

A Chromosome Study on Two Cyprinid Fishes, *Acrossocheilus labiatus* and *Pseudorasbora pumila pumila*, with Notes on Eurasian Cyprinids and their Karyotypes

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Chromosomes of cyprinid fishes have been studied more intensively than those of any other family of fishes except the family Cyprinodontidae (VASILIEV, 1980). As regards Japanese cyprinids, chromosomes of 20 genera and 35 species-subspecies have been hitherto reported (OJIMA & HITOTSUMACHI, 1967; OJIMA *et al.*, 1970, 1972, 1973, 1976; ITOH & NIYAMA, 1972; KOBAYASI *et al.*, 1970, 1973a, 1973b; ARAI & FUJIKI, 1977).

As I had the chance to observe chromosomes of two cyprinid fishes, *Acrossocheilus labiatus* from Taiwan and *Pseudorasbora pumila pumila* from Japan, their karyotypes are here described.

As regards Eurasian cyprinid fishes, karyotypes of 58 genera and 141 species-subspecies have been reported, including those of two species in this paper. Their karyotypes are reviewed in this paper and phylogenetic systematics of Eurasian cyprinid fishes are discussed on the basis of karyotypes and several morphological characters.

Method of chromosome preparation is the same as that of ARAI (1973). Classification of chromosomes is adopted from LEVAN *et al.* (1964). Metacentrics and submetacentrics are described as two-arm chromosomes, and subtelocentrics and acrocentrics as one-arm chromosomes. The definition of the new arm number (NAN) is referred to ARAI and NAGAIWA (1976).

All the specimens used for the experiments are deposited in the fish collection of the Department of Zoology, National Science Museum, Tokyo.

*Acrossocheilus labiatus* (REGAN)

(Figs. 1 A, C)

Two specimens (Nos. A·10·1 and A·10·2), 84.0 and 86.6 mm in total length, were used for experiments. These specimens were offsprings of fish which had been caught at Taiwan by Mr. Eizo KIMURA. Characters of material fish are shown in Table 1.

As shown in Table 2, the diploid chromosome number of this species is 50. The karyotype comprises 8 pairs of metacentric, 6 pairs of submetacentric, 2 pairs of sub-

telocentric and 9 pairs of acrocentric chromosomes. The arm number is 78.

As regards *Acrossocheilus*, the karyotype of *A. sumatranus* was reported (SUZUKI & TAKI, 1981). Its diploid chromosome number is 98 which differs from  $2n=50$  of *A. labiatus*. *Acrossocheilus labiatus* also differs from *A. sumatranus* in the number of branched dorsal rays, i. e., 8 in *A. labiatus* versus 9 in *A. sumatranus*.

Table 1. Characters of two species of material fishes.

Species	No. of fish	S. L. (mm)	Dorsal	Anal	Vertebrae
<i>Acrossocheilus labiatus</i>	2	67.9–72.1	iv, 8	iii, 5	21+17–18
<i>Pseudorasbora pumila pumila</i>	2	54.2–55.6	iii, 7	iii, 6	20–21+15

Table 2. Frequency distributions of diploid chromosome counts in two species of material fishes.

Species	2n								Total
	44	45	46	47	48	49	50	51	
<i>Acrossocheilus labiatus</i>		1		2	1	3	16	2	25
<i>Pseudorasbora pumila pumila</i>		1	1		2	8	36	1	49

***Pseudorasbora pumila pumila* MIYADI “Shinai-motsugo”**

(Figs. 1 B, D)

Two specimens (Nos. A·3·2 and A·3·3), 66.1 and 64.6 mm in total length, were collected from Akita Prefecture, Japan (Table 1).

The diploid chromosome number is 50 (Table 2). The karyotype comprises 13 pairs of metacentric, 10 pairs of submetacentric and 2 pairs of subtelocentric chromosomes. The arm number is 96.

The karyotype of this species agrees with that of *P. parva* in the diploid chromosome number, but differs from *P. parva* in the number of metacentrics, i. e., 26 in *P. p. pumila* versus 14 in *P. parva* (OJIMA *et al.*, 1972). The lateral line of *P. parva* is complete, while that of *P. p. pumila* is incomplete. From the viewpoint of the lateral line, *P. p. pumila* is considered to be more specialized than *P. parva*. Such interpretation seems to be supported by karyological analysis.

**Eurasian Cyprinid Fishes and their Karyotypes**

The family Cyprinidae is the greatest in diversity in most areas within its distribution range. It contains about 275 genera and about 1600 species, the largest number of species in fish families (NELSON, 1976).

The Cyprinidae is so large that its phylogenetic study is very difficult. HOWES (1978, p. 61) said “Various classifications of the Cyprinidae have been made by attaching significance to superficial resemblances and by utilizing only single character or a

