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SUBSPECIFIC DIFFERENTIATION OF *Paracobitis variegatus* WITH COMMENTS ON ITS ZOOGEOGRAPHY*

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Abstract The distribution of the loach *Paracobitis variegatus* is confined to upper Yangtze, Huanghe and Nanpanjiang drainages. The number of branched dorsal fin rays, morphology of anterior nostril, colour pattern of head and the length of maxillary barbel indicate that it has differentiated into two subspecies. Both subspecies are isolated geographically: *P. variegatus variegatus* restricted to the upper Yangtze and the upper Huanghe Rivers, and *P. variegatus longidorsalis*, new subspecies, to the upper Nanpanjiang River. The subspecific differentiation is supposed to correlated to the sharp uplift of the eastern Yunnan Plateau during late Pleistocene. The taxonomic status of *Nemachilus berezowskii* Gunther, 1896 and *Nemacheilus oxygnathus* Regan, 1908 are also discussed and they are considered to be the synonyms of *P. variegatus variegatus*.

Key words *Paracobitis variegatus*, Subspecific differentiation, New subspecies, Zoogeography

1 Introduction

The loaches of the genus *Paracobitis* (subfamily Nemacheilinae) include small to medium size fishes distinguished by having adipose keels along dorsal and ventral mid lines of caudal peduncle, nostrils close together, and upper jaw with a dentiformis process. So far 15 species and subspecies have been recorded from China and South-Western Asia. 6 species occur in China (Zhu, 1989; Ding *et al.*, 1990).

The loach *Paracobitis variegatus* was originally described by Sauvage *et al.* de Thiersant (1874) under the name *Nemacheilus variegatus* from Schansi (=Shanxi Province). About its generic status, three opinions have been presented: Nichols (1943)

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referred it to the genus *Barbatula*; Banarescu *et al.* (1974) to the genus *Schistura* and Zhu *et* Wang (1985) to the genus *Paracobitis*. The last designation has been commonly followed by Chinese authors (Chen, in Anonym, 1987; Yang, in Chu *et al.*, 1990; Ding *et al.*, 1990; Cao, in Zheng, 1989). Considering their greatly disjunct range, Kottelat (1990) tentatively considered the Chinese and South-Western species as representing two genera: *Paracobitis* being the name of the South-Western ones and *Homatula* the earliest available name for the Chinese ones. This hypothesis has yet to be supported or refuted. Therefore we have decided to follow the nomenclature currently used in Chinese literature and treat them as a single genus, *Paracobitis*. Since Sauvage and Dabry de Thiersant(1874), two nominal species related to *P. variegatus* have been described: *Nemacheilus berezowskii* Gunther (1896) from Huisien Co. (Gansu Province) and *Nemachilus oxygnathus* Regan (1908) from Yunnan Fu (= Kunming, Yunnan). They are now considered to be synonyms of *P. variegatus* (Chen, in Anonym, 1987; Yang, in Chu *et al.*, 1990; Ding *et al.*, 1990; Zhu, 1989). So far, *P. variegatus* has been reported from the tributaries of the upper Yangtze River, Huanghe River and Nanpanjiang River of China. It can be recognized by having a complete lateral line; head, thorax and abdomen without scales, but scales present at least on postdorsal body; vertebrae 4 + 41-44; dorsal fin with 8-9 branched fin rays (Zhu, 1989). Recently we closely compared the materials from the three drainages and found that the specimens from the upper Nanpanjiang River are obviously different from those of the upper Yangtze and Huanghe Rivers and represents a new subspecies which is named here *Paracobitis variegatus longidorsalis*.

2 Material and Methods

Specimens examined belong to the Collections of Kunming Institute of Zoology, the Chinese Academy of Sciences, Kunming (KIZ); Institute of Hydrobiology, the Chinese Academy of Sciences, Wuhan (IH); British Museum (Natural History) (BMNH); Collections of Maurice Kottelat (CMK). Counts and measurements follow Chu *et al* (1989). The abbreviations used in this paper are: BD, body depth; DCP, depth of caudal peduncle; ED, eye diameter; HL, head length; IW, interorbital width; LCP, length of caudal peduncle; LS, length of snout; PRL, predorsal length; SL, standard length; TL, total length.

