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A review and species diversity of the genus *Distoechodon* (Teleosei: Cyprinidae), with a description of a new species

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Abstract

Distoechodon is a morphologically distinctive cyprinid group restricted in its distribution to China. Previous studies recognized only two species in the genus, viz., *D. tumirostris* and *D. hupeinensis*. A morphological analysis of more than 150 specimens from different localities suggests that *D. hupeinensis* should be referred to the genus *Xenocypris* and four species of *Distoechodon* can be recognized. *Distoechodon tumirostris* is restricted to small coastal rivers in Zhejiang Province. *Distoechodon multispinnis* is widely distributed in Chang Jiang and Zhu Jiang basins. *Distoechodon compressus* is known only from the Fujian Province and Taiwan. *Distoechodon macropthalmos*, sp. n., is known only from the Chenghai Lake, Chang Jiang River basin in Yunnan Province. A key to all the genera of the Xenocyprininae is also provided and the status of the genus *Distoechodon* is discussed.

Contents

Introduction

The east Asian genus Distoechodon was established by Peters (1881), with the single species, D. tumirostris, type locality Ningpo (now known as Ningbo), Qiantang Jiang River, Zhangjiang Province, China. It can be distinguished from Xenocypris Günther, 1868 by having a transverse instead of a concave mouth and possessing only two instead of three rows of pharyngeal teeth (Peters, 1881).

The status of Distoechodon is ambiguous and confusing both at genus and species levels. Nichols (1925) described Xenocypris compressus,which has a deeper body and longer pectoral fin, from Yenping (now known as Nanping), Min Jiang River, Fujian Province. Later, Nichols (1928) synonymized Distoechodon with Xenocypris, without providing any specific explanation. Yang (1964) revalidated Distoechodon on the basis of possessing only two instead of three rows of pharyngeal teeth. Yih (1964) added another species to the genus, Distoechodon hupeinensis, from the Liangzi Hu Lake, Chang Jiang River basin, in Hubei Province. Compared to all other Distoechodon species, D. hupeinensis has fewer lateral-line scales, fewer gill rackers, and lacks the dark horizontal stripes along the sides of the body (Yih, 1964). Bănărescu (1970) disagreed with Yang's (1964) synonymy due to the fact that having reduced rows of pharyngeal teeth is common among cyprinid fishes, which does not qualify as a genetic diagnostic character. He thus synonymized Distoechodon back as a subgenus of Xenocypris, and placed three subspecies under the species X. (D.) tumirostris, based mainly on lateral-line scale count and number of gill rakers: X. (D.) t. tumirostris (Zhejiang Province, 71-77 lateral-line scales, 80-85 gill rakers), X. (D.) t. compressus (Fujian Province; 74-75 lateral-line scales, 93-98 gill rakers), and X. (D.) t. multispinnis, a new subspecies which occurs in Chang Jiang River basin, Sichuan Province, with 77-84 lateral-line scales and 91-108 gill rakers. Almost all contemporary Chinese systematic work on xenocyprinine genera follows Yang's (1964) revalidation, that Distoechodon is a valid genus having two instead of three rows of pharyngeal teeth (Lian, 1984; Chen and Liu, 1989; Liu and He, 1998).

Yang (1964), while revalidating the genus Distoechodon, also regarded D. compressus as a valid speices. In 1970 Bănărescu synonymized Xenocypris compressus with X. tumirostris, and treated it as a subspecies, X. (D.) t. compressus. However, Lian (1984) followed Yang (1964), and still recognized Distoechodon compressus as a valid species. In 1998, Liu and He synonymized Distoechodon compressus again with D. tumirostris, based on the fact that the number of lateral-line scales and gill rakers among Distoechodon populations are overlapping. However, Shan (1998) indicated differences between D. compressus and D. turmirostris in lateral-line scale count, shapes of the dentary and pasioccipital masticatory plates, and thus revalidated D.

compressus. Molecular analysis on nucleotides of the mitochondrial D-loop region and a complete cytochrome b gene supported D. compressus as a distinct species (Liu, 2002).

In 1994, Ding tentatively synonymized Xenocypris tumirostris multispinnis with Distoechodon tumirostris without providing specific explanation. Liu (2002) suggested that D. t. multispinnis is genetically closely related to D. tumirostris.

In a phylogenetic study based on morphological characters, Shan (1998) placed Distoechodon hupeiensis under Xenocypris. Molecular study on cytochrome b gene from a number of xenocyprinine species showed that D. hupeiensis is indeed more closely related to Xenocypris argentea and X. davidi than to other Distoechodon species (Xiao et al., 2001).

In the course of reviewing the genus Distoechodon as well as clarifying the species diversity of the genus, 164 specimens of Distoechodon from different localities in China were examined, allowing the recognition of the genus, redescription of the type species, D. tumirostris, revalidation of both D. compressus and D. multispinnis, as well as a new species, which is herein described. A key to different genera in Xenocyprininae is also provided, with external morphological characters only applied.

Material and methods

One hundred and sixty-four specimens of Distoechodon and more than 57 specimens of Xenocypris were examined, for this study. Detailed specimen information of Distoechodon was listed in each species' description. Comparative material of Xenocypris was listed in Appendix 1. Specimens were obtained from the ECOCARP field material, which were collected in Hunan, Sichuan and Guangxi Provinces, P. R. China. Further specimens were obtained from the fish collections of the Institute of Zoology (IZB); Institute of Hydrobiology (IHB); Kunming Institute of Zoology (KIZ), Chinese Academy of Sciences; Shanghai Fishery University and Swedish Museum of Natural History (NRM). Institutional abbreviations were as listed in Leviton et al. (1985) and Leviton and Gibbs (1988).

Measurements were taken point to point with a digital calliper (Mitutoyo CD-20C) to 0.1 mm. Morphometric and meristic characters were selected according to methods described by Fang (1997). Post-predorsal length was measured from the nape to the dorsal-fin insertion. Measurements and counts were taken on the left side of the body whenever possible. Gill rakers were only counted in the lower part of the first gill arch, on ceratobranchial and hypobranchial bones.

Dorsal, anal and caudal-fin rays, and vertebrae were counted on radiographs. Specimens were radiographed with Philips MG 150 low voltage X-ray unit with and Kodak X-Omat V film. Abdominal vertebrae include the Weberian apparatus. Predorsal vertebrae were counted from the first free vertebra to the vertebra before the first dorsal-fin pterygiophore. Caudal vertebrae were counted from the first vertebra with haemal spine to the last half centrum.

Most of the coordinates provided in material examined list were inferred by author. The local Chinese toponymy is employed for all localities in the present study. The Chinese names for the Yangtze and Pearl Rivers are Chang Jiang and Zhu Jiang, respectively.

Morphometric and meristic information was analyzed and organized using SYSTAT version 10 (Wilkinson, 2001).

Key to the subfamily Xenocyprininae

The most recent key to Chinese Xenocyprinine genera is mainly based on the number of pharyngeal rows, and thus impractical as it requires extensive dissection (Liu and He, 1998). The alternative key is proposed here, using only external characters, which is more user-friendly and practical.

Key to genera
1. Lateral line absent; mouth terminal, upward-directed ……..… Xenocyprioides
   Lateral line present; mouth inferior……...…… ……2
2. Abdominal keel from pelvic-fin base to vent ……..…. Pseudobrama
   Abdominal keel absent or rather short…..……..…….. 3
3. Mouth transverse; pectoral-fin axillary fold present ……... Distoechodon
   Mouth concave; pectoral-fin axillary fold absent …….….. Xenocypris

Note: The genus Xenocyprioides was established by Chen in 1982. Two species were included in the genus, Xenocyprioides parvulus Chen, 1982 and X. carinatus Chen et Huang, 1985 (Luo et al., 1985). Both of them are small-sized (21 - 30 mm SL), without a stout last unbranched dorsal-fin ray, without a lateral line, with fewer number of vertebrae (33-35 vs. 40-48) and fewer vertical scale rows along the sides (31-35 vs. 57-84), which make them differ from all other extant xenocypinines. Actually Shan (1998) had already demonstrated that this genus was outside the true Xenocyprininae. However, neither further discussions nor nomenclatual actions were made. In the present studyI adopt the broad concept of Xenocyprininae (sensu Zhang et al., 1996) and leave a thorough phylogenetic analysis for further study.

Distoechodon tumirostris Peters, 1881
(Fig. 1A)
Distoechodon tumirostris Peters, 1881, Mber. Akad. Wiss. Berl. 45:925 (Ningpo, now known as Ningbo); Mao, 1991, Fauna of Zhejiang Freshwater fishes: 76-77 (Anji, Tonglu, Tiantai, Yunhe).
Xenocypris tumirostris Nichols, 1928, Bull. Am. Mus. Nat. Hist. 58(1): 24 (Ningpo).
Xenocypris (Distoechodon) tumirostris tumirostris Bănărescu, 1970, Rev. Roum. Biol. (zool) 15 (6): 400 (Ningpo).