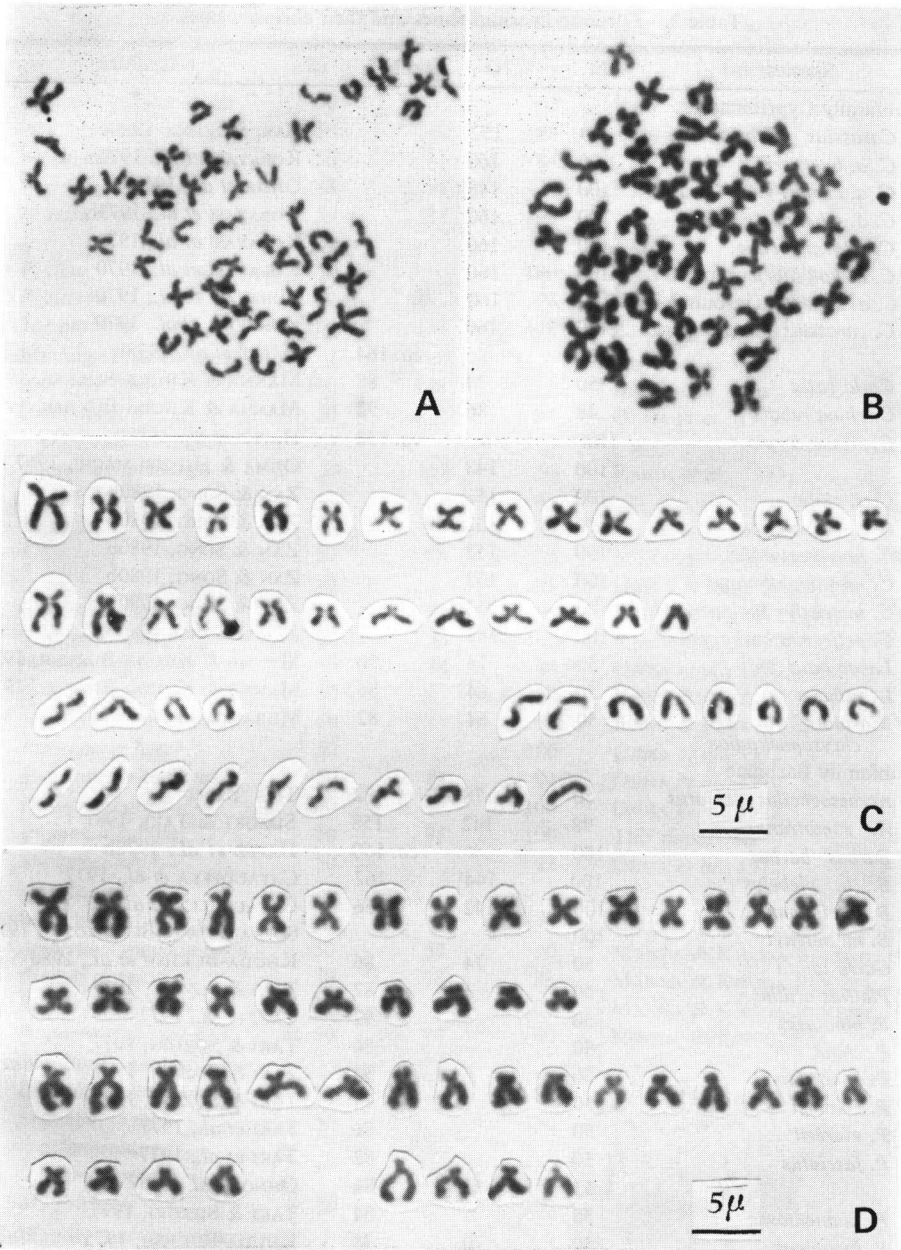


Fig. 1. Photomicrographs of mitotic metaphase chromosomes and karyotypes from gill epithelial cells of two cyprinid fishes. — A, *Acrossocheilus labiatus* (No. A·10·2),  $2n=50$ ,  $\times 1,350$ ; B, *Pseudorasbora pumila pumila* (No. A·3·2),  $2n=50$ ,  $\times 1,650$ ; C, *Acrossocheilus labiatus*, from Fig. A, NF=78,  $\times 1,710$ ; D, *Pseudorasbora p. pumila*, from Fig. B, NF=96,  $\times 1,750$ .

Table 3. Eurasian cyprinid fishes and their chromosomes.

Species	2n	NF <sub>1</sub>	NF <sub>2</sub>	Literature
Subfamily Cyprininae				
<i>Carassius auratus</i>	100	152		ZAN & SONG, 1980a
<i>C. a. buergeri</i>	100	160		KOBAYASI <i>et al.</i> , 1973a
<i>C. a. cuvieri</i>	100	148		OJIMA <i>et al.</i> , 1966
<i>C. a. gibelio</i>	100	160		KOBAYASI <i>et al.</i> , 1973b
<i>C. a. grandoculis</i>	100	160		KOBAYASI <i>et al.</i> , 1973a
<i>C. a. langsdorfi</i>	100	160		KOBAYASI <i>et al.</i> , 1970
<i>C. a.</i> subsp. (Kin-buna)	100	160		KOBAYASI <i>et al.</i> , 1970
<i>C. carassius</i>	{ 100	160		KOBAYASI <i>et al.</i> , 1970
	{ 100		ca. 164	HAFEZ <i>et al.</i> , 1978b
<i>Catla catla</i>	50	74	88	MANNA & KHUDA-BUKHSH, 1977
<i>Cirrhina reba</i>	48	86	92	MANNA & KHUDA-BUKHSH, 1977
<i>Cyprinus carpio</i>	{ 100		ca. 152	HAFEZ <i>et al.</i> , 1978b
	{ 100	148		OJIMA & HITOTSUMACHI, 1967
<i>C. c. chilia</i>	100	152		ZAN & SONG, 1980b
<i>C. c. rubrofuscus</i>	100	152		ZAN & SONG, 1980b
<i>C. longipectoralis</i>	100	152		ZAN & SONG, 1980b
<i>C. megalophthalmus</i>	100	152		ZAN & SONG, 1980b
<i>C. micristius fuxianensis</i>	100	152		ZAN & SONG, 1980b
<i>C. pellegrini barbatus</i>	100	152		ZAN & SONG, 1980b
<i>Labeo bata</i>	50	74	90	MANNA & KHUDA-BUKHSH, 1977
<i>L. calbasu</i>	50	64	86	MANNA & KHUDA-BUKHSH, 1977
* <i>Morulius chrysophekadion</i>	50	64	82	MURAMOTO <i>et al.</i> , 1968
Subfamily Barbinae				
<i>Acrossocheilus labiatus</i>	50	78	82	This paper
<i>A. sumatranus</i>	98	142	158	SUZUKI & TAKI, 1981
<i>Barbus barbatus</i>	100		ca. 160	HAFEZ <i>et al.</i> , 1978b
<i>B. b. plebejus</i>	100	144	162	CATAUDELLA <i>et al.</i> , 1977
<i>B. meridionalis</i>	100	142	156	CATAUDELLA <i>et al.</i> , 1977
<i>B. m. petenyi</i>	100			SOFRADŽIJA & BERBEROVIĆ, 1973
<i>Garra lamta</i>	50	74	86	KHUDA-BUKHSH <i>et al.</i> , 1980
<i>Puntius arulius</i>	50		82	TAKI & SUZUKI, 1977
<i>P. binotatus</i>	50		92	TAKI <i>et al.</i> , 1977
<i>P. chola</i>	50		56	TAKI & SUZUKI, 1977
<i>P. conchoniensis</i>	50		94	TAKI & SUZUKI, 1977
<i>P. cumingi</i>	50		94	TAKI & SUZUKI, 1977
<i>P. everetti</i>	50		86	TAKI <i>et al.</i> , 1977
<i>P. fasciatus</i>	{ 50		82	TAKI <i>et al.</i> , 1977
	{ 52	82	86	OHNO <i>et al.</i> , 1967
<i>P. filamentosus</i>	50		84	TAKI & SUZUKI, 1977
<i>P. japonicus</i>	50	70	78	KHUDA-BUKHSH, 1975
<i>P. lateristriga</i>	50		88	TAKI <i>et al.</i> , 1977
<i>P. nigrofasciatus</i>	50		100	TAKI & SUZUKI, 1977
<i>P. oligolepis</i>	50		88	TAKI <i>et al.</i> , 1977
<i>P. orphoides</i>	50		92	TAKI <i>et al.</i> , 1977

\* *Morulius* was reported as *Labeo*.



Table 3 (continued).