3 Systematic Accounts

Paracobitis variegatus variegatus Sauvage and Dabry de Thiersant.

Nemacheilus variegatus Sauvage and Dabry de Thiersant, 1874: 14(Schansi = Shanxi Province of China, in Huanghe Drainage).

Barbatula (Homatula) variegatus: Nichols, 1943: 215 (China).

Nemachilus oxygnathus Regan, 1908: 357 (Yunnan Fu = Kunming of Yunnan).

-Chang, 1944: 51(Guanxian Co., Yaan, Sichang of Sichuan).

Nemachilus berezowskii Gunther, 1896: 217 (Huisien Co. of Gansu Province). -Liu, 1964: 112 (Mianjiang River, Qingyijiang River, Anninghe River).

Schistura variegata: Banarescu and Nalbant, 1974: 96 (Guanxian Co., Leshan of Sichuan).

Paracobitis variegatus: Chen, in Anonym, 1987: 18-19 (Lueyang, Fengxian Cos. of Shaanxi Province, Wenxian of Gansu Province).-Zhu, 1989: 32-34 (Guanxian Co., Sichuan Province; Tianshui, Gansu Province; Fengxian, Shaanxi Province; Jiuxiang of Yiliang Co., Yunnan Province). - Ding and Deng, 1990: 286 (Ganluo, Leshan, Chengkou, Yaan, Xichang, Wulong, Wuxi, Anxian, Guanxian, Guangyuan of Sichuan Province).

Paracobitis variegatus variegatus: Yang, in Chu and Chen, 1990: 29-30 (Weixin, Yanjing Cos., Yunnan Province).

Material examined KIZ 82101110 -82101117, 82101120 -82101127, 82101134 -82101145, 28 ex., 63.0 -119.0 mm SL, Yunnan: Yanjing and Weixin Cos., October, 1982; KIZ 90110161 -90110218, 58 ex., 55.0 -148.5 mm SL, Sichuan: Huidong Co., November, 1990; IH 7340737 -7340738, 7360831 -7360832, 8060956-8060978, 8252278 -8252283, 8260100 -8260110, 44 ex., 64.0 -140.0 mm SL, Shaanxi: Zhouzhi Co., April and June, 1973; June, 1980; May and June, 1982; IH 7940719 -7940730, 7940613 -7940614, 7940812, 7940482, 16 ex., 59.5 -141.5 mm SL, Sichuan: Erbian, Ermei and Leshan, April, 1979 MNHN 7854, B-2641 (syntypes), 2 ex., 96.8 -103.5 mm SL, Pere David, China: Schansi; BMNH 1908.2.27: 23, 1908. 2. 27: 24 (syntypes), 2 ex., 86.7 -113.3 mm SL, John Graham, China: Yunnan Fu (=Kunming), February, 1908.

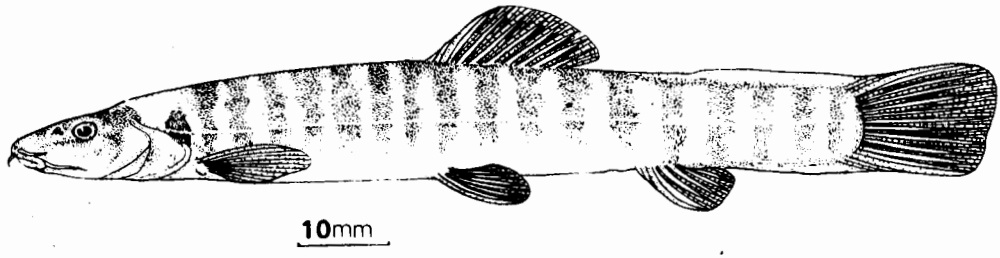

Figure 1 *Paracobitis variegatus variegatus*

Diagnosis This subspecies is distinguished from *P. variegatus longidorsalis* by the following combination of characters: dorsal fin with 8 branched rays (0.7% specimens with 9 branched fin rays); anterior nostril situated at a nostral valve (Fig. 2A); no scales on the back in front of dorsal fin origin, scales only present behind dorsal fin origin, or with rudimentary scales on sides of posterior half of predorsal(specimens from Erbian, Ermei Cos. of Sichuan and from Yanjing, Weixin Cos. of Yunnan);

maxillary barbel reaching to the vertical from middle to posterior margin of eye; head without vermiform markings or with 1–4 faint vermiform markings on parietal area.

