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PHYLOGENY OF THE SINIPERCINE FISHES WITH SOME TAXONOMIC NOTES

Liu Huanzhang Chen Yiyu
(*Institute of Hydrobiology, CAS, Wuhan* 430072 *China*)

Abstract Phylogeny of the sinipercine fishes, their relationships with some fossils and their systematic position were studied in this paper. Consisting of 2 sister groups, the sinipercine fishes were grouped as 2 genera -- *Coreoperca* and *Siniperca*, while the genus *Coreosiniperca* was unwarranted for its type being a member in *Siniperca*, Having many special characters, *Tungtingichthys* was denied as the ancestor of the sinipercine fishes, however, *Siniperca wusiangensis* was taken as one member in *Siniperca* and some fossil percoids found in Japan had close relationship with sinipercine fishes. All characters of the sinipercine fishes are not concordant with that in Serranidae or Percichthyidae which leads to the conclusion that either the sinipercine fishes are not in Percichthyidae, or the defining characters of Percichthyidae listed by Gosline (1966) are wrong. But at present, we can only put the sinipercine fishes in Percichthyidae.

Key words Sinipercine fishes, Phylogeny, Percichthyidae

1 Introduction

Living in freshwater as important economic fish, distributing only in east Asia, having no certain systematic position in lower percoids, the sinipercine fishes are of great interest to ichthyologists. In 1842, for the first time, Temminck and Schlegel described a sinipercine species *Serranus kawamebari* ' in "Pisces, Siebold's Fauna Japonica", which is now referring as *Coreoperca kawamebari*. From then on, about 40 species have been described, but most of them are not valid (Cheng *et al*, 1987; Fang *et al*, 1932; Nichols, 1943; Zhou *et al*, 1988). Though 3 genera have been proposed respectively without any phylogenetic evidence, at present, the 1 genus and 2 or 3 genera classifications are all employed by different authors (Zheng, 1989; Zhou *et al*, 1988).

For a long time, the fossil percoids *Tungtingichthys* were taken as the ancestor of the sinipercine fishes (Liu *et al*, 1962; Zhang *et al*, 1985). In fact, the characters of *Tungtingichthys* were so special that they imply the *Tungtingichthys* were far from the

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sinipercine fishes, not the direct ancestor of the sinipercine fishes. Up to now, no person declared it clearly. As to another fossil species *Siniperca wusiangensis*, though damage of the specimen, characters preserved in it are enough to demonstrate its position in sinipercine fishes.

Most authors put the sinipercine fishes under family Serranidae whose classification is notoriously unsatisfactory (Nichols, 1943; Zhou *et al*, 1988). In 1966, Gosline established a new family Percichthyidae with the sinipercine fishes placed under this family. But the classification of Percichthyidae is also unsatisfactory with the position of the sinipercine fishes being uncertain.

So, up to now, in the sinipercine fishes, the validity of species, the systematic position, the relationship between modern and fossil groups remained unresolved. In this paper, based on extensive studies of living and fossil specimens both in and abroad, we studied phylogeny of the sinipercine fishes, and gave some taxonomic notes.

2 Materials and Methods

Skeleton specimens were made to 11 species (without *S. robusta*), which were stained by alizarin staining, and preserved in alcohol (70%). Specimens employed were listed below.

Skeleton specimens:

L. japonicus	No. Qingdao 91001,	*S. herzi*	No. Korea 9125001,
S. kawamebari	No. Japan 91001,	*S. whiteheadi*	No. Guizhou 8841045,
S. obscura	No. Zhejiang 74Ⅳ4667,	*S. loona*	No. Guizhou 87Ⅴ036,
S. roulei	No. Hunan 98Ⅶ2183,	*S. fortis*	No. Guangxi 87035117,
S. undulata	No. Guangxi 85100210,	*S. scherzeri*	No. Guangxi 75Ⅳ1578,
S. kneri	No. Guangxi 87Ⅻ0242,	*S. chuatsi*	No. Hubei 910001.

Those specimens belong to the Institute of Hydrobiology, Chinese Academy of Sciences.

Fossil specimens:

T. gracilis V 5603, *T. wusiangensis* V 2457.

Those specimens belong to the Institute of Vertebrate Palaeontology and Palaeoanthropology, Chinese Academy of Sciences.

Some more specimens of the sinipercine fishes were examined and measured.

