Bull. Natn. Sci. Mus., Ser. A (Zool.), 3 (3), September 22, 1977

Chromosomes of Three Races of Goldfish, Kuro-demekin, Sanshiki-demekin and Ranchu

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In Japan many races of goldfish have been kept (Matsui, 1934). As regards their chromosomes, Makino (1941) observed chromosomes of 14 races and reported 94 as diploid chromosome number and 47 as haploid chromosome number on the basis of osmic fixed testicular materials and of the classical sectioning method. He (Makino, 1941) also reported the occurrence of larger numbers of chromosomes than the normal basic number (n=47) in some races of goldfish, i.e., Ranchu (n=49, 50), Osaka-ranchu (n=48, 49, 50), Oranda-shishigashira (n=48, 49, 50, 51), Shiro-demekin (n=48), Sanshiki-demekin (n=49), Comet (n=48), Calico (n=49), Shukin (n=48), and Shubunkin (n=49). Ojima and others (1966) studied the karyotypes of two races of goldfish, Wakin and Ryukin, by the air-drying method and described that their diploid chromosome number is 100 and that in karyotypes no differences are found among Ma-funa (=Gin-funa), Gengoro-funa, Wakin and Ryukin.

Ranchu (lionhead) and Demekin (telescope) are very specialized goldfish, i.e., typical Ranchu has no dorsal fin and Demekin has eyes abnormally large and protruded. If these characterized fishes were found in nature, they might be classified into species different from the funa (*Carassius auratus*). The present study was carried out to know whether chromosomes of Ranchu and Demekin differ from those of the other races of goldfish and the funa.

The classification of species and subspecies of the genus *Carassius* is followed that of Nakamura (1969).

Method of chromosome preparation is the same as that of Arai and Katsuyama (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.

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

Kuro-demekin

(Fig. 1)

Three black telescopes (Nos. E·84·1–E·84·3), 70.1 to 74.0 mm in total length, were purchased from a goldfish dealer and used for experiment (Table 1). Anal fins of two specimens are paired, and that of the remaining one is unpaired.

As shown in Table 2, the diploid chromosome number is 100. The karyotype comprises 8 pairs of metacentric, and 42 pairs of submetacentric-subtelocentric-acrocentric chromosomes. We could not get clear chromosome figures sufficient for

Table 1. Characters of three races of the goldfish.

Race	No. of fish	S.L. (mm)	Dorsal*	Anal	Pectoral	Ventral	VN**
Kuro-demekin	3	41.7–42.3	iv–v,15–16	iii, 5–6	16–17	i, 9–10	17–18+12
Sanshiki-demekin	2	44.0–49.5	iv, 17	iii, 6–7	17	0–i, 9	16–17+13
Ranchu	3	29.5–37.9	none	iii, 6	17–20	i, 9	17–18+12–13

* Main dorsal spines are 3 in number, and additional 1 to 2 spines are minute and difficult to observe.

** Following to FORD (1937), a vertebra with two pairs of haemal spines and neural spines is counted as two vertebrae.

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

Race	2n												Total
	94	95	96	97	98	99	100	101	102	103	104	105	
Kuro-demekin	1			2	3	8	11	1	4				30
Sanshiki-demekin		2	1	1	2		7	2	2				17
Ranchu			3	5	3	8	23	6	2	1	1		52

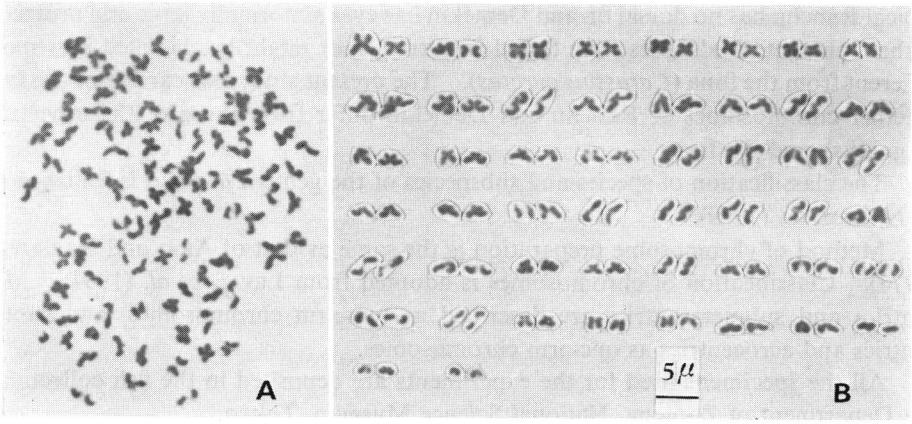

Fig. 1. Chromosomes of Kuro-demekin. —— A, Photomicrograph of mitotic metaphase chromosomes from a gill epithelial cell, 2n=100, ×1,150; B, karyotype from Fig. A, ×1,150.

distinguishing submetacentric chromosomes from subtelocentrics. Therefore, the arm number is unknown.