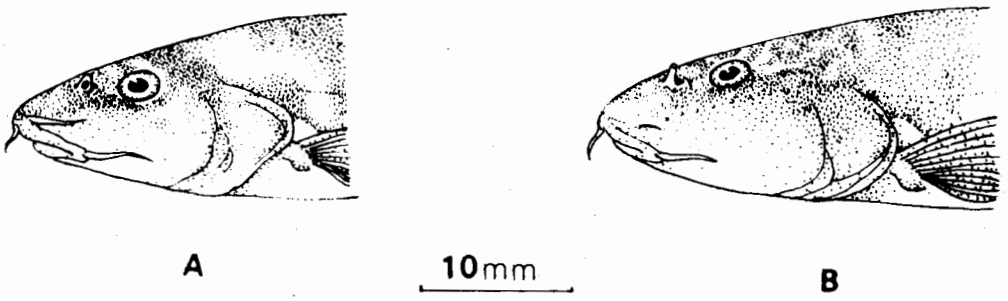

Figure 2　Lateral view of head　A: *P. variegatus variegatus*; B: *P. variegatus longidorsalis*

Tab. 1　Characters distinguishing the two subspecies of *Paracobitis variegatus* from related taxa (mean values in brackets)

	P. v. variegatus	*P. v. longidorsalis*
No. specimens	146	32
D	3, 8(0.7% specimens with 9)	3, 9
P	1, 9–11	1, 10–11
V	1, 6–7	1, 7
A	3, 5	3, 5
in % of standard length		
BD	9.7–14.6(11.9)	11.4–14.4(13.0)
HL	15.5–22.7(17.6)	18.3–23.9(21.4)
LCP	18.2–24.6(20.9)	18.3–23.7(19.6)
DCP	8.6–12.7(10.4)	10.4–12.3(11.5)
PRL	41.1–50.6(45.1)	42.4–47.9(45.8)
in % of head length		
LS	34.6–42.0(39.2)	37.3–40.0(38.4)
ED	11.5–16.7(14.5)	13.7–17.2(14.9)
IW	18.6–30.3(24.2)	23.2–27.3(25.0)
in % of caudal length		
DCP	38.2–66.7	45.5–66.7(59.2)
vertebrae	4 + 41–44	4 + 42–44
colour pattern of head	1–4 vermiform markings on parietal area or obscure	numerous vermiform markings on top of head
maxillary barbel reaching to	middle and posterior margin of eye	anterior margin and middle of eye
anterior nostril situated at	a nostral valve	a short tube
back of predorsal body	devoid of scales	scaled

Distribution　This subspecies occurs in the tributaries of upper Yangtze River and upper Huanghe River.

Comments　One of us (MK) examined the type specimens of *Nemacheilus*

variegatus Sauvage Dabry de Thiersant. They were collected by Pere David from Schansi of China (now Shanxi Province, in Huanghe Drainage). All data obtained indicate that our specimens from Huanghe and Yangtze Drainages agree well with the type specimens which have adipose keels along dorsal and ventral middle lines of caudal peduncle, 8 branched dorsal fin rays (Table 1–3). It is undoubted that our specimens from Huanghe and Yangtze drainages represent *P. variegatus variegatus*. Other problems needed to be clarified are the taxonomic status of *Nemacheilus berezowskii* Gunther, 1896 and *Nemachilus oxygnathus* Regan, 1908. *Nemachilus berezowskii* was collected from Huisien of Kansu (now Huixian Co., Gansu), in the upper Yangtze Drainage. According to Gunther(1896), *N. berezowskii* could be distinguished from *P. variegatus* by having 9 branched dorsal fin rays. Among all 146 specimens examined by us from upper Yangtze River, 145 specimens have 8 and only one specimen (accounting for 0.7%) have 9 branched dorsal fin rays; the latter one specimen agrees well with the former ones in morphormetric and meristic characters except for the number of branched dorsal fin rays. So we consider here that *N. berezowskii* is the synonym of *P. variegatus variegatus*. *Nemachilus oxygnathus* was reported from Yunnan Fu (= Kunming, in upper Yangtze Basin). The original description of Regan and the data (Table 3) obtained by Dr. Maurice Kottelat indicate that although both the lectotype and