Species	2n	NF <sub>1</sub>	NF <sub>2</sub>	Literature
<i>Puntius partipentazona</i>	50		90	TAKI <i>et al.</i> , 1977
<i>P. pentazona</i>	50		98	TAKI <i>et al.</i> , 1977
<i>P. schwanenfeldi</i>	50		84	TAKI <i>et al.</i> , 1977
<i>P. sophore</i>	48	54		RISHI <i>et al.</i> , 1977
<i>P. tetrazona</i>	{ 50	84	90	OHNO <i>et al.</i> , 1967
	{ 50		84	TAKI <i>et al.</i> , 1977
<i>P. ticto</i>	50		100	TAKI & SUZUKI, 1977
<i>P. titteya</i>	50		98	TAKI & SUZUKI, 1977
<i>Tor putitora</i>	100	134	148	KHUDA-BUKHSH, 1980
Subfamily Gobioninae				
<i>Aulopyge huegeli</i>	100	148		BERBEROVIĆ <i>et al.</i> , 1973
<i>Gnathopogon</i>	50		94	OJIMA <i>et al.</i> , 1972
<i>elongatus elongatus</i>				
<i>Gobio albipinnatus</i>	50	98	98	RAICU <i>et al.</i> , 1973
<i>vladykovi</i>				
<i>G. gobio</i>	{ 50	96	98	RAICU <i>et al.</i> , 1973
	{ 50	88		SOFRADŽIJA & BERBEROVIĆ, 1975
	{ 50		98	HAFEZ <i>et al.</i> , 1978b
<i>G. kessleri banaticus</i>	50	94	98	RAICU <i>et al.</i> , 1973
<i>G. uranoscopus</i>	52	88	100	RAICU <i>et al.</i> , 1973
<i>Hemibarbus barbuis</i>	50	84	94	OJIMA <i>et al.</i> , 1970
<i>H. labeo</i>	50		90	KANG & PARK, 1973
<i>H. longirostris</i>	50		92	KANG & PARK, 1973
<i>Pungtungia herzi</i>	50		100	OJIMA <i>et al.</i> , 1972
<i>Pseudogobio esocinus</i>	50	84	94	OJIMA <i>et al.</i> , 1970
<i>Pseudorasbora parva</i>	50		100	OJIMA <i>et al.</i> , 1972
<i>P. pumila pumila</i>	50	96	100	This paper
<i>Sarcocheilichthys</i>	50		92	OJIMA <i>et al.</i> , 1972
<i>variegatus</i>				
Subfamily Rasborinae				
<i>Amblypharyngodon mola</i>	50	82	90	MANNA & KHUDA-BUKHSH, 1977
<i>Esomus danrica</i>	50	78	88	MANNA & KHUDA-BUKHSH, 1977
<i>Rasbora buchanani</i>	50	98	100	MANNA & KHUDA-BUKHSH, 1977
<i>R. daniconius</i>	50	74	80	KHUDA-BUKHSH, 1979
Subfamily Gobiobotiinae				
<i>Gobiobotia brevibarba</i>	50		82	UENO, 1981
<i>Microphysogobio</i>	50		100	UENO, 1981
<i>tafangensis</i>				
<i>longidorsalis</i>				
<i>M. yalnensis</i>	50		100	UENO, 1981
Subfamily Abramidinae				
<i>Abramis ballerus</i>	52	70		NYGREN <i>et al.</i> , 1975
<i>A. brama</i>	{ 52	82		NYGREN <i>et al.</i> , 1975
	{ 50		ca. 80	HAFEZ <i>et al.</i> , 1978b
<i>Alburnus</i>	50	87		FONTANA <i>et al.</i> , 1970
<i>albidus alborella</i>				

Table 3 (continued).

Species	2n	NF <sub>1</sub>	NF <sub>2</sub>	Literature
<i>Alburnus alburnus</i>	{ 50 50 50	76	92 86	CATAUDELLA <i>et al.</i> , 1977 HAFEZ <i>et al.</i> , 1978a SOFRADŽIJA <i>et al.</i> , 1979a
<i>Alburnoides bipunctatus</i>	50	88		SOFRADŽIJA <i>et al.</i> , 1979a
<i>Aspius aspius</i>	52	94		NYGREN <i>et al.</i> , 1975
<i>Vimba vimba carinata</i>	50	82		RUDEK, 1974
<i>V. v. vimba</i>	{ 50 52	82	76-80	RUDEK, 1974 SHINDERITE & VASILIEV, 1976
Subfamily Cultrinae				
<i>Anabarilius alburnops</i>	48	82, 84	96	ZAN & SONG, 1980b
<i>A. andersoni</i>	48	84	96	ZAN & SONG, 1980b
<i>A. grahami</i>	48	82	96	ZAN & SONG, 1980b
<i>A. macrolepis</i>	48	84	96	ZAN & SONG, 1980b
<i>Ischikauia steenackeri</i>	48		88	OJIMA <i>et al.</i> , 1972
<i>Megalobrama amblycephala</i>	48	92		ZAN & SONG, 1979
<i>Rohtee cotio</i>	48	84	92	MANNA & KHUDA-BUKHSH, 1977
* <i>Salmostoma bacaila</i>	50	72	82	MANNA & KHUDA-BUKHSH, 1977
Subfamily Hypophthalmichthyinae				
<i>Aristichthys nobilis</i>	{ 48 48	86	96	BOZHKO <i>et al.</i> , 1976 ZAN & SONG, 1980a
<i>Hypophthalmichthys molitrix</i>	{ 48 48	80	86	MANNA & KHUDA-BUKHSH, 1977 ZAN & SONG, 1980a
Subfamily Danioninae				
<i>Barilius barila</i>	50	78	86	KHUDA-BUKHSH & NAYAK, 1981
<i>B. bendelisis</i>	{ 50 50	62	72 94	KHUDA-BUKHSH, 1979 SHARMA & TRIPATHI, 1981
* <i>Bola bola</i>	50	70	80	KHUDA-BUKHSH & NAYAK, 1981
<i>Danio albolineatus</i>	50	99		FONTANA <i>et al.</i> , 1970
<i>D. rerio</i>	50	99		FONTANA <i>et al.</i> , 1970
<i>D. devario</i>	50	60		FONTANA <i>et al.</i> , 1970
<i>D. malabaricus</i>	50	60		FONTANA <i>et al.</i> , 1970
<i>Opsariichthys uncirostris</i>	78		86	OJIMA <i>et al.</i> , 1972
<i>Zacco platypus</i>	48		88	OJIMA <i>et al.</i> , 1972
<i>Z. temmincki</i>	48		88	OJIMA <i>et al.</i> , 1972
Subfamily Acheilognathinae				
* <i>Acanthorhodeus longipinnis</i>	44	72		OJIMA <i>et al.</i> , 1973
<i>Acheilognathus cyanostigma</i>	44	72		OJIMA <i>et al.</i> , 1973
<i>A. lanceolata</i>	48	76		OJIMA <i>et al.</i> , 1973
<i>A. limbata</i>	48	76		OJIMA <i>et al.</i> , 1973
<i>A. moriokae</i>	44	72		OJIMA <i>et al.</i> , 1973
<i>A. tabira</i>	44	72		OJIMA <i>et al.</i> , 1973

\* Each of *Salmostoma*, *Bola* and *Acanthorhodeus* was reported as *Chela*, *Barilius* and *Acheilognathus*, respectively.

Table 3 (continued).