Sanshiki-demekin

(Figs. 2 A and C)

Two calico telescopes (Nos. E·85·4 and E·85·5), 66.9 and 72.3 mm in total

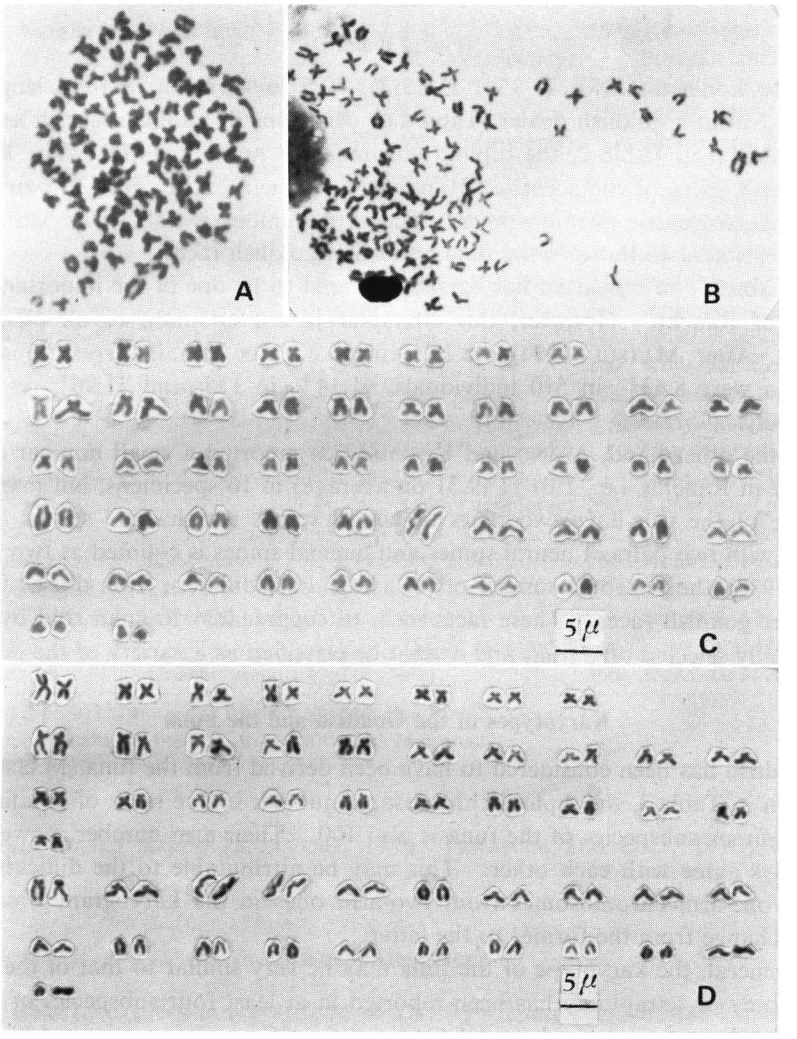

Fig. 2. Photomicrographs of mitotic metaphase chromosomes and karyotypes from gill epithelial cells of goldfish. —— A, Sanshiki-demekin, 2n=100, ×1,270; B, Ranchu, 2n=100, ×960; C, Sanshiki-demekin, from Fig. A, NF=156, ×1,270; D, Ranchu, from Fig. B, NF=158, ×960.

length, were obtained from a goldfish dealer. Characters of material fish are shown in Table 1. A specimen had paired anal fins and the other an unpaired anal fin.

The diploid chromosome number is 100 (Table 2). The karyotype comprises 8 pairs of metacentric, 20 pairs of submetacentric, and 22 pairs of subtelocentric-acrocentric chromosomes. The arm number is 156. The diploid chromosome number of Sanshiki-demekin agrees with that of Kuro-demekin.

Ranchu

(Figs. 2 B and D)

Three lionheads (Nos. E·85·1–E·85·3), 40.5 to 48.7 mm in total length, were purchased from a goldfish dealer (Table 1). Anal fins of all material fish are paired.

As shown in Table 2, the diploid chromosome number is 100. The karyotype comprises 8 pairs of metacentric, 21 pairs of submetacentric, and 21 pairs of subtelocentric-acrocentric chromosomes. The arm number is 158. The karyotype of Ranchu is similar to those of the funa and other goldfish races.