3 Selection of Out-group

Many authors thought sinipercine fishes are close to epinephelines, for the presence of 3 anal spines and a supplementary maxillary (Zhou *et al*, 1988). Gosline (1966) took species with 3 opercular spines (such as epinephelines) as Serranidae, the other species with 2 opercular spines as Percichthyidae. The skeleton specimens of *Lateolabrax japonicus* and some epinephelines were made and studied leading to the conclusion that epinephelines have many derived characters (such as outer row of the jaw teeth developed; with small, projecting jaw teeth; small serrations on the post-ventral edge of the preopercular etc.), and the relationship is far from the sinipercine fishes, while *L. japonicus* has many primitive characters (such as the villiform teeth on the jaw; 4 large spines on the post-ventral edge of the preopercular etc.). So, we selected *L. japonicus* as the out-group for this study, supplemented with some characters in epinephelines.

4 Anatomical Characters and Their Phylogenetic Significance

4.1 Vomer teeth (Fig. 1)

The vomer of most percoids bears teeth. In *L. Japonicus* and epinephelines, the teeth arrange in a "U" shape, while in *S. herzi*, *S. kawamebari* and *S. whiteheadi* the teeth in a "U" shape, in other sinipercine fishes, in a triangular mass shape. We took the "U" shape found in out-group as plesiomorph, the triangular mass shape as apomorph.

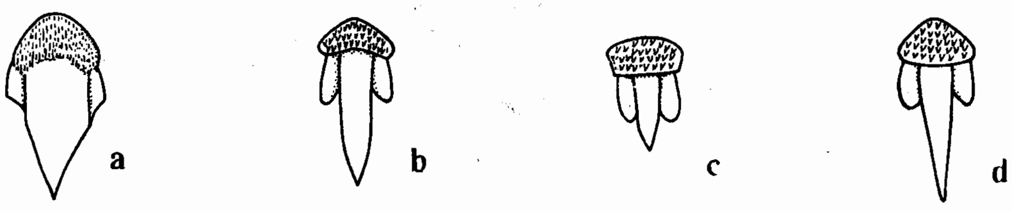

Figure 1 Vomer

a: *L. japonicus*, b: *S. kawamebari*, c: *S. roulei*, d: *S. fortis*

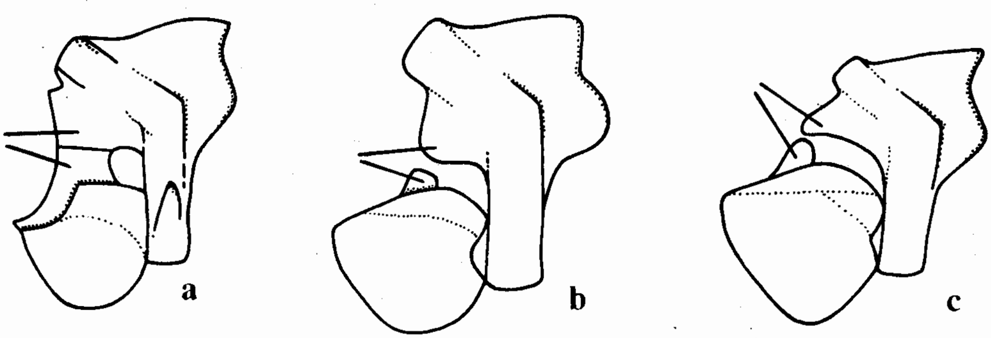

Figure 2 Connection between hyomandibular and metapterygoid

a: *L. japonicus*, b: *S. ovata*, c: *S. kneri*

4.2 Connection between hyomandibular and metaptergoid (Fig. 2)

In *L. japonicus* and epinepheline fishes the connection between hyomandibular and metaptergoid is strong and forms a line. In sinipercine fishes, the connection becomes weak and different states exist. The most advanced state is found in *S. chuatsi* and *S. kneri*, in which the hyomandibular and metaptergoid articulate freely, with the hyomandibular process tapered and very sharp. In other sinipercine fishes, the hyomandibular process is round and blunt. The out-group comparison shew that the hyomandibular connected with the metaptergoid strongly is plesiomorph, weakly is apomorph.