Species	2n	NF <sub>1</sub>	NF <sub>2</sub>	Literature
* <i>Paracheilognathus rhombea</i>	44	72		OJIMA <i>et al.</i> , 1973
<i>Pseudoperilampus typus</i>	44	72		OJIMA <i>et al.</i> , 1973
<i>Rhodeus atremius</i>	46	50		OJIMA <i>et al.</i> , 1973
<i>R. ocellatus ocellatus</i>	48	76		OJIMA <i>et al.</i> , 1973
<i>R. o. smithii</i>	48	76		OJIMA <i>et al.</i> , 1973
<i>R. sericeus amarus</i>	48	82		SOFRADŽIJA <i>et al.</i> , 1975
	48	80	84	BOZHKO <i>et al.</i> , 1976
	48		ca. 86	HAFEZ <i>et al.</i> , 1978b
<i>R. suigensis</i>	46	50		OJIMA <i>et al.</i> , 1973
<i>Tanakia tanago</i>	48	76		OJIMA <i>et al.</i> , 1973
Subfamily Leuciscinae				
<i>Ctenopharyngodon idellus</i>	48		84	OJIMA <i>et al.</i> , 1972
	48	96	96	BOZHKO <i>et al.</i> , 1976
	48	82	90	MANNA & KHUDA-BUKHSH, 1977
	48	88		ZAN & SONG, 1979
	48	96	96	LIU, 1980
<i>Leuciscus aula</i>	50	88		FONTANA <i>et al.</i> , 1970
<i>L. cephalus</i>	50	90		FONTANA <i>et al.</i> , 1970
	50		ca. 88	HAFEZ <i>et al.</i> , 1978b
<i>L. c. cabeda</i>	50	78	90	CATAUDELLA <i>et al.</i> , 1977
* <i>L. idus</i>	52			LUEKEN & FOERSTER, 1969
<i>L. leuciscus</i>	50		ca. 88	HAFEZ <i>et al.</i> , 1978b
<i>L. souffia muticellus</i>	50	88		FONTANA <i>et al.</i> , 1970
	50	82	90	CATAUDELLA <i>et al.</i> , 1977
<i>L. svallize</i>	50	74		BERBEROVIĆ & SOFRADŽIJA, 1972
<i>L. turskyi</i>	50	68		BERBEROVIĆ & SOFRADŽIJA, 1972
<i>Moroco jouyi</i>	52		92	OJIMA <i>et al.</i> , 1970
<i>M. lagowskii</i>	50		90	KANG & PARK, 1973
<i>M. oxycephalus</i>	50		90	KANG & PARK, 1973
<i>M. steindachneri</i>	50	86	94	OJIMA <i>et al.</i> , 1976
<i>Pachychilon pictum</i>	50			BERBEROVIĆ & SOFRADŽIJA, 1972
<i>Paraphoxinus adspersus</i>	50	88		BERBEROVIĆ & SOFRADŽIJA, 1972
<i>P. alepidotus</i>	50	76		BERBEROVIĆ <i>et al.</i> , 1969
<i>P. croaticus</i>	50	86		BERBEROVIĆ & SOFRADŽIJA, 1972
<i>P. metohiensis</i>	50	82		BERBEROVIĆ & SOFRADŽIJA, 1972
<i>P. pstrossi</i>	50			SOFRADŽIJA <i>et al.</i> , 1972
<i>Phoxinus phoxinus</i>	50	82		BERBEROVIĆ & SOFRADŽIJA, 1974
	50	76	92	CATAUDELLA <i>et al.</i> , 1977
	50		ca. 90	HAFEZ <i>et al.</i> , 1978b
<i>Rutilus rubilio</i>	50	84		BERBEROVIĆ & SOFRADŽIJA, 1972
	50	78	94	CATAUDELLA <i>et al.</i> , 1977
<i>R. rutilus</i>	50	68		BERBEROVIĆ & SOFRADŽIJA, 1972
	50	76		NYGREN <i>et al.</i> , 1975
	50		82	HAFEZ <i>et al.</i> , 1978a

\* Each of *Paracheilognathus* and *Leuciscus* was reported as *Acheilognathus* and *Idus*, respectively.

Table 3 (continued).

Species	2n	NF <sub>1</sub>	NF <sub>2</sub>	Literature
<i>Scardinius erythrophthalmus</i>	48	60		FONTANA <i>et al.</i> , 1970
	48	90		NYGREN <i>et al.</i> , 1975
	50	82	94	CATAUDELLA <i>et al.</i> , 1977
	50		ca. 84	HAFEZ <i>et al.</i> , 1978b
	50	82		SOFRADŽIJA, <i>et al.</i> , 1979b
<i>Tinca tinca</i>	48	82		FONTANA <i>et al.</i> , 1970
	48	84		NYGREN <i>et al.</i> , 1975
	48	84	90	BOZHKO <i>et al.</i> , 1976
	48	68	78	CATAUDELLA <i>et al.</i> , 1977
	48	84		BERBEROVIĆ <i>et al.</i> , 1978
	48		ca. 86	HAFEZ <i>et al.</i> , 1978b
<i>Tribolodon ezoë</i>	50	80	92	ITOH & NIYAMA, 1972
	50	84	92	OJIMA <i>et al.</i> , 1976
<i>T. hakonensis</i>	50	80	92	ITOH & NIYAMA, 1972
	50	84	92	OJIMA <i>et al.</i> , 1976
Subfamily Chondrostomatinae				
<i>Chondrostoma kneri</i>	50	80		BERBEROVIĆ <i>et al.</i> , 1970
<i>C. phoxinus</i>	50	86		BERBEROVIĆ <i>et al.</i> , 1970
<i>C. soetta</i>	50	80	94	CATAUDELLA <i>et al.</i> , 1977
<i>C. toxostoma</i>	50	80	94	CATAUDELLA <i>et al.</i> , 1977
	50		ca. 90	HAFEZ <i>et al.</i> , 1978b

series of too few characters. In some cases the significance of these features has defied interpretation.”

As regards subfamilies, classification of cyprinid subfamily has not been fixed. HENSEL (1970) reviewed the history of cyprinid classification. For example, GÜNTHER (1868) classified 11 subfamilies excepting Catostomina, Homalopterina and Cobitidina. Thereafter, his Cyprinina was divided into four subfamilies, Cyprininae, Barbinae, Schizothoracinae and Gobioninae by NIKOLSKII (1954). Similarly, his Leuciscina was separated into Leuciscinae and Chondrostomatinae, and his Abramidina into Leuciscinae and Cultrinae (NIKOLSKII, 1954). On the contrary, GÜNTHER's three subfamilies, Leuciscina, Rasborina and Danionina were united into a single subfamily Leuciscinae (CHEN, 1935). BERG (1912) separated the Russian Cyprinidae into 10 subfamilies, but later he (1940) lumped them into 4 subfamilies. CHU (1935) classified Chinese cyprinid fishes into 8 subfamilies, and WU *et al.* (1964) separated CHU's Cyprininae into Cyprininae and Barbinae. KRYZANOVSKY (1947) divided all the Cyprinidae mainly on the basis of the embryonic and the zoogeographical data into 4 subfamilies. These facts show how to difficult to study phylogenetic systematics of the Cyprinidae.

Several investigators concluded that the family cannot be divided readily into subfamilies or other well-defined groupings. However, it will be more convenient to divide the Cyprinidae into subfamilies when the whole scheme of the Cyprinidae is viewed. Therefore, cyprinid fishes are separated into subfamilies in Tables 3 and 4.

On the other hand, karyological approach to fish phylogeny has been considered

to be very important. Cyprinid karyotypes have been studied rather well. However, the Cyprinidae is so large that their karyological data are not enough to analyze inter-relationships of cyprinids. Nevertheless, relationships between karyotypes and Eurasian cyprinids will be discussed in the following lines. Table 3 lists Eurasian cyprinid chromosomes. Classification of subfamilies is adopted generally from GÜNTHER (1868), although GÜNTHER's Cyprinina, Leuciscina and Abramidina are divided into Cyprininae, Barbinae, Gobioninae, Leuciscinae, Chondrostomatinae, Abramidinae and Cultrinae. In this paper, Cyprininae is represented by GÜNTHER's 5th to 12th genera, Barbinae by his 13th to 23rd genera, Gobioninae by his 30th to 43rd genera, Leuciscinae by his 56th to 62nd genera, Abramidinae by his 79th to 82nd genera and Cultrinae by his 83rd to 95th genera.