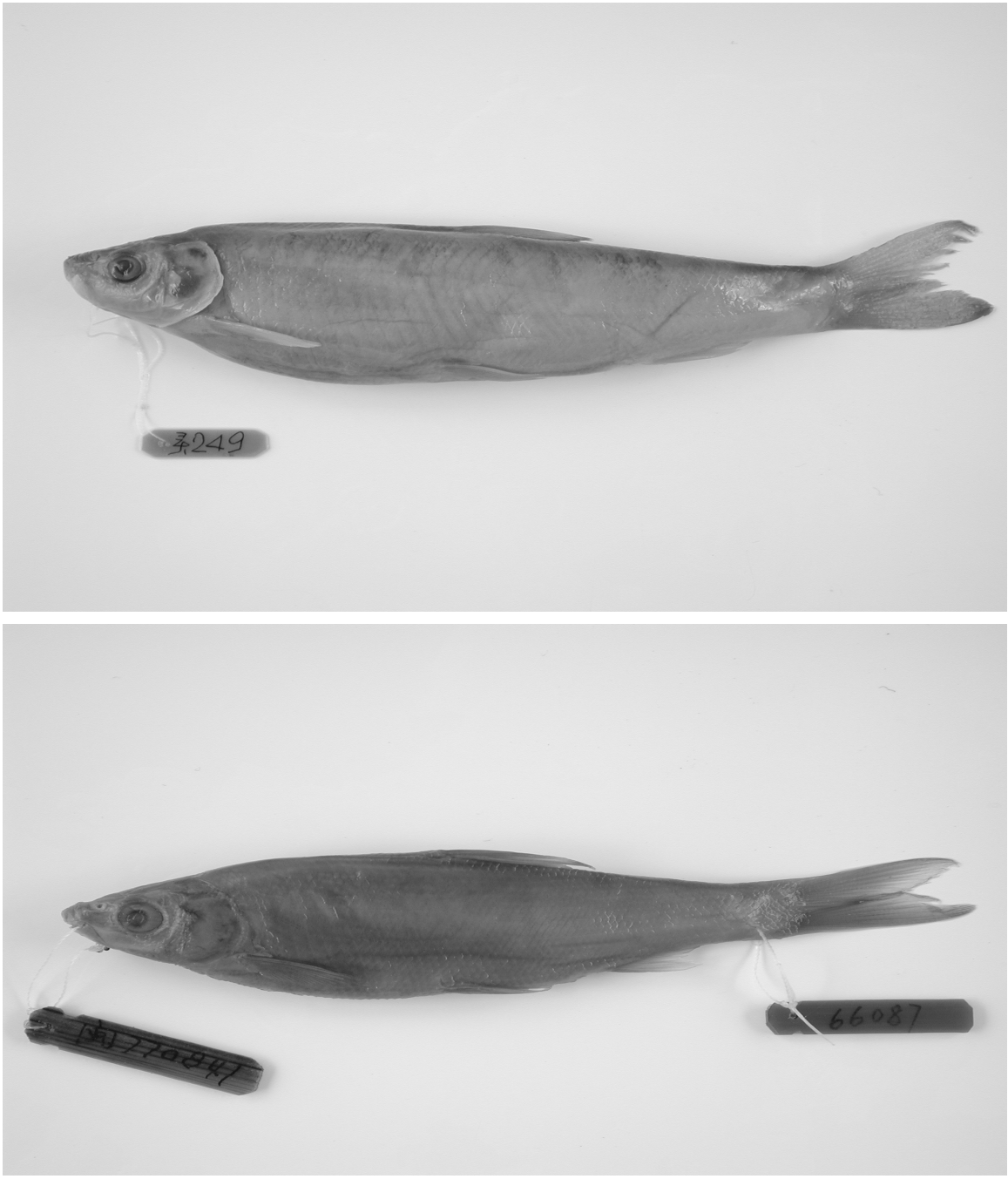


Figure 1 A: Distoechodon tumirostris, IZB73089, 201.9 mm SL. B: Distoechodon compressus, IZB66087, 116.0mm SL.

Specimens examined. All specimens examined were collected from China, without collector's information. Zhejiang Province: Ou Jiang River basin: IZB64104-64105 (3), 154.4-159.8 mm SL, Lishui (28°27' N, 119°54' E), Apr. 27, 1972; IZB61771-61773 (3), 111.5-126.2 mm SL, Qingtian (28°09'N, 120°18'E), Apr. 28, 1972; IHB0002420 (5), 159.2-318.0 mm SL, Lishui and

Jinyun (28°39'N, 120°04'E). Ling Jiang River basin: IZB73089-73092 (4), 99.1-156.8 mm SL, Xianju (28°51'N, 120°44'E) and Linhai (28°51'N, 121°07'E), May 29, 1972; IZB62312-62316 (5), 172.3-243 mm SL, Xianju and Linhai, May 31, 1972; IHB0002422 (15), 91.3-242.0 mm SL, Linhai, Xianju and Tiantai (29°08'N, 121°02'E), Sep., 1974. Yong Jiang River basin: IZB0002421 (5), 146.0-245.0 mm SL, Ningbo (29°52'N, 121°33'E) and Fenghua (29°39'N, 121°24'E), Sep., 1974 and May, 1976. Xin'an Jiang River basin: IHB0002426 (1), 298.3 mm SL, Chun'an (29°37'N, 119°02'E), June, 1977. Cao'e Jiang River basin: IHB0002423 (2), 103.3-149.5 mm SL, Shengzhou (29°36'N, 120°49'E), Sep., 1974. Qiantang Jiang River basin: IHB0002424 (1), 88.7 mm SL, Hangzhou (30°16'N, 120.10'E), Aug. 8, 1929. River unknown: IZB62137-62139 (3), 75.5-96.3 mm SL, May, 1972; IHB0002425 (4), 100.0-203.1 mm SL. Jiangxi Province: Chang Jiang River basin: IHB0002428 (3), 127.8-130.36 mm SL, Jingdezhen (29°17'N, 117°13'E), May, 1990; IHB0002427 (8), 107.4-243.9 mm SL, Yujiang (28°12'N, 116°49'E) and Guixi (28°17'N, 117°12'E), Apr., 1990.

Diagnosis. Distoechodon tumirostris can be distinguished from all other Distoechodon species by having a combination of following characters: lateral-line scales 68-77, mostly 72; predorsal scale 30-36, mostly 33 (Fig. 2); relatively smaller eye, being 6.98% vs. 7.77-8.28% SL. Distoechodon tumirostris is similar to D. compressus in lateral-line scale count, but is different from it by having more predorsal scales and smaller eyes (Fig. 3, 4A, Table 1). Distoechodon tumirostris is similar to D. multispinnis in predorsal-scale count and eye diameter, but is different from the latter species in having fewer lateral-line scales (Fig. 2), shorter dorsal-fin and anal-fin lengh (Fig. 4B, Table 4).

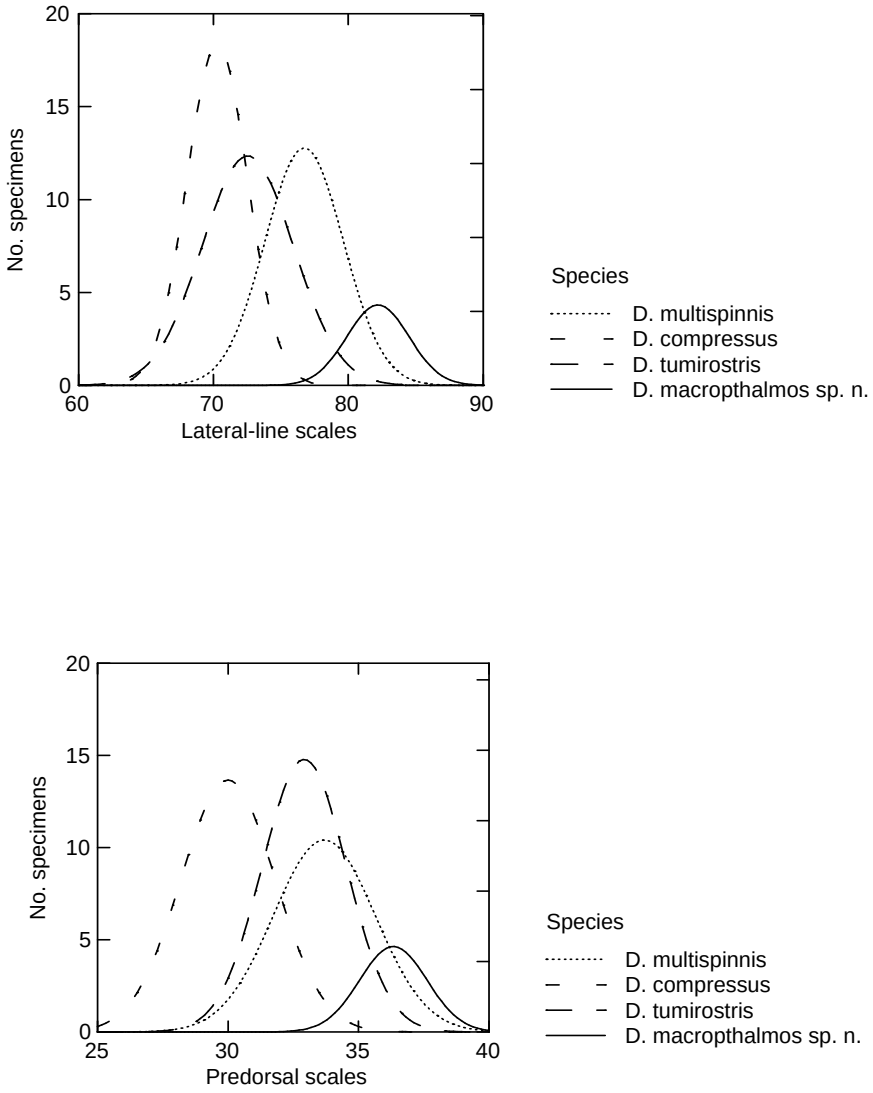


Figure 2 Differences in lateral-line scale (above) and predorsal scale counts (below) amongst four Distoechodon species.