4.3 Preoperculum (Fig. 3)

The post edge of the preoperculum of many percoids is serrated. Most have 4 large spines on the postventral edge of the preoperculum, others only small serrations (Gregory, 1933). In *L. japonicus*, *S. obscura*, *S. loona*, *S. roulei*, *S. fortis*, *S. undulata*, *S. scherzeri*, *S. kneri* and *S. chuatsi*, there are 4 large spines on the postventral edge of the preoperculum and we took it as plesiomorpy. In *S. herzi*, *S. kawamebari* and *S. whiteheadi*, there are only small serrations somewhat like in 4 groups, and we took it as apomorph.

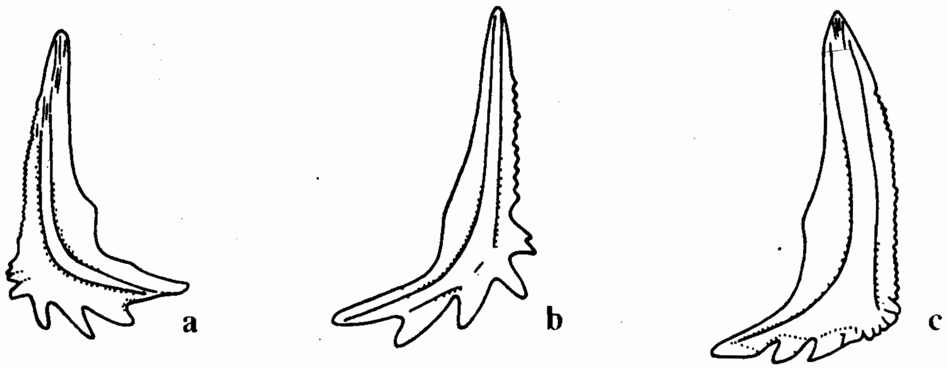

Figure 3 Preoperculum

a: *L. japonicus*, b: *S. kneri*, c: *S. whiteheadi*

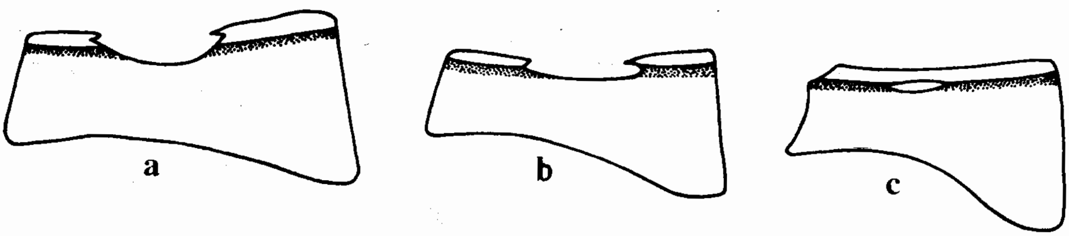

Figure 4 Ceratohyal

a: *L. japonicus*, b: *S. roulei*, c: *S. kneri*

4.4 Ceratohyal (Fig. 4)

Gosline (1966) listed 17 characters separating Percichthyidae from Serranidae, Character two is, in Percichthyidae, the upper border of ceratohyal is either approximately straight or with an oblong hollow excaved in it while in Serranidae smoothly concave. In *L. japonicus*, *S. herzi*, *S. kawamebari*, *S. whiteheadi*, *S. obscura*, *S. loona* and *S. roulei*, the upper border of ceratohyal is with an oblong hollow excaved in it, while in *S. fortis*, *S. undulata*, *S. scherzeri*, *S. kneri* and *S. chuatsi*, there is a BCF (berycoid foramen) in the ceratohyal. We suggest that the presence of a BCF in the creatohyal is apomorph while the opposite condition plesiomorph.