**Diploid chromosome number.** Species with  $2n=50$  are distributed widely in Cyprininae, Barbinae, Gobioninae, Rasborinae, Leuciscinae, Chondrostomatinae, Danioninae, Abramidinae and Gobiobotiinae. Species with  $2n=48$  are found in Cyprininae, Cultrinae, Hypophthalmichthyinae, Danioninae, Acheilognathinae and Leuciscinae. Species with  $2n=44-46$  are limited in Acheilognathinae. Species with  $2n=98-100$  are distributed in Cyprininae, Barbinae and Gobioninae. Species with  $2n=52$  are found in Barbinae, Gobioninae, Abramidinae and Leuciscinae. Only a single species with  $2n=78$  is found in Danioninae.

**Arm number.** The arm number as well as  $2n$  has been considered to be valuable in karyotype analysis. Polarity of the arm number is from small to large. There have been two types of definition on the arm number. In one definition ( $NF_1$ ), metacentrics and submetacentrics are counted as two, in the other ( $NF_2$ ), metacentrics, submetacentrics and subtelocentrics as two.

As regards cyprinid karyotypes, these two types of arm numbers have been reported. As these two types of NF have been confused frequently, both  $NF_1$  and  $NF_2$  are separately presented in Table 3.

When the karyotype of the same species is studied by plural investigators, it is very frequent that NF does not agree with one another (see *Puntius fasciatus*, *P. tetrazona*, *Gobio gobio*, *Alburnus alburnus*, *Hypophthalmichthys molitrix*, *Barilius bendelisis*, *Rhodeus sericeus amarus*, *Ctenopharyngodon idellus*, *Leuciscus cephalus*, *L. souffia muticellus*, *Phoxinus phoxinus*, *Rutilus rutilus*, *Scardinius erythrophthalmus*, *Tinca tinca*, *Tribolodon ezoe*, *T. hakonensis* and *Chondrostoma toxostoma* in Table 3). Such disagreement in NF may be caused by intraspecific variation or by experimental artifacts. Actually, the disagreements by artifacts are more possible than those by intraspecific variation, because gradual changes of centromeric position make difficult to separate submetacentrics from subtelocentrics or subtelocentrics from acrocentrics. Therefore, it should be noted that NF in the Cyprinidae is not always useful for karyotype analysis. This is the reason why NF is excluded from Table 4.

**Polarity of the diploid chromosome number and some morphological characters.**

When phylogenetic systematics are studied by cladistic analysis, polarity of each character needs to be determined. In this study, several characters known in all sub-

Table 4. Comparison of selected characters. Data of morphological characters are limited to species whose karyotypes have been reported.

Genus	2n	Rows of pharyngeal teeth	Barbels	Branched dorsal rays (br. D)	Branched anal rays (br. A)	br. D minus br. A
Cyprininae						
<i>Carassius</i>	100	1	0	12-18	5, 6	+ 7-13
<i>Catla</i>	50	3	0	14-16	5	+ 9-11
<i>Cirrhina</i>	48	3	2	8- 9	5	+ 3- 4
<i>Cyprinus</i>	100	3	4, 2	10-22	5	+ 5-17
<i>Labeo</i>	50	3	4, 2	9-15	5	+ 4-10
<i>Morulius</i>	50	3	4	15-18	5	+10-13
Barbinae						
<i>Acrossocheilus</i>	{ 50 98	3	4	8	5	+ 3
		3	4	9	5	+ 4
<i>Barbus</i>	100	3	4	8	5	+ 3
<i>Garra</i>	50	3	4	8- 9	5	+ 3- 4
<i>Puntius</i>	50	3	4	8	5	+ 3
<i>Tor</i>	100	3	4	9	5	+ 4
Gobioninae						
<i>Aulopyge</i>	100	1	4	7	5	+ 2
<i>Gnathopogon</i>	50	2	2	7	6	+ 1
<i>Gobio</i>	50	2	2	7	6	+ 1
<i>Hemibarbus</i>	50	3	2	7	6	+ 1
<i>Pseudogobio</i>	50	2	2, 0	7	6	+ 1
<i>Pseudorasbora</i>	50	1	0	7	6	+ 1
<i>Pungtungia</i>	50	1	2	7	6	+ 1
<i>Sarcocheilichthys</i>	50	2	2, 0	7	6	+ 1
Rasborinae						
<i>Amblypharyngodon</i>	50	3	0	7	5	+ 2
<i>Esomus</i>	50	1	2	6	5	+ 1
<i>Rasbora</i>	50	3	0	7	5	+ 2
Gobiobotiinae						
<i>Gobiobotia</i>	50	2	8	7	6	+ 1
<i>Microphysogobio</i>	50	1	2	7	6	+ 1
Abramidinae						
<i>Abramis</i>	50, 52	1	0	8- 9	24-44	-15-36
<i>Alburnoides</i>	50	2	0	7- 8	12-17	- 5- 9
<i>Alburnus</i>	50	2	0	7- 8	15-20	- 8-12
<i>Aspius</i>	52	2	0	8- 9	12-14	- 5- 6
<i>Vimba</i>	50, 52	1	0	8	15-21	- 7-13
Cultrinae						
<i>Anabarilius</i>	48	3	0	7	9-12	- 2- 5
<i>Ischikauia</i>	48	3	0	7	13-14	- 6- 7
<i>Megalobrama</i>	48	3	0	7	27-32	-20-25
<i>Rohtee</i>	48	3	0, 2	8	27-33	-19-25
<i>Salmostoma</i>	50	3	0	7	11-13	- 4- 6

Table 4 (continued).

Genus	2n	Rows of pharyngeal teeth	Barbels	Branched dorsal rays (br. D)	Branched anal rays (br. A)	br. D minus br. A
Hypophthalmichthyinae						
<i>Aristichthys</i>	48	1	0	7	12-13	- 5- 6
<i>Hypophthalmichthys</i>	48	1	0	7	12-13	- 5- 6
Danioninae						
<i>Barilius</i>	50	3	0, 4	7	7-10	- 0- 3
<i>Bola</i>	50	2	0	7- 8	10	- 2- 3
<i>Danio</i>	50	3	0, 2, 4	7-16	12-16	- 0- 6
<i>Opsariichthys</i>	78	3	0	7	9	- 2
<i>Zacco</i>	48	3	0	7	9-10	- 2- 3
Acheilognathinae						
<i>Acanthorhodeus</i>	44	1	0	14-16	13-15	+ 0- 1
<i>Acheilognathus</i>	48	1	2	8- 9	9-11	- 1- 3
	44	1	2	8-10	8- 9	+ 0- 1
<i>Paracheilognathus</i>	44	1	2	12-13	9-10	+ 2- 3
<i>Pseudoperilampus</i>	44	1	0	10	10	0
<i>Rhodeus</i>	48	1	0	8-12	8-12	0, 1, -1
	46	1	0	10-11	10-11	- 0- 1
<i>Tanakia</i>	48	1	2	8	8	0
Leuciscinae						
<i>Ctenopharyngodon</i>	48	2	0	7	8	- 1
<i>Leuciscus</i>	50	2	0	7- 8	8- 9	- 1
<i>Moroco</i>	50, 52	2	0	7	7	0
<i>Pachychilon</i>	50	1	0	7- 8	8- 9	- 0- 1
<i>Paraphoxinus</i>	50	1	0	7	7	0
<i>Phoxinus</i>	50	2	0	7	7	0
<i>Rutilus</i>	50	1	0	9-11	9-11	0
<i>Scardinius</i>	50	2	0	8- 9	9-11	- 1- 2
<i>Tinca</i>	48	1	2	8	6- 8	+ 0- 2
<i>Tribolodon</i>	50	2	0	7	7- 8	- 0- 1
Chondrostomatinae						
<i>Chondrostoma</i>	50	1	0	8- 9	8-11	- 0- 2

families are selected. Polarity is determined mainly by MASLIN (1952). Table 4 shows 2n, number of rows of pharyngeal teeth, number of barbels, number of branched dorsal rays, number of branched anal rays, and the value of number of branched dorsal rays *minus* number of branched anal rays in Eurasian cyprinid fishes whose karyotypes have been reported. Data of these five characters except 2n are adopted from GÜNTHER (1868), DAY (1875), BERG (1949), WU *et al.* (1964, 1977), STERBA (1967), NAKAMURA (1969) and others. Although it is desirable that osteological characters are included in Table 4, they have been studied in very limited groups in the Cyprinidae to be included therein.