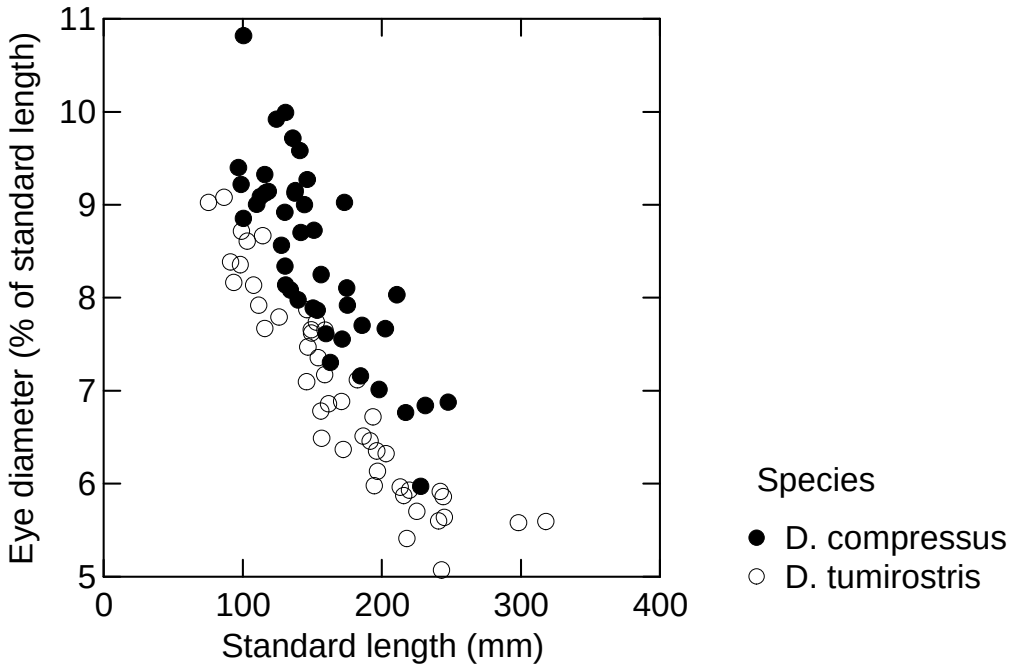
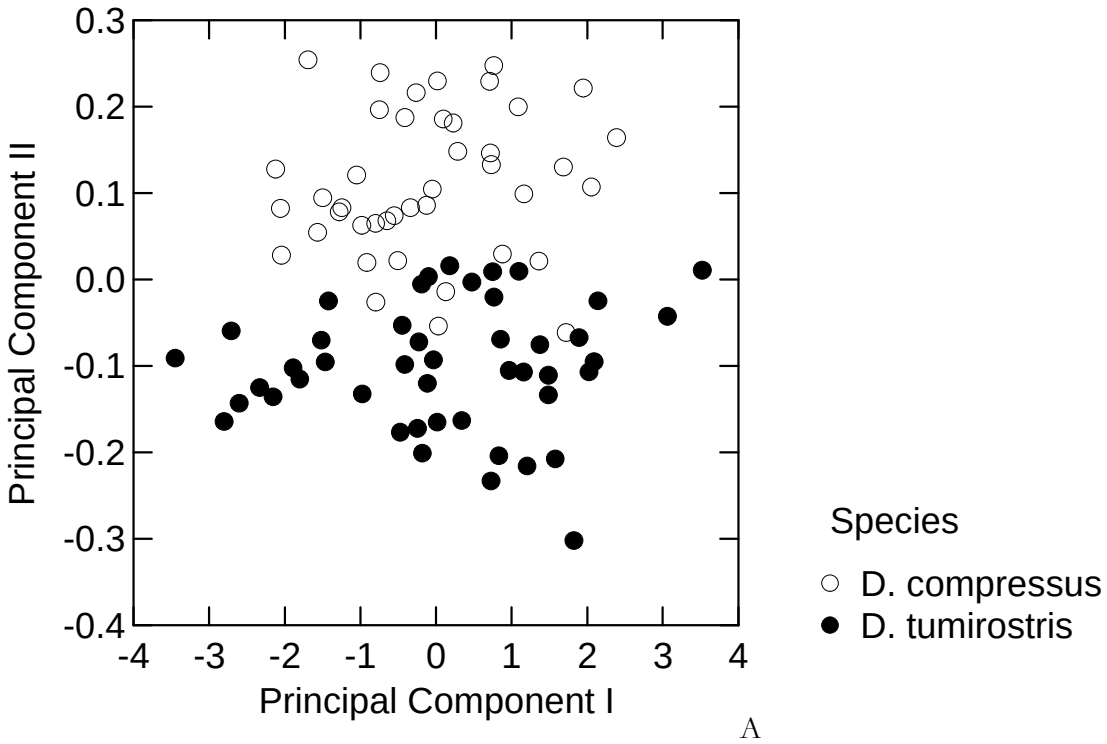
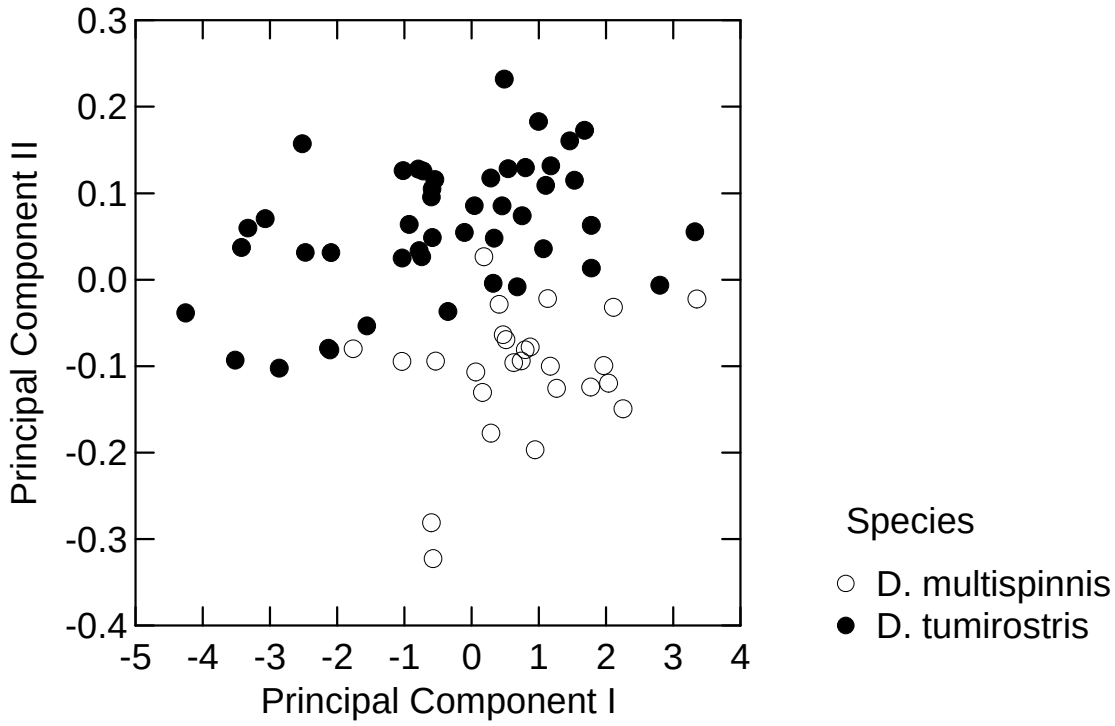


Figure 3 Eye diameter (% SL) plotted against standard length (mm) for Distoechodon tumirostris and D. compressus.



A



B

Figure 4 A: Distoechodon tumirostris and D. compressus. Plot of scores of principal component II on principal component I. B: Distoechodon tumirostris and D. multipinnis. Plot of scores of principal component II on principal component I.

Table 1. Character loadings on principal components I-III for measurement from specimens of Distoechodon tumirostris (46 specimens) and D. compressus (51 specimens) (Three highest loadings on PC II indicated by boldface.)

	PC I	PC II	PC III
Standard length	0.2997	-0.0319	0.0052
Body depth	0.3116	0.0021	0.0058
Predorsal length	0.2931	-0.0247	0.0017
Post-predorsal length	0.3107	**-0.0412**	0.0055
Prepectoral length	0.2687	0.0052	-0.0059
Prepelvic length	0.2900	-0.0247	0.0015
Preanal length	0.2974	-0.0271	0.0038
Caudal peduncle length	0.3026	**-0.0566**	-0.0086
Caudal peduncle depth	0.3150	-0.0077	0.0010

Dorsal-fin base length	0.2934	0.0223	0.0255
Anal-fin base length	0.2860	-0.0000	0.0227
Dorsal-fin length	0.2832	0.0333	0.0253
Anal-fin length	0.3114	0.0247	0.0269
Pectoral-fin length	0.2855	0.0157	0.0195
Pelvic-fin length	0.2872	0.0171	0.0267
Head length	0.2661	0.0119	-0.0087
Head depth	0.3003	-0.0111	-0.0083
Head width	0.3231	-0.0019	-0.0186
Snout length	0.3099	0.0175	-0.0317
Eye diameter	0.1713	**0.0726**	-0.0137
Interorbital width	0.3444	-0.0024	-0.0121
Upper jaw length	0.2826	0.0152	-0.0348
Mouth width	0.3325	0.0262	-0.0269
Variance Explained by Components	2.0138	0.0175	0.0076
Percent of Total Variance Explained	97.0340	0.8423	0.3664

Table 2. Character loadings on principal components I-III for measurement from specimens of Distoechodon tumirostris (46 specimens) and D. multispinnis (36 specimens) (Three highest loadings on PC II indicated by boldface.)