The absence of dorsal fin has been considered to be one of the important characteristics of Ranchu. However, this character is not common to all offsprings of Ranchu. After MATSUI (1934), in offsprings of three females, specimens without dorsal fin were 8.63% in 510 individuals, 41.14% in 175, and 31.96% in 194 fish, respectively.

On the other hand, ASANO and KUBO (1972) reported a small number of caudal vertebrae in Ranchu, i.e., 7 to 11 (9.31 on average) in 16 specimens, but many caudal vertebrae of the fish have two pairs of neural spines and haemal spines. When a vertebra with two pairs of neural spines and haemal spines is counted as two vertebrae (FORD, 1937), the vertebral number of Ranchu is little different from those of the funa and other goldfish races. These facts seem to suggest that Ranchu sold by a dealer is artificially selected offsprings and cannot be classified as a variety of the goldfish.

Karyotypes of the Goldfish and the Funa

Goldfish has been considered to have been derived from the funa (MATSUI, 1934). As shown in Table 3, the diploid chromosome number in five races of goldfish is 100, and that in six subspecies of the funa is also 100. Their arm number, however, does not always agree with each other. This may be attributable to the difficulty to distinguish one-arm chromosomes from two-arm ones in the karyogram which shows gradual change from the former to the latter.

In general, the karyotype of the funa may be very similar to that of the goldfish, but triploidy or tetraploidy has been reported in at least four subspecies of the funa, Naga-funa *Carassius auratus buergeri,* Gengoro-funa *Carassius auratus cuvieri,* Gin-funa *Carassius auratus langsdorfi,* and silver crucian carp *Carassius auratus gibelio* (Table 3). Polyploidy similar to the case of *Carassius* has been reported in the family Cobitidae, i.e., three species–subspecies of *Cobitis* from Japan, *Cobitis biwae, Cobitis taenia taenia,*

Table 3. Chromosomes of the genus *Carassius*.

Species	Common name	Sex	2n		NF	Literature
C. auratus auratus	Wakin	♂	100		148	OJIMA *et al.*, 1966
"	"	♂,♀	100		160	KOBAYASI *et al.*, 1970
"	Ryukin	♂	100		148	OJIMA *et al.*, 1966
"	Kuro-demekin		100			This paper
"	Sanshiki-demekin		100		156	This paper
"	Ranchu		100		158	This paper
"	Goldfish		96–104			OHNO and ATKIN, 1966
C. auratus buergeri	Naga-funa	♂,♀	100		160	KOBAYASI *et al.*, 1973a
	"		?*	(triploidy)		SEKIYA and HONMA, 1975
C. auratus cuvieri	Gengoro-funa	♀	100		148	OJIMA *et al.*, 1966
	"	♂, ♀	100			MURAMOTO, 1975
	"	♀	?*	(triploidy)		MURAMOTO, 1975
C. auratus gibelio	Silver crucian carp	♂, ♀	94			CHERFAS, 1966, 1972
	"	♂, ♀	100		160	KOBAYASI *et al.*, 1973b
	"	♀	141	(triploidy)		CHERFAS, 1966, 1972
	"	♀	156	(triploidy)	252	KOBAYASI *et al.*, 1973b
C. auratus grandoculis	Nigoro-funa	♂, ♀	100		160	KOBAYASI *et al.*, 1973a
C. auratus langsdorfi	Gin-funa	♀	100		148	OJIMA *et al.*, 1966**
	"	♂, ♀	100		160	KOBAYASI *et al.*, 1970
	"	♀	100		156	MURAMOTO, 1975
	"		153	(triploidy)		SEKIYA and HONMA, 1975
	"	♀	153–156***	(triploidy)		HAYASHI *et al.*, 1976
	"	♂, ♀	153–165	(triploidy)		MURAMOTO, 1975
	"	♀	156	(triploidy)	252	KOBAYASI *et al.*, 1970
	"	♀	206	(tetraploidy)	352	KOBAYASI *et al.*, 1970
C. auratus subsp.	Kin-funa	♂, ♀	100		160	KOBAYASI *et al.*, 1970
C. auratus subsp. ?	Tetsugyo (Ironfish)	♂, ♀	100			SEKIYA and HONMA, 1975
	"	♀	153	(triploidy)		SEKIYA and HONMA, 1975
C. carassius	Crucian carp	♂, ♀	100		160	KOBAYASI *et al.*, 1970

* The diploid chromosome number was not described.
** Japanese name of material fish reported as Mabuna.
*** 153 in mode.

and *Cobitis taenia striata* (KOBAYASI, 1976; TAKAHASI and OKA, 1976; UENO and OJIMA, 1976).

Acknowledgment

We wish to express our gratitude to Dr. Morizumi NAKAMURA, Department of Zoology, National Science Museum, Tokyo, for giving valuable advice in the course of the present study.

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