Table 2 Comparisons among populations of *P. variegatus variegatus*

Populations	A	B	C	D
No. specimens	28	58	16	44
D	3, 8	3, 8	3, 8 (1 specimem with 9)	3, 8
P	1, 9–10	1, 10–11	1, 10–11	1, 10–11
in % of standard length				
BD	9.7–14.5(12.4)	10.1–12.1(11.3)	11.5–14.6(13.1)	10.4–14.6(12.1)
HL	17.2–22.7(19.7)	19.0–21.7(20.7)	15.5–20.6(18.5)	15.7–20.7(18.5)
LCP	18.9–23.8(20.7)	18.5–23.2(20.5)	19.5–23.8(21.4)	18.2–24.6(21.4)
DCP	9.2–12.7(11.0)	9.1–11.6(10.5)	9.5–11.4(10.2)	8.6–12.4(10.0)
PRL	41.7–50.0(47.0)	42.4–48.3(45.6)	41.1–47.3(44.6)	41.7–50.6(43.5)
in % of head length				
LS	38.5–41.7(39.3)	37.5–42.0(39.6)	34.6–40.9(38.1)	36.4–41.8(38.9)
ED	13.0–15.9(14.6)	11.5–16.7(14.1)	12.0–16.1(14.4)	12.4–16.5(15.0)
IW	20.8–30.3(24.2)	23.4–26.5(25.1)	22.7–27.9(25.3)	18.6–25.0(22.6)
in % of Caudal length				
DCP	38.5–66.7(53.5)	39.1–60.6(51.6)	40.9–58.1(48.1)	38.2–59.0(49.2)

A, Yanjing and Weixin; B, Huidong; C, Erbian, Ermei and Leshan; D, Zhouzhi. A–C in Yangtze River, D in Huanghe River. Mean values in brackets

paralectotype have 9 branched dorsal fin rays, they agree well with *P. variegatus variegatus* by having no scales on the back in front of dorsal fin origin, anterior nostril situated at a nostral valve, maxillary barbel reaching beyong the vertical through middle

of eye, no obvious vermiform markings on back of head. It is obvious that *N. oxygnathus* is a synonym of *P. variegatus variegatus*.

Table 3 The morphometric and meristic data of the syntypes of *Nemacheilus variegatus* and *Nemachilus oxygnathus*

	N. variegatus		*N. oxygnathus*	
	Lecto.	Paralecto.	Lect.	Paralecto.
TL	108.2	115.8	128.6	99.8
SL	96.8	103.5	113.3	86.7
HL	17.0	18.0	21.7	18.5
PRL	44.1	46.6	50.3	41.4
BD	9.0	10.0	11.5	9.0
DCP	7.5	8.5	10.3	7.1
LCP	21.9	22.9	23.0	16.8
LS	6.5	7.0	9.4	7.3
ED	2.8	2.8	3.7	3.4
IW	3.4	3.6	4.1	3.6
length P	12.2	12.8	14.7	12.7
length V	10.8	10.7	13.1	10.7
length C	13.8	16.0	17.4	14.4
length A	13.0	13.8	15.3	11.5
length D	11.0	10.2	12.7	12.1
lateral line pores	110	?	110	>100
D	3, 8	3, 8	3, 9	3, 9
P	1, 10	1, 10–11	1, 10	1, 10
V	1, 7	1, 7	1, 7	1, 7
A	3, 5	3, 5	3, 5	3, 5
C (branched)	17	17	17	17
vertebrae	4 + 42	4 + 44	4 + 41	4 + 41