	PC I	PC II	PC III
Standard length	0.3172	0.0157	0.0135
Body depth	0.3353	-0.0315	0.0212
Predorsal length	0.3042	0.0141	0.0124
Post-predorsal length	0.3226	0.0119	0.0252
Prepectoral length	0.2787	0.0149	-0.0054
Prepelvic length	0.3005	0.0161	0.0074
Preanal length	0.3102	0.0151	0.0131
Caudal peduncle length	0.3347	0.0015	0.0297
Caudal peduncle depth	0.3461	-0.0328	0.0123
Dorsal-fin base length	0.3210	0.0036	0.0027
Anal-fin base length	0.3122	-0.0061	-0.0003
Pectoral-fin base length	0.3240	**0.0384**	-0.0103
Pelvic-fin base length	0.3458	-0.0123	0.0095
Dorsal-fin length	0.3181	**-0.0375**	-0.0113
Anal-fin length	0.3542	**-0.0452**	-0.0140
Pectoral-fin length	0.3032	-0.0087	-0.0151
Pelvic-fin length	0.3193	-0.0327	-0.0086
Head length	0.2703	0.0134	-0.0063
Head dorsum length	0.2774	0.0241	-0.0142
Head depth	0.3042	0.0061	0.0108
Head width	0.3308	0.0183	0.0158
Snout length	0.3316	0.0069	-0.0368
Eye diameter	0.1735	0.0176	-0.0069
Interorbital width	0.3546	-0.0026	0.0144
Upper jaw length	0.2963	-0.0165	0.0050
Mouth width	0.3554	0.0286	-0.0087
Prenostril length	0.3323	0.0008	-0.0605
Variance Explained by Components	2.6935	0.0122	0.0095
Percent of Total Variance Explained	97.4509	0.4421	0.3446

Table 3. Morphometry of four Distoechodon species. Main measurements are in per cent of SL (in mm).

	Distoechodon tumirostris					***Distoechodon compressus***				
	N	min	max	mean	SD	N	min	max	mean	SD
SL (mm)	46	75.47	318.00	171.16	56.34	51	96.92	247.73	151.33	35.06
Body depth	46	22.89	29.67	25.61	1.61	51	22.17	32.03	26.82	2.15
Predorsal length	46	49.99	56.25	53.28	1.41	51	50.58	57.40	53.85	1.46
Preanal length	46	73.58	83.05	77.30	2.19	51	74.46	82.87	77.99	1.87
Prepectoral length	46	20.82	26.14	23.76	1.29	51	21.21	28.20	25.09	1.54
Prepelvic length	46	50.33	56.22	53.03	1.49	51	50.99	57.63	53.71	1.54
Caudal-peduncle length	46	13.14	17.08	14.93	1.01	51	12.32	16.51	14.46	0.87
Caudal-peduncle depth	46	9.43	11.82	10.82	0.56	51	9.63	12.59	11.15	0.67
Pectoral-fin length	46	14.31	19.00	16.72	0.96	51	16.17	19.91	18.03	0.86
Pelvic-fin length	46	12.12	16.03	14.20	0.81	51	13.75	17.03	15.43	0.72
Dorsal-fin length	46	16.49	21.73	19.42	1.15	51	19.43	24.25	21.73	1.11
Anal-fin length	46	11.47	14.73	13.23	0.84	51	12.96	16.20	14.44	0.69
Head length	46	20.15	26.43	22.85	1.39	51	21.44	26.84	24.28	1.28
Head depth	46	15.41	19.68	17.68	0.83	51	15.90	20.66	18.06	1.05
Snout length	46	7.09	10.02	8.16	0.56	51	7.39	10.09	8.64	0.72
Eye diameter	46	5.07	9.08	6.98	1.09	51	5.97	10.82	8.28	1.04
Interorbital width	46	7.73	10.55	8.90	0.55	51	7.97	10.76	9.09	0.65
Mouth width	46	5.83	9.25	7.66	0.65	51	6.61	9.54	8.18	0.67

	Distoechodon multispinnis					***Distoechodon macropthalmos* sp. n.**				
	N	min	max	mean	SD	N	min	max	mean	SD
SL (mm)	52	111.56	326.80	191.67	43.82	15	104.23	200.14	152.99	31.12
Body depth	52	21.68	32.37	25.98	2.41	15	22.92	26.58	24.82	0.89
Predorsal length	52	49.66	56.35	52.54	1.46	15	51.59	55.82	53.46	1.23
Preanal length	52	73.73	81.72	76.64	1.65	15	74.71	78.76	76.72	1.30
Prepectoral length	52	21.56	26.36	23.46	1.10	15	20.99	25.61	23.68	1.47
Prepelvic length	52	49.88	55.38	52.18	1.26	15	49.21	56.59	52.39	1.79
Caudal peduncle length	52	12.93	17.51	15.43	1.06	15	12.09	16.35	14.42	1.09
Caudal peduncle depth	52	9.30	13.21	11.40	0.82	15	9.25	11.31	10.41	0.58
Pectoral-fin length	52	15.39	20.85	16.81	1.04	15	16.68	18.90	17.80	0.81
Pelvic-fin length	52	13.63	17.63	15.06	0.85	15	14.46	15.87	15.32	0.48

Dorsal-fin length	42	18.97	24.13	20.52	1.17	15	18.06	22.82	20.20	1.09
Anal-fin length	42	12.22	16.58	14.38	1.07	15	12.41	15.37	14.33	0.73
Head length	52	20.30	24.95	22.27	1.11	15	21.38	24.49	22.79	1.08
Head depth	52	15.98	19.70	17.42	0.86	15	16.24	17.82	17.07	0.53
Snout length	52	7.13	9.18	8.20	0.51	15	7.30	8.41	7.77	0.38
Eye diameter	52	4.58	8.32	6.37	0.81	15	6.54	9.44	7.97	1.03
Interorbital width	52	8.02	10.24	9.14	0.43	15	7.76	9.32	8.43	0.47
Mouth width	52	6.28	8.60	7.67	0.51	15	6.63	7.80	7.24	0.39

Table 4. Character loadings on principal components I-III for measurement from specimens of Distoechodon mocropthalmos sp. n. (15 specimens) and D. multispinnis (22 specimens from upper Chang Jiang River basin) (Three highest loadings on PC II indicated by boldface.)

	PC I	PC II	PC III
Standard length	0.1985	0.0072	-0.0055
Body depth	0.1956	-0.0080	-0.0362
Predorsal length	0.1813	0.0121	0.0013
Post-predorsal length	0.1946	0.0087	-0.0010
Prepectoral length	0.1647	0.0044	0.0168
Prepelvic length	0.1894	0.0092	0.0086
Preanal length	0.2001	0.0082	0.0040
Caudal peduncle length	0.2173	**-0.0435**	-0.0451
Caudal peduncle depth	0.2320	-0.0221	-0.0106
Dorsal-fin base length	0.1917	-0.0171	0.0164
Anal-fin base length	0.1693	0.0015	-0.0293
Pectoral-fin length	0.1745	**0.0424**	-0.0212
Pelvic-fin length	0.1847	0.0144	0.0085
Head length	0.1618	0.0060	0.0083
Head depth	0.1960	-0.0017	0.0060
Head width	0.2033	-0.0145	0.0175
Snout length	0.1997	0.0005	-0.0144
Eye diameter	0.0672	**0.0815**	-0.0088
Interorbitalr width	0.2258	-0.0110	0.0199
Upper jaw length	0.2176	-0.0013	0.0528
Gape width	0.2044	-0.0041	0.0180

Variance Explained by Components	0.7729	0.0122	0.0097
Percent of Total Variance Explained	94.2409	1.4905	1.1848

Description. General body features and colour pattern are shown in Figure 1A. Proportional measurements as percentages of standard length of Distoechodon tumirostris are given in Table 3.

Medium to big-sized cyprinid fish. Body elongate and moderately compressed; dorsal profile straight or slightly concave; ventral profile convex; abdomen round; abdominal keel absent. Head rather small and compressed; snout round, anterior tip truncated; snout length longer than eye diameter; mouth inferior, transverse, with cuticular edge; mouth wide, as wide as head width at that point; no barbel; nostrils closer to eyes than to tip of snout; eyes relatively small.

Scales moderately large. Lateral-line scales complete, 68-77, mostly 72, rarely 76 and 77. Lateral line descending to above pectoral-fin ray, being parallel to the horizontal scale row, and ascending to the body midline above anal-fin base, and running until the end of caudal peduncle. Scales above lateral line 12-13, rarely 14; scales below lateral line 7-8, rarely 9; circumpeduncular scales 26; predorsal scales irregularly arranged, being 30-36, mostly 33; scales cover abdomen. Pectoral-fin axillary fold present; pelvic-fin axillary scales well-developed. Gill rakers tiny, numerous and triangular, 53-64 in lower part of the first gill arch.

Pectoral-fin insertion slightly anterior to vertical through posterior margin of operculum. Pectoral fin short, reaching to midway between pectoral and pelvic-fin insertions. Pelvic fin short, reaching to midway between pelvic-fin insertion and vent. Dorsal-fin origin midway between snout tip and caudal-fin base, and slightly posterior to pelvic-fin insertion. Anal-fin insertion midway between pelvic-fin origin and caudal-fin base. Dorsal-fin rays iii, 7 (11), last unbranched dorsal-fin ray ossified but smooth. Anal-fin rays iii, 9 (9), 8 (2). Pectoral-fin rays i, 14 (6), 15 (3), 16 (2). Pelvic-fin rays i, 8 (11), Caudal fin forked, lobes almost equal in length; procurrent caudal-fin rays 9 (2), 10 (7), 11 (2) dorsally, 8 (2), 9 (9) ventrally.

Osteological features. Total vertebrae 25+20=45 (3), 26+19=45 (5), 26+20=46 (2), 27+19=46 (1); predorsal vertebrae 9(3), 10 (7), 11 (1). Pharyngeal teeth 2 rows, 3, 6; 6, 3. The first row of pharyngeal teeth strong, deeply compressed, with curved and pointed tips; the second row of pharyngeal teeth not well-developed, with very sharp tips.

Coloration in preservative.— Alcohol preserved specimens generally grayish to brownish, without special markings.

Sexual dimorphism.— Not observed.

Geographical distribution. Costal rivers (Ou Jiang, Ling Jiang, Yong Jiang, Qiantang Jiang and Cao'e Jiang River basins) in Zhejiang Province; Chang Jiang River in Jingdezhen, Xin Jiang River in Yujiang and Guixi, Jiangxi Province (Fig. 5).

Local names. Migu, Qingcao, Wucao, Meicao, Yucao, Wuwei.