Interrelations in the diploid chromosome number, number of rows of pharyngeal



teeth, the value of number of branched dorsal rays *minus* number of branched anal rays, and number of barbels are shown in Table 5.

1) **Diploid chromosome number.** In Cyprinidae,  $2n$  ranges from 44 to 100 ( $2n=153-206$  in gynogenetic *Carassius* is excluded). Ninety eight to one hundred in  $2n$  may be resulted by polyploidization of  $2n=50$  or 48. Seventy eight in  $2n$  is extraordinarily large number observed in only *Opsariichthys uncirostris*. According to HOWES (1980), *O. uncirostris* is not so primitive as *Barilius* species whose  $2n$  is 50. Therefore,  $2n=78$  is not considered to represent plesiomorphic character state. On the other hand, *O. uncirostris* has the largest number of one-arm chromosomes among the Cyprinidae except for species with  $2n=98$  or 100. This fact seems to demonstrate that  $2n=78$  is formed by centric fission of  $2n=50$  or 48. The diploid chromosome number of *Abramis*, *Aspius* and *Vimba*, all of which belong to the subfamily Abramidinae, is 50 or 52. These diploid chromosome numbers may reflect interspecific variation. Pharyngeal teeth of Abramidinae are arranged in one or two rows. Fifty two in  $2n$  has not been found in species with 3 rows of pharyngeal teeth. Although OHNO *et al.* (1967) reported  $2n=52$  in *Barbus fasciatus* (= *Puntius fasciatus*), TAKI *et al.* (1977) reported  $2n=50$  in the same species. From these facts, it is estimated that  $2n=52$  is resulted by aneuploidy or centric fission. Fifty in  $2n$  is distributed most widely in Cyprinidae and has been found in all the subfamilies except for Hypophthalmichthyinae and Acheilognathinae. On the other hand, distribution of  $2n=48$  is more limited than that of  $2n=50$ . A pair of large chromosomes in *Anabarilius* ( $2n=48$ , NAN=50) and *Acheilognathus lanceolata* and *A. limbata* ( $2n=48$ , NAN=50) suggest that  $2n=48$  in them is resulted from Robertsonian fusion. These facts seem to show that  $2n=50$  is more primitive than  $2n=48$ .

From above discussion, it may be concluded that  $2n=50$  is the most primitive character state in the Cyprinidae and that  $2n=50$  is specialized into several different directions, i. e., (1) increase by aneuploidy or centric fission,  $2n=50 \rightarrow 52$ , (2) increase by centric fission,  $2n=50$  or  $48 \rightarrow 78$ , (3) increase by polyploidization,  $2n=50 \rightarrow 100$  or 98, (4) decrease by Robertsonian fusion,  $2n=50 \rightarrow 48$  (*Anabarilius*, *Acheilognathus*),  $2n=48 \rightarrow 44$  (*Acanthorhodeus*, *Acheilognathus*, *Paracheilognathus*, *Pseudoperilampus*), and (5) decrease by deficiency,  $2n=48 \rightarrow 46$  (*Rhodeus*).

2) **Pharyngeal teeth.** Polarity of pharyngeal teeth is from three rows to one row (CHU, 1935). Such interpretation seems to be supported by many ichthyologists, e. g., VASNECOV (1939), KRYZANOVSKY (1947), and HENSEL (1970).

3) **Barbels.** The number of barbels is rather conservative in cyprinid genus, although there are genera whose species have 0-4 barbels, i. e., *Cyprinus*, *Barbus*, *Puntius* and others.

Species with barbels belong to Cyprininae, Barbinae, Gobioninae, Rasborinae, Gobiobotiinae, Cultrinae, Danioninae and Acheilognathinae, but are not found in Abramidinae, Hypophthalmichthyinae, Leuciscinae except for *Tinca*, and Chondrostomatinae. Eight barbels are limited in only subfamily Gobiobotiinae. As this subfamily is considered as one of specialized subfamilies, eight barbels are not plesio-

Table 5. Interrelation between 2n and some morphological characters in Eurasian cyprinids.

2n	Rows of pharyngeal teeth	br. D minus br. A	Barbels	Genus
100, 98	1	+2, 7-13	4, 0	<i>Aulopyge, Carassius</i>
	3	+3-17	4, 2	<i>Acrossocheilus, Barbus, Cyprinus, Tor</i>
78	3	-2	0	<i>Opsariichthys</i>
52	1	-7-36	0	<i>Abramis, Vimba</i>
	2	-5-6	0	<i>Aspius</i>
50	1	{+1 -0-2	2, 0	<i>Esomus, Microphysogobio, Pseudorasbora, Pungtungia</i>
	2	{+1 -0-12	0	<i>Chondrostoma, Pachychilon, Paraphoxinus, Rutilus</i>
		{+1 -0-12	2, 8	<i>Gnathopogon, Gobio, Gobiobotia, Pseudogobio, Sarcocheilichthys</i>
	3	{+1-13 -0-6	0	{ <i>Alburnoides, Alburnus, Bala, Leuciscus, Moroco,</i> <i>Phoxinus, Scardinius, Tribolodon</i>
		{+1-13 -0-6	4, 0	{ <i>Acrossocheilus, Amblypharyngodon, Catla, Garra, Hemibarbus,</i> <i>Labeo, Morulius, Puntius, Rasbora</i>
		{+0-2 -0-6	4, 2, 0	<i>Barilius, Danio, Salmostoma</i>
48	1	{+0-2 -0-6	2, 0	<i>Rhodeus, Tinca</i>
	2	-1	2, 0	<i>Acheilognathus, Aristichthys, Hypophthalmichthys, Tanakia</i>
	3	{+3-4 -2-25	0	<i>Ctenopharyngodon</i>
46	1	-0-1	2	<i>Cirrhina</i>
	1	-0-1	2, 0	<i>Anabarilius, Ischikauia, Megalobrama, Rohtee, Zaeco</i>
44	1	-0-3	0	<i>Rhodeus</i>
44	1	+0-3	2, 0	{ <i>Acheilognathus, Acanthorhodeus, Paracheilognathus</i> <i>Pseudoperilampus</i>

morphic. As six barbels on the lower jaw of *Gobiobotia* are not found in all other cyprinid genera, these barbels may have been formed secondarily. Four barbels are found in species with 3 rows of pharyngeal teeth in Cyprininae, Barbinae and Danioninae, but not in species with two rows of pharyngeal teeth. As regards species with one row of pharyngeal teeth, four barbels have been recognized exceptionally in one species, *Aulopyge huegeli*. Two barbels are shared by species with 1–3 rows of pharyngeal teeth in Cyprininae, Gobioninae, Rasborinae, Cultrinae, Danioninae and Acheilognathinae. Species without barbels are found in all subfamilies except for Gobiobotiinae. All species have no barbels in both of Hypophthalmichthyinae and Leuciscinae (except *Tinca*), which consist of species exclusively with one or two rows of pharyngeal teeth. It was suggested that species with barbels are more primitive than those without barbels in Japanese bitterlings (ARAI, 1978). HOWES (1978, p. 60) suggested that barbel-less state was plesiomorphic, but later he (1980, p. 177) changed his opinion, i. e., having barbels was plesiomorphic character state. These facts seem to show that the possession of 4 barbels is the most primitive character state. The number of barbels is specialized into two different directions, i. e., (1) decrease from 4 to 2 and to 0, and (2) increase from 2 to 8 (*Gobiobotia*).