Paracobitis variegatus longidorsalis, new subspecies

Paracobitis variegatus variegatus: Zhu and Wang, 1985: 208 (upper Nanpanjiang). –Cao, in Zheng, 1989: 48 (Jiuxiang of Yiliang Co. Yunnan Province). Holotype. KIZ 874048, 82.0 mm SL; Yunnan: Yiliang Co.: Jiuxiang(25° 06′ N 103° 24′ E); Yang Jun-Xing and Chen Yin-Rui, April, 1987.

Paratypes KIZ 874042–874043, 874045–874047, 874050, 874198–874216, CMK 5871, 29 ex., 46.1–89.5 mm SL, same data as holotype. Other specimens examined are: IH 820093, 820107, 70.0–139.0 mm SL, collected in Jiuxiang of Yiliang Co., Yunnan in 1982.

Diagnosis A subspecies distinguished from *P. variegatus variegatus* by the following combination of characters: dorsal fin with 9 branched fin rays; anterior nostril situated at a short tube (Fig. 2B); scales present on the back and sides of posterior half of predorsal; maxillary barbel reaching to the vertical from anterior margin to middle of eye; numerous vermiform markings present on top of head.

Description Morphometric and meristic data are given in Table 1. Body elongated and cylindrical in front of dorsal fin origin. Head conical. Dorsal fin origin nearer to tip of snout than to caudal fin base; distal margin of dorsal fin convex. Pectoral fin reaches 45.8–50.5(mean: 48.8)% of distance between pectoral and pelvic fin origins. Pelvic fin reaches 44.4–53.8 (mean: 48.9)% of distance between pelvic and anal fin origins; tip of pelvic fin not reaching to anus; distance between its tip and anus equal to about 1.5–2.7 eye diameters. Axillary lobe present at pelvic fin base. Anus situated about 1.2–1.3 eye diameters in front of anal fin origin. Anal fin origin nearer to pelvic fin origin than to caudal fin base (sometimes at the middle); distal margin convex; tip of anal fin not reaching to caudal fin base. Caudal fin slightly emarginated posteriorly, both lobes rounded and the upper one slightly longer than the lower one. Caudal peduncle deep and compressed, with adipose keels along dorsal and ventral middle lines; dorsal adipose keel extending forwards to the vertical through anal fin origin; ventral adipose keel extending forwards to the midlength of caudal peduncle.

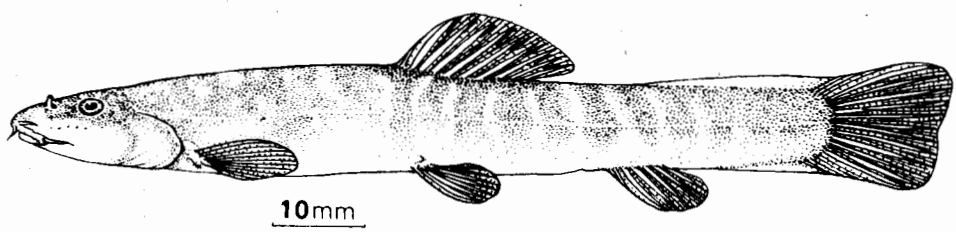

Figure 3 *Paracobitis variegatus longidorsalis*, new subspecies

Head small, slightly depressed, width of head slightly larger than its depth. Interorbital area flat. Snout conical, equal to or slightly shorter than postorbital length of head. Nostrils close together, nearer to eye than to tip of snout; anterior nostril situated at a short tube (Fig. 2B). Eye small, invisible from below ventral. Mouth inferior. Upper lip with a median notch; lower lip also with a median notch in addition to 2 furrows on each side. Upper jaw with a dentiformis process; lower jaw without a notch. Barbels 6, inner rostral barbel almost reaching mouth angle, outer rostral barbel to or slightly beyond mouth angle; maxillary barbel extending to the vertical through anterior margin or middle of eye. Lateral line complete, straight, along middle of body. Head, thorax, abdomen and anterior half of predorsal without scales; scales only present on the back and sides of posterior half of predorsal as well as postdorsal.