Remarks. Most of characters observed in this study agree with that from the original description (Peters, 1881), except for body depth, which was stated as 4.75 in the original description, but 3.4-4.3 in our study. Only one type material was included in the original description. The differences in body depth may have been caused by different way of measuring standard length. Type material not checked. Some of the material included in this study were from Ningbo, the type locality of the species, and can well be regarded as topytypes.

Distoechodon compressus Nichols, 1925
(Fig. 1B)
Xenocypris compressus Nichols, 1925, Am. Mus. Novit. (185):6 (Yenping, now known as Nanping); Nichols, 1928, Bull. Am. Mus. Nat. Hist. 58(1): 24 (Fukien, now known as Fujian); Nichols, 1943, Nat. Hist. Central Asia, 9:124 (Kienning and Yenping).
Xenocypris (Distoechodon) tumirostris compressus Bănărescu, 1970, Rev. Roum. Biol. (zool) 15 (6): 400-401 (Yenping).
Distoechodon tumirostris Lian, 1984, in The fishes of Fujian Province: 253-254 (Nanping, Jianyang, Chong'an, Songxi, Jian'ou, Shunchang, Shaowu, Fu'an, Gutian, Putian, Xianyou, Nan'an, Anxi, Zhangzhou, Pinghe, Zhangping, Shanghang in Fujian Province).
Distoechodon compressus Yang, 1964, in The cyprinid fishes of China:131 (Nanping in Fujian Province, Zhejiang Province). Lian, 1984, in The fishes of Fujian Province: 254-255 (Nanping, Jianyang, Jian'ou, Fu'an, Putian, Yongtai, Xianyou, Quanzhou, Yongchun, Nan'an, Zhangzhou, Pinghe, Liancheng, Shanghang, Youxi, Qingliu, Ninghua in Fujian Province).

Specimens examined. All specimens examined were collected from China, without collector information. Fujian Province: Min Jiang River basin: IZB67298-67305 (8), 134.2-160.6 mm SL, Jianyang (27°20' N, 118°07'E), Jianxi River, June 15, 1977; IZB66084-66089 (6), 81.2-115.0 mm SL, Jian'ou (27°03'N, 118° 19'E), Jianxi River, April and May, 1977; IHB0002431 (3), 112.7-153.6 mm SL, Nanping (26°38'N, 118°10'E), April, 1957. Jiulong Jiang River basin: IHB0002432 (4), 98.8-134.2 mm SL, Zhangzhou (24°31'N, 117°39'E), May, 1974; SHFUA004217 (1), SHFU6164-6169 (6), 130.8-159.9 mm SL, Jimei (24°34'N, 118°07'E). Ting Jiang River basin: IHB0002423 (1), 96.9 mm SL, Shanghang (25°03'N, 116°24'E), June, 1974; IHB0002434 (7),

171.5-247.7 mm SL, Liancheng (25°42'N, 116°44'E), June, 1974 and 1976; SHFU6185 (1), SHFU6212 (2), SHFUnoNumber2 (1), SHFU6181 (1), SHFU6184 (1), SHFU6219 (1), SHFU6199 (1), SHFU6217 (1), SHFU6204 (1), SHFU6201 (1), SHFU6206 (1), 100.7-210.8 mm SL, Liancheng, June, 1975. Ao Jiang River basin: IHB0002437 (5), 115.9-139.8 mm SL, Lanjiang (26°12'N, 119°31'E), June and July, 1974. Jiangxi Province: Chang Jiang River basin: IHB0002429 (2), 187.2-203.3 mm SL, Huichang (25°34'N, 115°47'E), Gan Jiang River, September, 1974.

Diagnosis. Distoechodon compressus can be distinguished from the rest of Distoechodon species in a combination of characters, by having the least number of lateral-line scales 67-74, mostly 70, the least number of predorsal scales 27-33, mostly 30 (Fig. 2), and the relative bigger eye, being 8.28% vs. 6.37-7.77% SL. The differences between D. compressus and D. tumirostris have been presented in the diagnosis for the type species.

Description. General body features and colour pattern are shown in Figure 1B. Proportional measurements as percentages of standard length of Distoechodon tumirostris are given in Table 3.

Medium to big-sized cyprinid fish. Body elongate and moderately compressed; dorsal profile straight or slightly concave; ventral profile convex; abdomen round; abdominal keel absent. Head relatively big and compressed; snout round, anterior tip truncated; snout length longer than eye diameter; mouth inferior, transverse, with cuticular edge; mouth wide, as wide as head width at that point; no barbel; nostrils closer to eyes than to tip of snout; eyes relatively big.

Scales moderately large. Lateral-line scales complete, 67-74, mostly 70. Lateral line descending to above pectoral-fin ray, being parallel to the horizontal scale row, and ascending to the body midline above anal-fin base, and running until the end of caudal peduncle. Scales above lateral line 12-13; scales below lateral line 7-8; circumpeduncular scales 26; predorsal scales irregularly arranged, being 27-33, mostly 30; scales cover abdomen. Pectoral-fin axillary fold present; pelvic-fin axillary scales well-developed. Gill rakers tiny, numerous and triangular, 51-65 in lower part of the first gill arch.

Pectoral-fin insertion slightly anterior to vertical through posterior margin of operculum. Pectoral fin short, reaching to midway between pectoral and pelvic-fin insertions. Pelvic fin short, reaching to midway between pelvic-fin insertion and vent. Dorsal-fin origin midway between snout tip and caudal-fin base, and slightly posterior to pelvic-fin insertion. Anal-fin insertion midway between pelvic-fin origin and caudal-fin base. Dorsal-fin rays iii, 7 (8), last unbranched dorsal-fin ray ossified but smooth. Anal-fin rays iii, 9 (8). Pectoral-fin rays i, 14 (3), 15 (2), 16 (3). Pelvic-fin rays i, 8 (8), Caudal fin forked, lobes

almost equal in length; procurrent caudal-fin rays 9 (1), 10 (6), 11 (1) dorsally, 8 (3), 9 (5) ventrally.

Osteological features. Total vertebrae 25+19=44 (1), 26+18=44 (1), 26+19=45 (5), 26+20=46 (1); predorsal vertebrae 9(2), 10 (5), 11 (1). Pharyngeal teeth 2 rows, 3, 6; 6, 3. The first row of pharyngeal teeth strong, deeply compressed, with curved and pointed tips; the second row of pharyngeal teeth not well-developed, with very sharp tips.
Coloration in preservative.— Alcohol preserved specimens generally grayish to rownish, without special markings.

Sexual dimorphism--not observed.

Geographical distribution. Costal rivers (Min Jiang, Jiulong Jiang, Ting Jiang and Ao Jiang River basins) in Fujian Province; Gan Jiang River in Huichang, Jiangxi Province; Taiwan Island (historical record, Shen and Tzeng, 1993). (Fig. 5)

Local names. Yanyu, Anyu, Huoshaowei, Hongshaowei, Xile, Chiweile, Niyu, Maishao.

Distoechodon multispinnis Bănărescu, 1970
(Fig. 6A)
Xenocypris (Distoechodon) tumirostris multispinnis Bănărescu, 1970, Rev. Roum. Biol. (zool) 15 (6): 401 (Suifu, Szechwan, now known as Shuifu in Sichuan Province).
Distoechodon tumirostris Tchang, 1933, Zool. Sinica 2:110 (Ningpo, Szechuan, now known as Sichuan, Yangtsekiang, now known as Chang Jiang River basin); Huang, 1981, in Freshwater fishes of Guangxi, 56 (Guilin, Sanjiang in Guangxi Zhuang Autonomous Region); He, 1989, in Fishes of the Zhujiang River, 115 (Longsheng, Rong'an in Guangxi Zhuang Autonomous Region); Zheng, 1989, in Fishes of Guizhou, 75-77 (Jinping, jiangkou, Tongren, Congjiang, Rongjiang in Guizhou Province); Xu, 1987, in Fishes of Qinling Mountains, 65-66 (Hanzhong, Ankang in Shannxi Province and Xiangfan in Hubei Province); Ding, 1994, in Fishes of Sichuan, China, 163-165 (Huanglongxi, Leshan, Yinbin, Luzhou, Shengzhong in Sichuan Province).

Specimens examined: All specimens examined were collected from China, some of them collector unknown. Chang Jiang River basin: Sichuan Province: NRMT3483 (1), NRMT3486 (1), NRMT3489-3495 (7), 141.9-187.6 mm SL, Leshan (29°34'00"N, 103°43'59"E), August 7, 2002 (Kullander, S. O.); IZB39779 (1), 183.0 mm SL; Min Jiang River, June, 1957; IZB55822 (1), 214.0mm SL, Tuo Jiang River; IHB0002417 (6), 111.6-224.1 mm SL, Tuo Jiang River, 1958. IHB0002578 (3), 120.3-200.8 mm SL, Leshan, 1978, 1982 and

1987. Shannxi Province: IZB 61555(2), 135.0-146.7 mm SL, Hanzhong (33°04'00''N, 107°02'00''E), Hanshui River, April 1990 (Zhang, C. G. and Jia, W. L.); IZB73551-73554 (4), 146.6-199.6 mm SL, Yangxian (33°13'00''N, 107°33'00''E), Hanshui River, July 12, 2003 (Xu, T. Q.); IHB0002439(2), 210.9-326.8 mm SL, Hanzhong, Hanshui River, 1966 and May, 1980. Hubei Province: IHB0002444 (7), 198.4-260.2 mm SL, Danjiangkou (32°33'00N, 108°30'00E), Hanshui River, June, 1976. Guizhou Province: IHB0002418 (1), 201.35 mm SL, Tongren (27°43'N, 109°12'E), Yuan Jiang River, April, 1988. Hunan Province: IHB0002436 (1), 145.2 mm SL, Luxi (28°17'N, 110°09'E), Yuan Jiang River, July, 1987. Zhu Jiang River basin: Guangxi Zhuang Autonomous Region: IZB63456-63457 (2), 188.4-237 mm SL, Sanjiang (25°47'N, 109°36'E), Rong Jiang River, May 14, 1975. IHB0002441 (2), 193.1-214.5 mm SL, Longsheng (25°47'N, 110°02'E), Rong Jiang River, April, 1975; IHB0002440 (3), 173.1-319.7 mm SL, Guilin (25°17'N, 110°17'E) and Yangshuo (24°46'N, 110°28'E), Li Jiang River, 1958, 1975 and 1981; IHB0002442 (5), 125.9-179.9 mm SL, Rong'an (25°13'N, 109°22'), Siweihe reservoir, July, 1973 and November, 1974. Guizhou Province: IZB65694-65697 (4), 146.6-224.0 mm SL, Duliujiang River, 1973.