4) **Branched dorsal and anal rays.** The number of branched dorsal rays ranges from 6 to 22 in species whose karyotypes have been studied. Seven or eight branched dorsal rays are found in species of all subfamilies. Branched dorsal rays of *Carassius*, *Cyprinus*, *Catla* and *Morulus* in Cyprininae and 3 genera in Acheilognathinae are more than 9 in number. Among these 7 genera, pharyngeal teeth are arranged in one row in *Carassius* and in three genera in Acheilognathinae. *Cyprinus* is very characteristic in having serrated 3rd anal spine which is considered to be more specialized character state than non-serrated one. From these facts, it may be evaluated that 7 or 8 branched dorsal rays are plesiomorphic.

The number of branched anal rays ranges from 5 to 44 for species whose karyotypes have been studied. In all genera of Cyprininae, Barbinae and Rasborinae, they are five in number, although those of *Carassius carassius* are exceptionally six. Six branched anal rays are found in all genera except for *Aulopyge* in Gobioninae and Gobiobotiinae. In Abramidinae, Cultrinae, Hypophthalmichthyinae, Danioninae and Chondrostomatinae, branched anal rays are generally more than 9. Branched anal rays in Leuciscinae and Acheilognathinae range from 7 to 15. From these facts, it seems to be difficult to determine polarity of the number of branched anal rays.

On the other hand, it has been known in many groups that the value of number of dorsal rays *minus* number of anal rays is conservative and not so variable as counts of dorsal and anal rays. Values of number of branched dorsal rays *minus* number of branched anal rays are examined. As the results, they are classified into three types of dorsal-anal ray patterns. In Type A, branched dorsal rays are more numerous than branched anal rays. In Type B, branched dorsal rays are not more numerous than branched anal rays. Type C is the mixture of Types A and B.

Type A is found in Cyprininae, Barbinae, Gobioninae, Rasborinae and Gobio-

botiinae. Type B occurs in Abramidinae, Cultrinae, Hypophthalmichthyinae, Danioninae, Leuciscinae (except for *Tinca*) and Chondrostomatinae. Type C is limited in Acheilognathinae. Species belonging to Type A have, in general, characters such as small number of branched anal rays and having barbels. Species with  $2n=98-100$  are limited to Type A. Large number of branched anal rays and no barbels are shared by fishes belonging to Type B except for the Danioninae. Difference of Type A from Type B seems to reflect that between habitats of fishes belonging to each Type, for instance, fishes of Type B are basically midwater groups (GOSLINE, 1975, p. 7) but fishes of Type A (except Rasborinae) are more benthic than those of Type B.

**Systematics.** From analysis of four characters discussed above, following problems are pointed out.

1. As reported by BERG (1949), phylogenetic position of *Tinca* is doubtful. KRYZANOVSKY (1947) separated *Tinca* from his Leuciscina, and erected *Tincina* on the basis of his experimental results that *Tinca* crossbred with representatives of the group Cyprinina, but not with some of Leuciscina. *Tinca* differs from all other genera in Leuciscinae by  $2n=48$ , 2 barbels and Type A on dorsal-anal ray pattern. Therefore, it may be more reasonable that *Tinca* is transferred from Leuciscinae into one of subfamilies belonging to Type A on dorsal-anal ray pattern, e. g., Cyprininae.

2. Both species with  $2n=50$  and that with  $2n=98$  are included in *Acrossocheilus*. As regards fish karyotypes, it is very rare that fishes of the same genus have diploid ( $2n=50$ ) and tetraploid chromosomes ( $2n=98$ ). Morphologically *A. sumatranus* differs from *A. labiatus* in such characters as  $2n=98$  and 9 branched dorsal rays, which are shared by *Tor putitora*.

*Acrossocheilus sumatranus* was described originally as *Lissochilus sumatranus* (WEBER & DE BEAUFORT, 1916). As the name *Lissochilus* had been preoccupied by a genus of fossil mollusks, SMITH (1945, pp. 196-197) classified this species into *Acrossocheilus* with some hesitation, although as originally defined *Acrossocheilus* did not apply to any of *Lissochilus* species. On the other hand, WEBER and DE BEAUFORT (1916) described two species of *Lissochilus*, *L. sumatranus* and *L. dukai*. The latter is closely related to *Tor putitora* (see DAY, 1875, p. 557). From these facts, the generic name of *A. sumatranus* should be changed from *Acrossocheilus* to *Tor*.

3. Phylogenetic position of *Hemibarbus* is noteworthy. *Hemibarbus* shares 3 rows of pharyngeal teeth with genera of Barbinae, but differs from them in having 2 barbels, 7 branched dorsal and 6 branched anal rays which are in common with Gobioninae. These facts may mean that *Hemibarbus* is a link between Barbinae and Gobioninae.

4. *Aulopyge* is characteristic in combination of characters such as  $2n=100$  (apomorphic), one row of pharyngeal teeth (apomorphic), 4 barbels (plesiomorphic) and five branched anal rays, by which this genus is differentiated from all other genera of Gobioninae. Such mixture of plesiomorphic and apomorphic characters peculiar to *Aulopyge* may be related with its polyploidy ( $2n=100$ ) whose morphological characters may be more hard to be influenced by mutation than those of the diploid. *Aulopyge*

shows a mosaic of barbinae and gobionine characters.

5. Some ichthyologists (CHU, 1935; WU *et al.*, 1964) have not differentiated Abramidinae from Cultrinae. However, karyologically these two subfamilies are specialized into different direction, i. e., decrease of  $2n$  in Cultrinae ( $2n=50, 48$ ) versus increase of  $2n$  in Abramidinae ( $2n=50, 52$ ). These facts may support NIKOLSKII's classification, in which he separated GÜNTHER's Abramidina into two groups. One group contained *Abramis*, *Alburnoides*, *Alburnus*, *Aspius* and *Vimba*, and the other belonged to Cultrinae. NIKOLSKII (1954) classified the former group into Leuciscinae, but I did them into Abramidinae.

From the viewpoint of comparative karyology, Abramidinae may be derived from Leuciscinae because almost genera of Leuciscinae is 50 in  $2n$ , while  $2n$  of Abramidinae is 50 or 52.

6. GOSLINE (1975) pointed out many characters which are shared by his Rasborinae (=Danioninae and Rasborinae by GÜNTHER) and cultrine *Salmostoma*. To conclude concerning the resemblances between his Rasborinae and Cultrinae in the *Chela-Salmostoma* area, he was of the opinion that they were the result of convergence.