4.5 The teeth in lower jaw (Fig. 5)

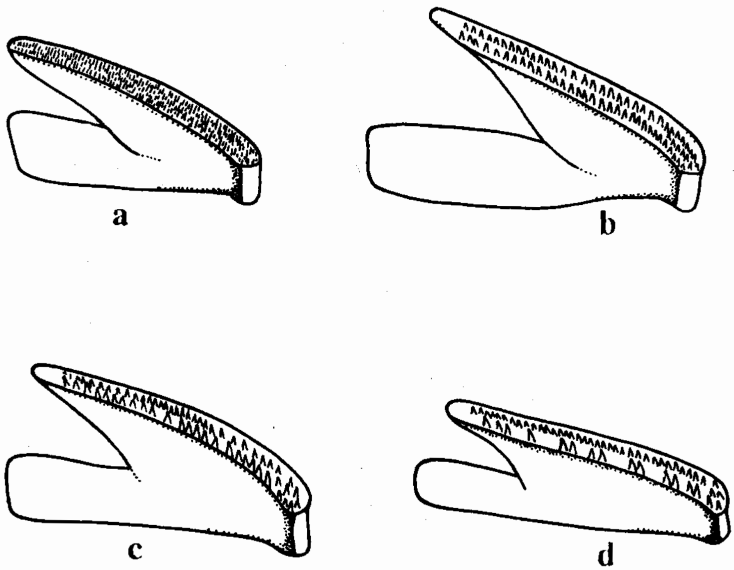

Figure 5 Dentary

a: *L. japonicus*, b: *S. herzi*, c: *S. kneri*, d: *S. roulei*

Though not stretching out, the teeth in low jaw of sinipercine fishes are still differentiated. In *L. japonicus*, the teeth are villiform. In *S. herzi*, *S. kawamebari*, *S. whiteheadi*, *S. obscura* and *S. loona*, the teeth became stronger but no differences between the inner and the outer row. In *S. fortis*, *S. undulata*, *S. kneri* and *S. chuatsi*, the teeth in inner row are stronger than that in outer and arrange densely, In *S. roulei* and *S. scherzeri*, the teeth in inner row are very strong and the number decrease, The evolutionary trend of the lower jaw teeth is the increase in size but decrease in number and this kind evolution benefits for capture food.

4.6 The supraoccipital crest (Fig. 6)

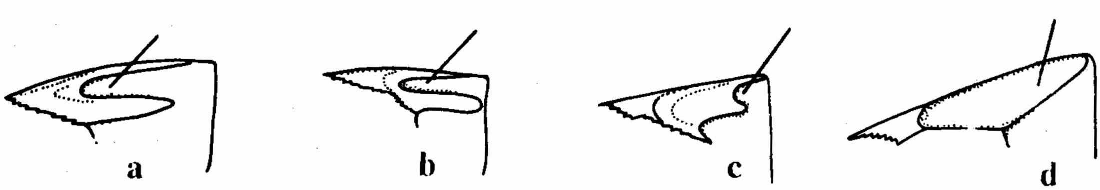

Figure 6 Supraoccipital

a: *L. japonicus*, b: *S. herzi*, c: *S. obscura*, d: *S. kneri*

In many percoids, there is a strong supraoccipital shelf (soc s) on the two lateral sides of the supraoccipital crest (soc c). In *L. japonicus*, *S. herzi*, *S. kawamebari* and *S. whiteheadi*, the soc s and the upper border form a deep fork shape. In *S. obscura* and *S. loona*, the deep fork became shallow while in *S. roulei*, *S. fortis*, *S. scherzeri*, *S. kneri* and *S. chuatsi* the soc s and the upper border integrated. We suggested the soc s and the upper border of soc became integrated is apomorph while the deep fork state plesiomorph.

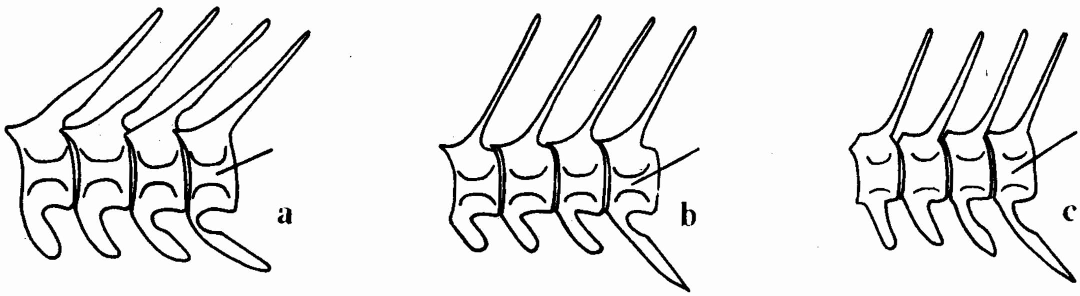

Figure 7　The last 3 precaudal and first caudal vertebra

a: *L. japonicus*, b: *S. herzi*, c: *S. kneri*

4.7 The last 3 precaudal vertebrae (Fig. 7)

On the lateral side of the centrum, there are two hollows in the upper and the lower portions. Generally, this character does not vary very much. But in sinipercine fishes they differentiated. Like in the out-group *L. japonicus*, in *S. herzi*, *S. kawamebari*, *S. whiteheadi*, *S. obscura*, *S. loona* and *S. roulei*, the distance between the two hollows in the upper and the lower portions of the last three precaudal vertebrae is short, shorter than half the length of the centrum. In *S. fortis*, *S. undulata*, *S. scherzeri*, *S. kneri* and *S. chuatsi*, this distance is longer than half the length of the centrum. We take the condition found in the out-group as plesiomorph, the opposite condition as apomorph.