Diagnosis. Distoechodon multispinnis is distinguished from the rest of Distoechodon species by a combination of characters: lateral-line scales 70-84, mostly 77; predorsal scale 29-37, mostly 34 (Fig. 2); relatively smaller eye, being 6.37% vs. 6.98-8.28% SL. Differences between D. multispinnis and D. tumirostris have been presented in the diagnosis for the type species.

Description. General body features and colour pattern are shown in Figure 6A. Proportional measurements as percentages of standard length of Distoechodon tumirostris are given in Table 3.

Medium to big-sized cyprinid fish. Body elongate and moderately compressed; dorsal profile straight or slightly concave; ventral profile convex; abdomen round; abdominal keel absent. Head rather small and compressed; snout round, anterior tip truncated; snout length longer than eye diameter; mouth inferior, transverse, with cuticular edge; mouth wide, as wide as head width at that point; no barbel; nostrils closer to eyes than to tip of snout; eyes relatively small.

Scales moderately small. Lateral-line scales complete, 70-84, mostly 77. Lateral line descending to above pectoral-fin ray, being parallel to the horizontal scale row, and ascending to the body midline above anal-fin base, and running until the end of caudal peduncle. Scales above lateral line 12-13; scales below lateral line 6-8; circumpeduncular scales 26; predorsal scales irregularly arranged, being 29-37, mostly 34; scales cover abdomen. Pectoral-fin axillary fold present; pelvic-fin axillary scales well-developed. Gill rakers tiny, numerous and triangular, 52-66 in lower part of the first gill arch.

Pectoral-fin insertion slightly anterior to vertical through posterior margin of operculum. Pectoral fin short, reaching to midway between pectoral and pelvic-fin insertions. Pelvic fin short, reaching to midway between pelvic-fin insertion and vent. Dorsal-fin origin midway between snout tip and caudal-fin base, and slightly posterior to pelvic-fin insertion. Anal-fin insertion midway between pelvic-fin origin and caudal-fin base. Dorsal-fin rays iii, 7 (17), last unbranched dorsal-fin ray ossified but smooth. Anal-fin rays iii, 8, (1), 9 (14), 10 (2). Pectoral-fin rays i, 14 (3), 15 (10), 16 (1), 17 (3). Pelvic-fin rays i, 8 (17), Caudal fin forked, lobes almost equal in length; procurrent caudal-fin rays 8 (1), 9 (2), 10 (14) dorsally, 7 (1), 8 (7), 9 (8), 10 (1) ventrally.

Osteological features. Total vertebrae 26+19=45 (3), 26+20=46 (7), 27+19=46 (2); 26+21=47 (2), 27+20=47 (3); predorsal vertebrae 9(1), 10 (13), 11 (3). Pharyngeal teeth 2 rows, 3, 7; 7, 3. The first row of pharyngeal teeth strong, deeply compressed, with curved and pointed tips; the second row of pharyngeal teeth not well-developed, with very sharp tips.

Coloration in preservative.— Alcohol preserved specimens generally grayish to rownish; dark brownish speckle on the gill cover, behind eyes; side with 10 to 12 stripes composed of black dots, but not clear.

Sexual dimorphism.— not observed.

Geographical distribution. Chang Jiang River basin (Sichuan, Hubei, Jiangsu and Guizhou provinces) and Zhu Jiang River basin (Guizhou and Guangdong provinces, Guangxi Zhuang Autonomous Region)(Fig. 5).

Local names. Yinyu, Xilinyu (small-scale fish) in Guizhou Province; Laibai, Shaya in Guangxi. Qingpian (Black slice) in Sichuan, Shannxi, Gansu, and Hubei provinces.

Remarks. Tchang (1933) reported two species, Distoechodon tumirostris with 82 lateral-line scales and Xenocypris compressus with 72 lateral-line scales, both according to the specimens from Sichuan Province. The former should belong to D. multispinnis, and the latter species with three rows of pharyngeal teeth is actually Xenocypris fangi.

Distoechodon macropthalmos, new species
(Fig. 6B)
Distoechodon tumirostris Chen and Liu, 1989, in The fishes of Yunnan, China, Part I Cyprinidae, 96-98 (Chenghai Lake in Yunnan Province).
Type materials were all collected from Chenghai Lake, Chang Jiang River basin, in Yongsheng County (26°42'N, 100°44'E), Yunnan Province, P. R. China, without collector information.

Holotype. KIZ 797297, 155.4 mm SL.

Paratypes. KIZ 797298 (1), KIZ 799738 (1), KIZ797295 (1), KIZ818413 (1), 104.2-155.4 mm SL. IHB 0002446 (10), 115.2-200.2 mm SL, 1964 and July, 1981.

Diagnosis. Distoechodon macropthalmos sp. n. is distinguished from other species of Distoechodon in averaging the highest lateral line scales 78-85, mostly 82, pre-dorsal scales 34-39, mostly 36 (Fig. 2) and relatively bigger eye, being 7.97% vs. 6.37-6.98% SL. D. macropthalmos sp. n. is similar to D. multispinnis in both scale counts. In geographical distribution, the new species is also comparable to D. multispinnis, especially the Sichuan Province population since they all belong to Chang Jiang River basin. D. macropthalmos sp. n. differs from D. multispinnis by having bigger eyes than the latter species (Fig. 7, 8, Table 4).

Description. General body features and colour pattern are shown in Figure 6B. Proportional measurements as percentages of standard length of Distoechodon tumirostris are given in Table 3.

Medium to big-sized cyprinid fish. Body elongate and moderately compressed; dorsal profile straight or slightly concave; ventral profile convex; abdomen round; abdominal keel absent. Head rather small and compressed; snout round, anterior tip truncated; snout length longer than eye diameter; mouth inferior, transverse, with cuticular edge; mouth wide, as wide as head width at that point; no barbel; nostrils closer to eyes than to tip of snout, first pair of nostrils small and round, second pair of nostrils transverse, after first pair immediately with membranes; eyes relatively big.

Scales moderately large. Lateral-line scales complete, 78-85, mostly 82. Lateral line descending to above pectoral-fin ray, being parallel to the horizontal scale row, and ascending to the body midline above anal-fin base, and running until the end of caudal peduncle. Scales above lateral line 12-13; scales below lateral line 7-8; circumpeduncular scales 26 (14), rarely 24 (1); predorsal scales irregularly arranged, being 34-39, mostly 36; scales cover abdomen. Pectoral-fin axillary fold present; pelvic-fin axillary scales well-developed. Gill rakers tiny, numerous and triangular, 53-59 in lower part of the first gill arch.

Pectoral-fin insertion slightly anterior to vertical through posterior margin of operculum. Pectoral fin short, reaching to midway between pectoral and pelvic-fin insertions. Pelvic fin short, reaching to midway between pelvic-fin insertion and vent. Dorsal-fin origin midway between snout tip and caudal-fin base, and slightly posterior to pelvic-fin insertion. Anal-fin insertion midway between pelvic-fin origin and caudal-fin base. Dorsal-fin rays iii, 7 (15), last

unbranched dorsal-fin ray ossified but smooth. Anal-fin rays iii, 9 (15). Pectoral-fin rays i, 14 (6), 15 (9). Pelvic-fin rays i, 8 (18), Caudal fin forked, lobes almost equal in length.

Pharyngeal teeth 2 rows, 2, 7; 7, 2. The first row of pharyngeal teeth strong, deeply compressed, with curved and pointed tips; the second row of pharyngeal teeth not well-developed, with very sharp tips.

Color in life.— Back dark grayish; abdomen silvery whitish; side with 10 to 12 horizontal stripes composed of black dots; dorsal and caudal fin light yellowish; pectoral, pelvic and anal fin light reddish (Chen and Liu, 1989).

Coloration in preservative.— Alcohol preserved specimens generally brownish, back blackish, without special markings;

Sexual dimorphism—not observed.

Geographical distribution. Distoechodon macrophthalmos sp. n. is known only from Chenghai lake in Yunnan Province (Fig. 5), situated 1,503 m above sea level. The average depth is 25.7 m and the total area 74.6 km^2. The pH value is high, from 8.71 to 9.30 (Tao et al., 1999).

Etymology. The specific name macropthalmos is a noun composed of the Greek words macros, meaning big or long, and opthalmos meaning eye, referring to the proportionally large eye.

Local name. Hongchiyu (Red-wing fish) in Yunnan Province, obviously referring to the light reddish pectoral, pelvic and anal fins.