As regards cultrine karyotypes,  $2n$  of *Salmostoma* is 50, while  $2n$  of all other genera examined is 48. As polarity of  $2n$  is from 50 to 48, *Salmostoma* is considered to be the most primitive in cultrine genera as treated here. In all genera of Rasborinae and the Danioninae except for both *Opsariichthys* and *Zacco*,  $2n$  is 50. From these facts, it may be estimated that Cultrinae is derived from Danioninae and that *Salmostoma* is a link between Danioninae and Cultrinae. My interpretation on interrelationships between Cultrinae and his Rasborinae differs from GOSLINE's one.

7. Rasborinae is separated from Barbinae by lateral line running along the lower half of the tail being shared by Danioninae (GÜNTHER, 1868). Since WEBER and DE BEAUFORT (1916) combined Danioninae with Rasborinae into a single subfamily, many ichthyologists followed their classification (GOSLINE, 1975). However, Rasborinae is similar to Barbinae in the number of branched dorsal and branched anal rays. As regards rasborine genera, *Esomus* differs from both *Amblypharyngodon* and *Rasbora* in having one row of pharyngeal teeth, 2 barbels and 6 branched dorsal rays. These facts suggest that Rasborinae is not monophyletic and that interrelationships in Barbinae, Rasborinae and Danioninae are in chaos, although Rasborinae may be more closely related to Danioninae than to Barbinae (GOSLINE, 1975).

8. Acheilognathinae is very characteristic among cyprinid fishes for the Type C in dorsal-anal ray pattern. In *Acheilognathus lanceolata* and *A. limbata*, anal branched rays are greater in number than branched dorsal rays (Type B). On the contrary, anal branched rays are not more numerous than branched dorsal rays in *A. cyanostigma*, *A. moriokae* and *A. tabira* (Type A). *Acheilognathus* contains both species with  $2n=48$  and those with  $2n=44$ . Each dorsal-anal ray pattern of species with  $2n=48$  and those with  $2n=44$  is Type B and Type A, respectively.

Considering the fact that the difference between species with  $2n=48$  and those with  $2n=44$  in *Acheilognathus* is larger than the difference between *Acheilognathus*

species with  $2n=44$  and *Paracheilognathus* species or *Acanthorhodeus* species in karyotypes, the dorsal-anal ray pattern and embryological data, it seems to be more reasonable that *Acheilognathus* species should be divided into two different fish groups. Phylogenetically, *Acheilognathus* species with  $2n=44$  may occupy the position between *Acheilognathus* species with  $2n=48$  and *Paracheilognathus* or *Acanthorhodeus* (ARAI, 1978).

9. Both *Aristichthys* and *Hypophthalmichthys* of Hypophthalmichthyinae resemble the cultrine *Ischikauia* in the intestine convolution, possessing a keel along the ventral side, 13 branched anal rays, numerous lateral line scales and dorsally directed mouth, but differ from it in the shape of pharyngeal teeth (MIYADI *et al.*, 1976). On the other hand, these two genera of Hypophthalmichthyinae are similar to the leuciscine *Mylopharyngodon* in the shape of pharyngeal teeth and the intestinal convolution, but not in its keel-less ventral side and 8 branched anal rays (CHU, 1935). MIYADI *et al.* (1976) combined the hypophthalmichthyine two genera with the leuciscine two genera, *Ctenopharyngodon* and *Mylopharyngodon*, and the cultrine *Ischikauia* into the subfamily Hypophthalmichthyinae.

As regards chromosomes, both *Hypophthalmichthys* and *Aristichthys* share  $2n=48$  with not only the leuciscine *Ctenopharyngodon* but also the cultrine *Ischikauia*. Chromosomes with secondary constriction are found in karyotypes of *Hypophthalmichthys*, *Aristichthys* and the cultrine *Anabarilius* and *Megalobrama*, but not in that of *Ctenopharyngodon* (ZAN & SONG, 1979, 1980a, 1980b). Presence or absence of secondarily constricted chromosomes in *Ischikauia* is unknown. Morphologically, each of the cultrine *Ischikauia*, the leuciscine two genera and the hypophthalmichthyine two genera cannot belong to the same monophyletic group because *Ctenopharyngodon* and *Mylopharyngodon* do not occupy the phylogenetic position between the cultrine and the hypophthalmichthyine genera. These facts suggest that the similarity in the shape of specialized pharyngeal teeth among them is the result of convergence. I currently adopt the hypothesis that Hypophthalmichthyinae may be derived from Cultrinae.

10. Gobiobotiinae was erected by MORI (1933) on the basis of the ossified gasbladder capsule, but not separated from Gobioninae by NIKOLSKII (1954) and BANARESCU and NALBANT (1973). WU *et al.* (1977) removed *Microphysogobio* (= *Abbotina*) and *Saurogobio* from Gobiobotiinae into Gobioninae, and only *Gobiobotia* was included in Gobiobotiinae.

The diploid chromosome number of both *Gobiobotia* and *Microphysogobio* is 50 which agrees with that of Gobioninae. *Gobiobotia* is very characteristic in having 8 barbels, 6 of which are placed on the lower jaw. As barbels on the lower jaw are not found in all other cyprinid genera, these six barbels may have been produced secondarily. These facts suggest that Gobiobotiinae is derived from Gobioninae.

11. Each of Barbinae, Cyprininae and Gobioninae is closely related one another in characteristics such as 5 or 6 branched anal rays, 2 or 4 barbels and presence of species with  $2n=98-100$ . If polyploidization, just as seen in *Barbus* and *Tor* (Barbinae), *Aulopyge* (Gobioninae), *Carassius* and *Cyprinus* (Cyprininae), relates with

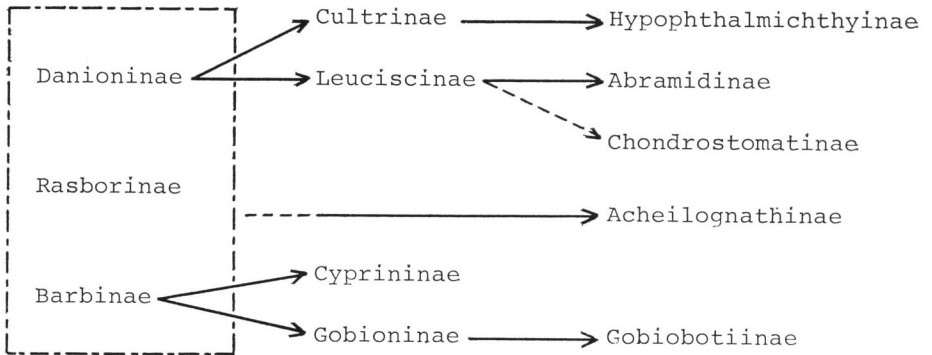


Fig. 2. Provisional interrelationships in Eurasian cyprinid subfamilies. Arrows show direction of specialization.

glaciation, some of these three subfamilies may have been distributed in common areas to them in the glacial period.

12. It is very difficult to construct phylogenetic tree of 12 subfamilies discussed in this paper, as the number of characters are too small to discuss on their interrelationships. Nevertheless, the provisional scheme of their interrelationships is presented here in Fig. 2 as the first step to the further investigation.

As far as I know, chromosomes of Schizothoracinae and Xenocyprininae have not been reported. Therefore, these subfamilies are excluded from Fig. 2. No data on chromosomes of Xenocyprininae which is considered to be closely related to Chondrostomatinae make it difficult to discuss on phylogenetic position of Chondrostomatinae in the family Cyprinidae.

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