Colour pattern Colour in life dark blue, with 14–17 vertical dark brownish bars crossing back and sides of body, spaces between bars pale, about equal to width of bars; another vertical dark bar present on caudal fin base. Head dark blue, with numerous blackish vermiform markings on top of head. Dorsal fin with an oblique,

broad dark band on middle part. Anal, pectoral and pelvic fins hyaline. Caudal fin without any spot and the upper lobe reddish.

Distribution. This subspecies occurs only in the tributaries of upper Nanpanjiang River.

Etymology. *Longus* (Latin): long; *dorsalis* (Latin): dorsal fin ; alluding to the 9 branched dorsal fin rays. Treated as a noun in apposition.

Comments. Zhu and Wang (1985) and Cao (in Zheng, 1989) ascribed the specimens from Jiuxiang of Yiliang Co., Yunnan, in the upper Nanpanjiang River to *P. variegatus variegatus*. Cao reported that one of the two specimens examined had 8 and the other one had 9 branched dorsal fin rays. In October, 1991, YJX reexamined Cao's specimens numbered IH820093 and 820107, and found that both specimens have 9 branched dorsal rays. So far, all specimens from the upper Nanpanjiang River examined by us have 9 branched dorsal rays and show obvious differentiation from those specimens of upper Yangtze and upper Huanghe Rivers (vs. 99.3% specimens with 8 branched dorsal rays). In addition, they are also different in the morphology of anterior nostril, body squamatia, the colour pattern of head and the length of maxillary barbel. Although the two populations show obvious differentiations, they cannot be distinguished adequately by any single character and therefore are believed to represent a single species. Based on facts mentioned above, we consider that the specimens from the upper Nanpanjiang River represent a distinct subspecies: *P. variegatus longidorsal.*

4 Discussion on Zoogeography

P. variegatus variegatus has a wide distribution range including the upper Yangtze and upper Huanghe Rivers. By contrast, *P. variegatus longidorsalis* is confined to the upper Nanpanjiang River. The two subspecies are isolated geographically by the watershed along northern margin of middle and east Yunnan Plateau. This distribution pattern suggests that the subspecific differentiation of *P. variegatus* is closely correlated to the origin of the barrier intervened between their distribution ranges and that their common ancestor might have occurred in a wide area of upper Yangtze River, upper Huanghe River and upper Nanpanjiang River prior to the rise of this barrier. During late Pleistocene, the eastern Yunnan Plateau lifted sharply, producing profound effects on the river systems and on the distribution of fishes in the plateau (Chen *et al.*, in Zheng, 1989). It might be this geological event that finally resulted in the origin of the barrier which subdivided the common ancestor into two geographically isolated populations: population of upper Nanpanjiang River, and population of upper Yangtze and upper Huanghe Rivers.

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红尾副鳅的亚种分化及其动物地理分析

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摘要　红尾副鳅 (*Paracobitis variegatus*) 广泛分布于黄河、长江和南盘江水系的上游。其背鳍分枝鳍条数目、前鼻孔的形态、头部斑纹、须的长度和前躯的被鳞程度等特征均表明红尾副鳅已分化为两个亚种。两个亚种的分布在地理上是相互隔离的：红尾副鳅指名亚种 (*P. variegatus variegatus*)的分布范围限于黄河、长江水系的上游；而新亚种长鳍副鳅 (*P. variegatus longidorsalis*) 则仅分布于南盘江的上游。亚种的分化可能与晚更新世时滇东高原的急剧抬升有关。本文还讨论了 *Nemachilus berezowskii* Gunther 1896 和 *Nemacheilus oxygnathus* Regan 1908 的分类地位。经查看其模式标本，认为上述两个名称应为红尾副鳅指名亚种的同物异名。

关键词　红尾副鳅，亚种分化，新亚种，动物地理