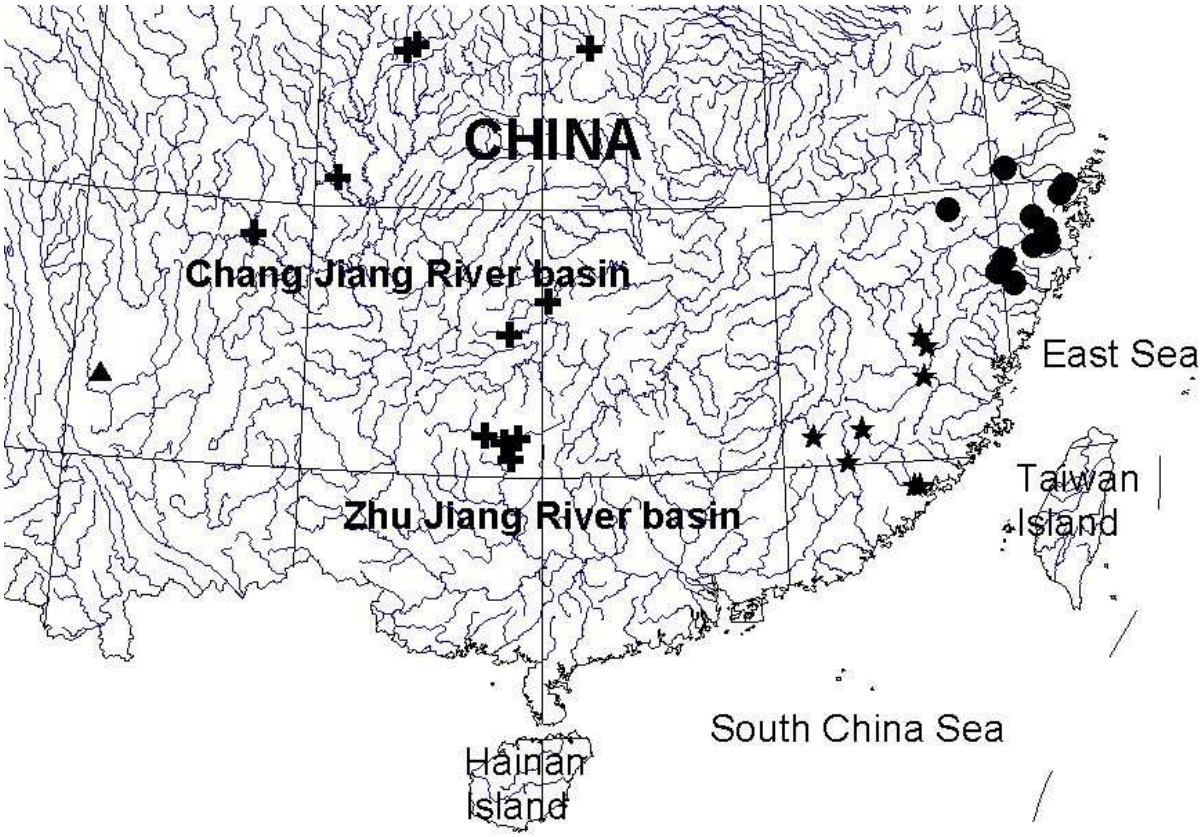


Figure 5 Distribution of Distoechodon species. (● Distoechodon tumirostris, ★ Distoechodon compressus, ✚ Distoechodon multispinnis, ▲ Distoechodon macropthalmos sp. n.)

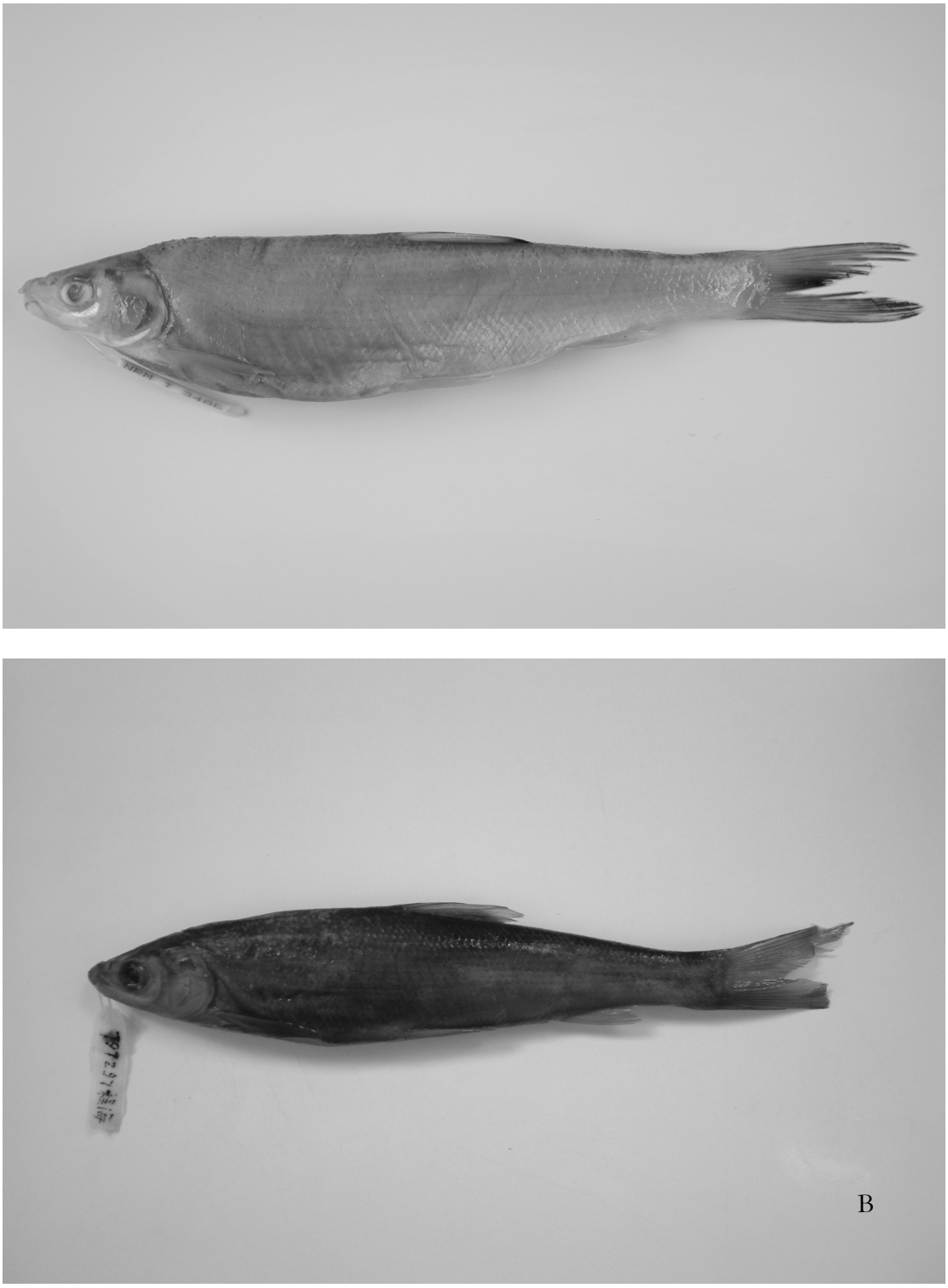


Figure 6 A: Distoechodon multispinnis, NRMT3486, 141.9mm SL. B: Distoechodon mocropthalmos sp. n.; KIZ797297, holotype, 155.4mm SL.

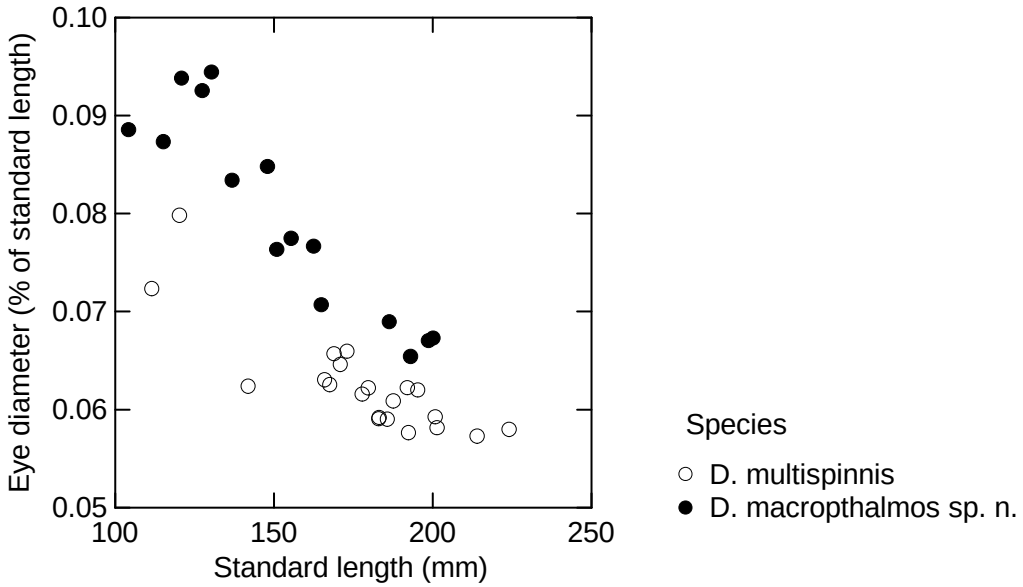


Figure 7 Eye diameter (% SL) plotted against standard length (mm) for Distoechodon multispinnis and D. macropthalmos sp. n.

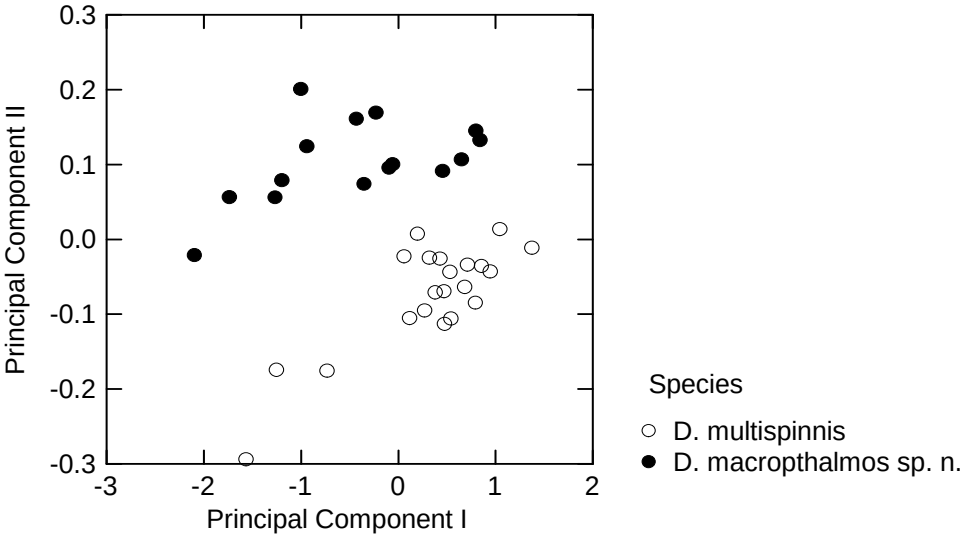


Figure 8 Distoechodon macropthalmos sp. n. and D. multispinnis. Plot of scores of principal component II on principal component I.