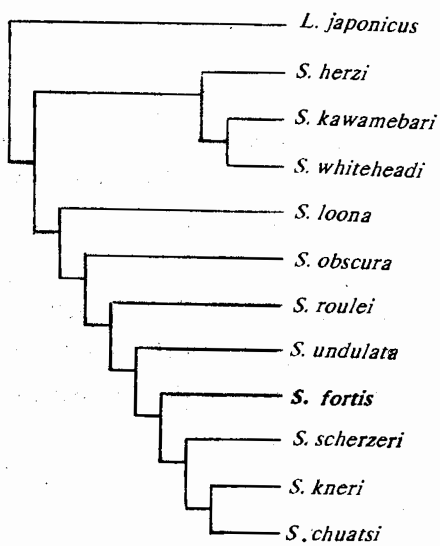

Figure 8　Cladogram of sinipercine fishes

4.8 Number of caecal lobules

The number of the caecal lobules varies greatly in sinipercine fishes. In the same species, the numbers of different individuals are different . Among different species, the numbers vary from 3 to several hundreds. Though the large differences, different species have distinctive range. In this paper, we take the least number 3 as the plesiomorph, number more than 3 as apomorph.

4.9 Other characters

There are still many other characters which are different in different species. We only take the conditions found in out-group as plesiomorph, the opposite conditions as apomorph (Wiley, 1981). The total number of the characters is 34. Giving the plesiomorph 0, apomorph 1, 2 or 3, we get a character matrix (Tab. 1). The matrix was dealt with a PAUP software in a computer getting a cladogram (Fig. 8).

Table 1 Character matrix of sinipercine fishes (see appendix for more information)

	1-5	6-10	11-15	16-20	21-25	26-30	31-34
L. japonicus	00000	00000	00000	00000	00000	00000	0100
S. herzi	11110	01111	11111	00010	00010	01101	0010
S. kawamebari	11110	01111	11110	10111	10010	01001	0020
S. whiteheadi	11111	01111	11111	10010	00010	00001	0010
S. ovata	11110	11211	11001	00010	00011	01110	0100
S. obscura	11110	11010	11001	01110	00011	01100	0100
S. roulei	11110	11010	11001	00010	00032	01110	0101
S. fortis	11110	11010	11001	01010	00122	10100	0200
S. undulata	11110	11010	11001	01110	10122	11110	0200
S. scherzeri	11110	11010	11001	01110	01132	10100	0301
S. kneri	11110	12001	12001	00010	01122	11110	1301
S. chuatsi	11110	12000	12001	00010	01122	11100	1302

5 Phylogeny of the Sinipercine Fishes

Based on the analysis, the sinipercine fishes represent a monophyly with synapomorphs C1, C2, C3, C4, C7, C11, C12 and C24. The result shows that sinipercine fishes consist of 2 sister groups —sinipercine and coreopercine group, with *S. herzi*, *S. kawamebari* and *S. whiteheadi* in the coreopercine group which has many primitive characters and apomorph, such as C24, C25, C32 and C13, C30; having some primitive characters such as C32, C23, C26, *S. obscura*, *S. loona* and *S. roulei* are the lower category in sinipercine group, and the other species in sinipercine group are the advanced category which have many evolved characters such as C32, C23, C25, C26, while the synapomorph of the sinipercine group is C25, C28, C32.

According to the result, we divide the sinipercine fishes into 2 genera: *Siniperca* and *Coreoperca*. The genus *Coreoperca* consists of 3 species: *C. herzi*, *C. kawamebari* and *C. whiteheadi*, while genus *Siniperca* 9 species. Because *S. roulei* is 1 species of group sinipercine, the existence of genus *Coreosiniperca* is unwarranted.

Liu *et al.* (1962) proposed *Tungtingichthys gracilis* as a new species and a new genus, and suggested that its systematic position might belong to the Toxotidae or

Serranidae (Regan), or even represents a new family of the Perciformes. After examining the specimen of *T. gracilis* found in coastal region of the Bohai Sea, the present authors found that the specimen has ctenoid scales; small serrations on the post edge of preoperculum; operculum ending in one spine; occipital region scaly; caudal fin forked, which implies its relationship far from the sinipercine fishes.

