAOKA, K. NAKAYA, H. IDA, Y. TANINO and T. SENTA (1982) *Fishes of the South China Sea.* Jap. Mar. Fish. Res. Centr., Tokyo. 333pp.

LEE, S. C. and J. T. CHANG (1981) Comparative studies of the fishes of the genus *Girella* from Taiwan. *Bull. Inst. Zool., Academia Sinica* **20**(1): 9-16.

LEE, S. C. and J. T. CHANG (1983) Interspecific variations of morphological characters and muscle proteins in the Formosan *Kyphosus* fishes. *Bull. Inst. Zool., Academia Sinica* **22**(1): 83-89.

MASUDA, H., K. AMAOKA, C. ARAGA, T. UYENO and T. YOSHINO (1984) *The fishes of the Japanese Archipelago.* Tokai Univ. Press, Tokyo. 437. pp.

NEI, M. (1972) Genetic distance between populations. *Amer. Natur.* **106**: 283-291.

SMITH, J. L. B. (1965) *The sea fishes of southern Africa.* Central News Agency, Ltd., South Africa (rev. ed.). 580pp.

SNEATH, P. H. D. and R. R. SOKAL (1973) *Numerical taxonomy.* W. H. Freeman and Co., San Francisco. 573pp.

TABETA, O. and H. KUMAGAI (1980) Morphological difference between Sabafugu (*Lagocephalus lunaris spadiceus*) and Doku-sabafugu (*L. lunaris lunaris*) with special reference to the food intoxication occurred in Kita-Kyushu City, 1959. *J. Food Hyg. Soc. Jap.* **21**(5): 405-407.

TANAKA, S. (1916) *Figures and descriptions of the fishes of Japan.* **24**: 419-440.

TEMMINCK, C. and H. SCHLEGEL (1850) *Siebold's fauna Japonica, Pisces.* Leiden. 323pp.

TURNER, B. J. (1974) Genetic divergence of Death Valley pupfish populations; species specific esterases. *Comp. Biochem. Physiol.* **46**B: 57-70.

WALLIS, G. P. and J. A. BEARDMORE (1984) An electrophoretic study of the systematic relationships of some closely related goby species (Pisces, Gobiidae). *Biol. J. Linn. Soc.* **22**: 107-123.

YANG, H. C. (1970) Studies on the puffers (Tetraodontidae) of Taiwan. *Ann. Rept. Sci, Taiwan Mus.* **13**: 131-165.

由肌肉蛋白之比較探討臺灣產鯖河魨屬魚類之系統分類

陳孟仙　張崑雄　李信徹

本文敍述滑背河魨 (*Lagocephalus inermis*)、毒鯖河魨 (*L. lunaris*)、白鯖河魨 (*L. wheeleri*) 及黑鯖河魨 (*L. gloveri*) 等四種魚類肌肉蛋白之電泳分析結果。進一步配合形態特徵資料之分析闡述種間之親緣關係。這幾種河魨之外形極爲相似，僅體色、脊椎上骨瘤之出現狀況，尾椎骨數量及體背細棘之分佈樣式等特質上有絲毫差異。然此等特徵尚可用以輔助種別之鑑定。電泳資料以 UPGMA 類聚分析法及 Fitch-Margoliash 分枝分類法所架構之親緣關係圖看來，白鯖河魨與黑鯖河魨乃最接近之種羣，同具十一枚尾椎及相似之體背細棘排列樣式。體背完全裸露無棘之滑背鯖河魨，似乎遠離其他三種。毒鯖河魨之背部雖佈滿細棘，然在距離上反而略接近於滑背河魨，而與白鯖河魨及黑鯖河魨稍遠。至於同具背棘之毒鯖河魨與白鯖河魨間稍微接近。體型方面，除了黑鯖河魨較細長外，其他三種均呈短壯之身。由以上之資料，不難發現鯖河魨屬魚類以生化系統分類方法所得之分類結果幾乎與傳統分類方法所得之結果符合。