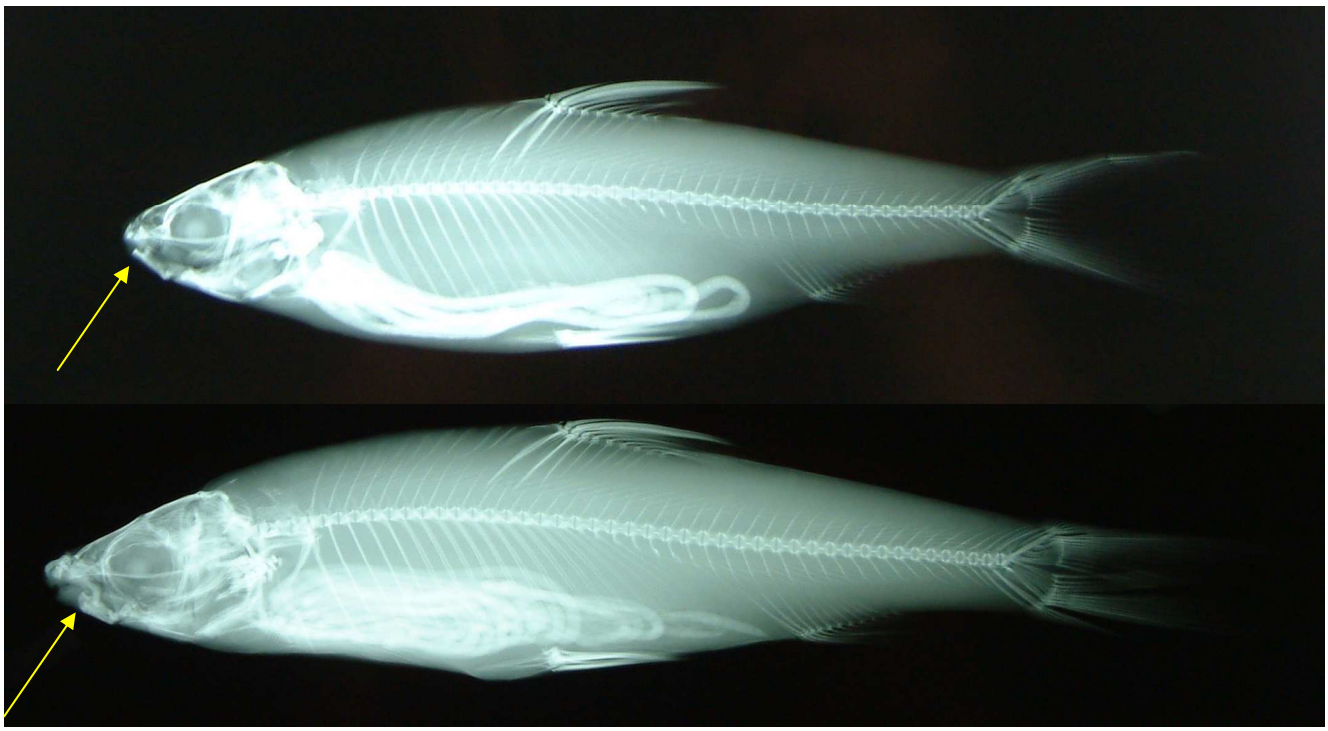


Figure 9 Radiograph of Xenocypris argentea (IZCAS 63153, above) and Distoechodon compressus (IZCAS 67303, below), showing the difference in the dentary part.

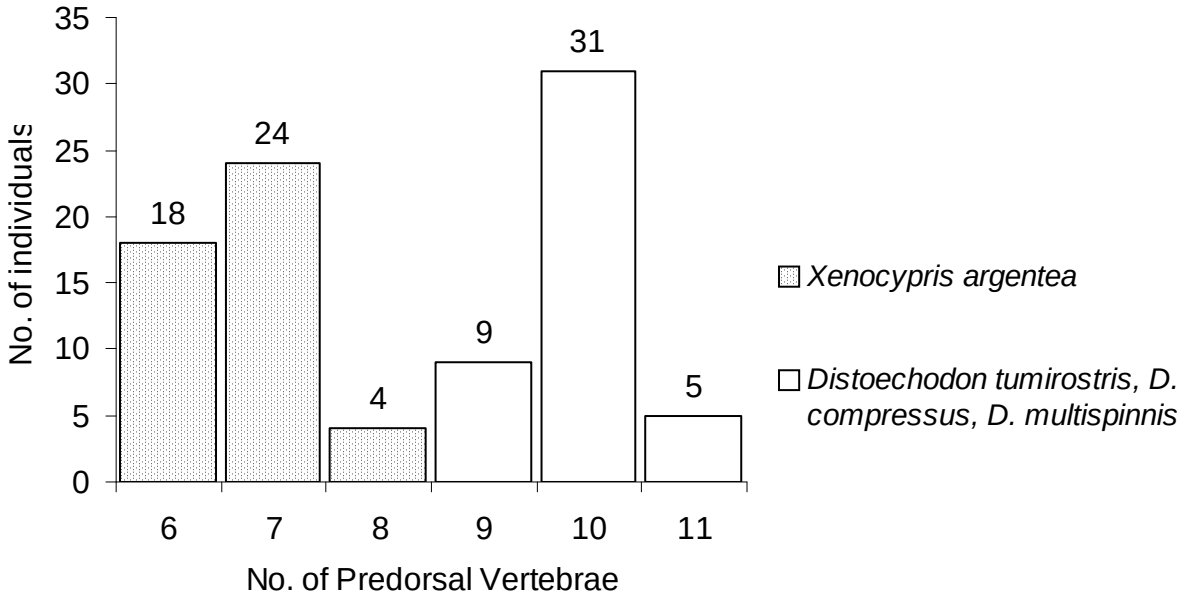


Figure 10 Differences in the number of predorsal vertebrae between Xenocypris argentea and Distoechodon species (D. tumirostris, D. compressus, D. multispinnis).

Discussion

In the subfamily Xenocyprininae (sensu Liu and He, 1998), the number of rows of pharyngeal teeth has been considered to be a main diagnostic character: Xenocyprioides and Xenocypris with three rows of pharyngeal teeth; Distoechodon, two rows; and Pseudobrama Bleeker, 1871, one row. Recent phylogenetic studies based on both morphological and molecular characters have proved that the number of pharyngeal teeth rows is not a phylogenetically informative character (Shan, 1998; Xiao et al., 2001). Xenocyprioides is a genus with many unique characters, which suggest that the genus is likely not a true member in the subfamily Xenocyprininae (Shan, 1998). Except for having one row of pharyngeal teeth, Pseudobrama also has another unique character, having abdominal keel from the pelvic-fin base to the vent. It also has the lowest number of lateral-line scales (41-47) and the highest number of gill rakers (128-139) amongst three genera. Compared to Xenocypris, Distoechodon has a transverse instead of concave mouth, a shorter dentary (Fig. 9), a well-developed (vs. weak or not developed) cutting edge on lower jaw, distinct pectoral-fin axillary folds, more gill rakers (85-122 vs. 39-61), and more predorsal vertebrae (Fig. 10). And thus Distoechodon is a diagnosible and valid genus.

Bănărescu (1970) recognized three subspecies of D. tumirostris based on different number of gill rakers and lateral-line scales. Our study, however, shows no particular variation in the gill-raker count amongst different species. The number of lateral-line scales, on the other hand, did show great variation among different species (Fig. 2).

Molecular study based on nucleotide sequences of the mitochondrial D-loop region and complete cytochrome b gene showed that the p-distance between Distoechodon specimens from Sichuan and Guangxi, and D. compressus is higher than the common intraspecific difference (Liu, 2002), which supports the current recognition of the D. multispinnis.

Comparative material examined.— Xenocypris argentea: Hunan Province: Yuan Jiang River: NRM-EC2002-2 (4), 12.9-24.5 mm SL, Taoyuan (28°53'59"N, 111°28'59"E), 18-19 Mar, 2002 (Fang, F, et al.). NRM-EC2002-3 (13), 63.0-123.0 mm SL, Taoyuan (28°53'59"N, 111°28'59"E), 18-19 Mar, 2002 (Fang, F). Hebei Province: IZB 15758-15763 (6), 74.5-131.5 mm SL, Tangshan. Xenocypris davidi: Hunan Province: Lishui River: NRM-EC2002-18 (2), 111-112 mm SL, Shimen (29°35'21"N, 111°17'43"E), 25 Mar, 2002 (Fang, F et al.). Guangxi Zhuang Autonomous Region: IZB 63153-63156 (4), 123-185 mm SL. Xenocypris sp.: Hunan Province: Yuan Jiang River: NRM-EC2002-5 (1), 50.0 mm SL, Chehuyuan (28°59'46"N, 111°31'35"E), Taoyuan, 18 Mar, 2002 (Malzahn, A et al.). NRM-EC2002-9 (25), 50-78 mm SL, Xinlongjie (28°47'54"N, 111°7'25"E), Taoyuan, 20 Mar, 2002 (Zhang, C. G.). NRM-

EC2002-41 (2), 134.0-146.0 mm SL, Hengdong (27°4'59"N, 112°56'59"E), 9 Apr, 2002 (Fang, F et al.).

Acknowledgement

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