The specimen of *Siniperca wusiangensis* is an incomplete skeleton with posterior part of body missing. The present author also examined this specimen and found its mouth with coniform teeth, not villiform; preoperculum with 4 large spines on the postventral edge; operculum with 2 spines (with the upper spine being pressed) and not 1 spine as the authors described. According to the characters preserved, the species resembles *S. scherzeri* mostly, not *S. chuatsi* or *S. roulei* (Liu *et al*, 1962). And the most important character is that the distance between the upper and the lower hollows in the last several precaudal vertebrae are larger than half the length of the centrum which demonstrate its position in the advanced group of the genus *Siniperca*.

Ohe and Ono (1975), Ohe and Hayata (1984) described 2 fossil *Coreoperca* fishes found in Japanese Miocene sediment respectively. The specimen of *C. fushimiensis* was heavy damaged only with its freshwater environment and cyclic scale implying its uncertain relationship with the sinipercine fishes. The specimen of *C. kaniensis* was well preserved and many characters can be recognized: 1. body compressed, sharp in head; 2. dentary teethed; 3. vomer conied; 4. first and second dorsal fin connected, D. Ⅻ, 13, P.10, V. 1. 4, A. Ⅲ. 9; 5. vertebrae 28; 6. caudal fin round. From the characters mentioned above, we know that those characters only prove the species' close relationship with the sinipercine fishes or a primitive sinipercine position, not enough to prove its position in genus *Coreoperca* as the authors said.

Generally, the sinipercine fishes are placed under Serranidae. Basing on Katayama's Serranidae, Gosline (1966) defined fishes with 3 spines on the operculum as Serranidae, the remaining with 2 spines as Percichthyidae, which includes the sinipercine fishes. Now Gosline's Serranidae is dealt as a monophyly and Pereichthyidae is accepted by many authors (Nelson, 1984). Gosline himself has not seen any sinipercine fishes, and any inappropriate in putting sinpercine fishes in Percichthyidae. Among the 17 characters, the ceratohyal of sinipercine fishes has a BCF, which is not concordant with any states of character 2 in Percichthyidae or Serranidae; the states of supraoccipital crest in sinipercine fishes are not concordant with any states of character 3 in Percichthyidae or Serranidae too; character 4 is the lower surface of lateral ethmoid with 3 articular facets in Serranidae, 2 in Percichthyidae, while sinipercine fishes have 3 articular facets on the lower surface of lateral ethmoid which is concordant with that in Serranidae but not Percichthyidae. We think either the sinipercines are not in Percichthyidae or the defining characters of Percichthyidae listed by Gosline (1966) are wrong. Percichthyidae might be a paraphyly or even a polyphyly. But at present, we can only put the sinipercine fishes in Percichthyidae.

6 Some Taxonomic Notes

Wu (1939) described *S. loona* found in Lijiang River. Later, few persons collected this species and many authors put it as the synonym of *S. obscura*. After examining the holotype of *S. loona* and topotype of *S. obscura*, we found that they are two valid species and most people put *S. loona* as *S. obscura*. Their differences lay that *S. loona* has scaly cheeks and lower body height, and distributes in Zhujiang River, middle and upper reach of the Changjiang River, while *S. obscura* in lower reach of the Changjiang River and southeastern part of China.

In 'Fishes of the Zhujiang River', Gao pointed out that Fang *et al*, (1932) put another species as *S. obscura*, and this species is *S. fortis* Lin (1932). Zhou *et al* (1987) described a new species *S. liuzhouensis* found in Lijiang River. According to the characters and distribution area, we think *S. liuzhouensis* is a synonym of *S. fortis*.

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Appendix: characters employed

1. Scales ctenoid; scales cycloid
2. Roof of head scaly; roof of head naked
3. Caudal forked; caudal round
4. Sensory canal on nostrial opened; sensory canal on nostrial closed
5. Nostrial bone in dumbbell shape; nostrial bone not in dumbbell shape
6. Vomer teeth arrange in 'U' shape; vomer teeth arrange in triangular shape
7. Without flat area on parietals; with flat area on parietals
8. Lacrychmal not enlarged; lacrychmal enlarged; lacrychmal enlarged and having the tendency to enclose the maxilla
9. Scale bone enlarged; scale bone not enlarged
10. Post edge of posttemperal serrated; post edge of posttemperal smooth
11. Inner process of the metopterygoid wide; inner process of the metopterygoid narrow
12. The process of the hyomandibular articulating with metopterygoid wide; that process blunt, round; that process sharp
13. Postventral edge of preoperculum with 4 spines; postventral edge of preoperculum with many small serrations

14. The lower opercular spine much larger than the upper one; the lower opercular spine about equal to the upper one
15. Upper edge of the operculum convexed; upper edge of the operculum flattened
16. Lower face of the interopercular coarsed; lower face of the interopercular not coarsed
17. Lower edge of the interopercular serrated; lower edge of the interopercular not serrated
18. Lower edge of the subopercular serrated; lower edge of the subopercular smooth
19. The upper angular of the uryohyal longer than the lower one; the upper angular of the uryhyal shorter or about equal to the lower one
20. Upper side of the uryohyal not convex; Upper side of the uryohyal convex
21. Without a ridge from the anterior part to the post upper portion on the lateral side of the uryohyal; with this ridge
22. Without a ridge parallel with the lower side of the uryohyal; with a ridge parallel with the lower side of the uryohyal
23. With a hollow on the upper edge of the uryohyal; with a BCF in the ceratohyal
24. Lower jar teeth villiform; lower jaw teeth a little enlarged, no differences between the inner and outer row; teeth on inner row larger and arranged densely; teeth on inner row very strong and the number decrease
25. Ridges on lateral sides of the supraoccipital crest arrange in deep fork; in shallow fork; integrated
26. The distance between the upper and the lower hollows in lateral side of the last several precaudal vertebrae longer than half the length of the centrum; this distance shorter than half the length of the centrum
27. Postedge of the posttemporal serrated; post edge the posttemporal smooth
28. Predorsal bones 0–0–0–1; predorsal bones 0–0–0–2
29. Cheeks scaly; cheeks smooth
30. With 3 dark stripes radiating backward from eye; without 3 dark stripes rediating backward from eye
31. With 1 oblique band from inside of snout, passing through eye, to base of anterior part of spinous dorsal; without this band
32. Number of caecal lobules 3; 5–20; 30–80; more than 80
33. Scales in lateral line more than 70; 60–70; less than 60
34. Scales in lateral line less than 80; 80–90; more than 90

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鳜类系统发育的研究及若干种类的有效性探讨

刘焕章 陈宜瑜

(中国科学院水生生物研究所 武汉 430072)

摘要 作为重要的淡水经济鱼类、东亚的特有类群和低等鲈类的特殊成分，鳜类在研究和应用上具有极重要的价值，并有大量学者对之进行了多方面的研究。从鳜类中的第一个种被描述起，到现在已有 150 多年的时间，但是有关鳜类的种类有效性，系统分类，系统位置，与化石的关系等问题都存在疑问，特别是系统发育问题没有人研究。经过对国内外大量鳜类现生种和化石种的标本进行外部形态观察和骨骼学研究，本文运用分支系统学的原理，以花鲈为外类群，对鳜类的系统发育问题进行了研究，并根据系统发育的研究结果提出系统分类的观点。

研究表明鳜类是一个单系群，以体被圆鳞，头顶裸露无鳞、鼻骨侧线管封闭、舌颌骨与后翼骨的联结变松等为共同离征。鳜类由两个姐妹群组成——少鳞鳜群和鳜群。少鳞鳜群的共同离征为前鳃盖骨后下角为小的锯齿、侧线鳞数目减少。鳜群的共同离征为上枕骨嵴愈合、幽门盲囊数量增加等。鳜类的两个姐妹群可分为两个属——少鳞鳜属和鳜属。长身鳜是鳜属中的一员，不能作为单独的一个属处理。

对化石的研究表明，洞庭鳜的性状很特化，不可能是鳜类的祖先；武乡鳜为鳜类中较特化的类群；日本中新世的淡水鲈类为原始的鳜类。

鳜类的特征同 Serranidae 及 Percichthyidae 特征均不完全相符，Serranidae 是一明显的单系，Percichthyidae 可能为并系甚至复系。但鳜类目前只能放入 Percichthyidae 中。

S. obscura Nichols 和 *S. loona* Wu 均应为有效种。*S. liuzhouensis* Zhou 等则是 *S. fortis* Lin 的同物异名。

关键词 鳜类，系统发育，暖鲈科