56. Differential Chromosomal Characteristics in the Funa Subspecies (*Carassius*)

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(Communicated by Sajiro MAKINO, M. J. A., June 15, 1978)

The Funa (*Carassius auratus*) is a common species of the fresh water teleosts of the Cyprinidae having a world-wide distribution. There is, however, a considerable discrepancy on its systematic classification, because of its polymorphic distributional features. Nakamura (1969) divided the Japanese genus *Carassius* into the following five subspecies: *C. a.* subsp.; *C. a. langsdorffi*; *C. a. grandoculis*; *C. a. buergeri*; and *C. a. cuvieri*. This is a unique classification-system in this genus. The chromosomes of *C. a. cuvieri* have been reported as $2n$, 100 in both sexes (Ojima *et al.* 1966, 1967). Kobayashi *et al.* (1970, 1973) reported the chromosome number of *C. a.* subsp. from Lake Kasumigaura as $2n$, 100 in both sexes. According to them, *C. a. langsdorffi* from Lake Shinji had $2n$, 100 in both male and female specimens. *C. a. langsdorffi* from Miyazaki district is in the same condition in their sexuality and chromosome number. In contrast, there were only female specimens having $3n$ -range and $4n$ -range chromosome numbers in those from the Kanto district (Kobayashi *et al.* 1970). It was remarked that $3n$ -individuals of *C. a. langsdorffi* propagated unisexually by gynogenesis (Kobayashi *et al.* 1970, 1972). Ojima *et al.* (1977) showed that the population of *C. a. langsdorffi* occurring in Lake Biwa was mostly consisted of females with $3n$ -chromosomes which bred by gynogenesis. A lot of similarities can be found between *C. a. buergeri* and *C. a. langsdorffi* in their sexuality and chromosome numbers. *C. a. buergeri* from Lake Suwa showed 50:50 sex ratio and the chromosome number of $2n$, 100 in both sexes. The Hokkaido population consisted, however, of females which were characterized by $3n$ -chromosomes as well as by gynogenetic reproduction (Kobayashi *et al.* 1973).

Impressive is the fact that the short arms of the large sub-metacentrics of the $3n$ -range complement of *C. a. langsdorffi* occurring in Lake Biwa were intensely C-banded. The present report deals with some C-banded markers found in 5 subspecies of *Carassius* after the Nakamura's classification-system (1969).

Materials and methods. Five females of *C. a. langsdorffi* from

Lake Biwa; 3 males and 2 females of *C. a. cuvieri* from Lake Biwa; 4 males and 2 females of *C. a. grandoculis* from Lake Biwa; 2 males and 2 females of *C. a. buergeri* from Lake Suwa; 5 females of *C. a.* subsp. from Lake Kasumigaura, and 4 males and 2 females from Pond Jyo (Gunma) provided materials for study. Their subspecific identification followed the descriptions of Nakamura (1969). The kidney culture method was applied to all of them together with ovary cultures for females. In some cases, the direct chromosome preparations from the kidney tissue were made with satisfactory results. The Giemsa C-banding technique was applied to them for the chromosome analysis.

Results and discussion. Fig. 1 is the karyotype of *C. a. langsdorfii* from Lake Biwa, which is characterized by a pair of marker chromosomes with deeply stained C-bands on the short arms of the second largest submetacentric chromosomes. The karyotype of *C. a. cuvieri* (Fig. 2) showed the chromosome number of $2n$, 100 in both sexes, which consisted of 6 pairs of metacentric chromosomes, 18 pairs of submetacentric chromosomes and 26 pairs of acro- or telocentric chromosomes, as shown by Ojima *et al.* (1966, 1967). Many deeply stained C-bands were shown in the centromere regions. The markers as found in *C. a. langsdorfii* could not be demonstrated in this subspecies. Generally speaking, *C. a. cuvieri* showed no difference in the C-band pattern between males and females. Figs. 3 and 4 show the karyotypes of *C. a. grandoculis* and *C. a. buergeri*, respectively, which indicate the chromosome number of $2n$, 100 with the same constitution as that of *C. a. cuvieri*. The same is with the C-band

Fig. 1. C-banding karyotype of *C. a. langsdorfii* (the lower row). The arrows denote two large submetacentrics having intensely C-banded short arms.

pattern; as in *C. a. cuvieri* many deeply stained bands were found in the centromere regions. No remarkable sexual difference of the karyotype was detected. In Figs. 5 and 6 are presented the karyotypes of females and males of *C. a. subsp.* They were characterized by $2n, 100$ as well as by the same constitution as that of *C. a. cuvieri*. In contrast, the C-band pattern was corresponding to that of *C. a. langsdorfi*: there were markers with C-banded short arms of the second largest submetacentrics. Noticeable is the occurrence of two markers in the female while one in the male.

Fig. 2. C-banding karyotype of *C. a. cuvieri* (the lower row).

Fig. 3. C-banding karyotype of *C. a. grandoculis* (the lower row).

In some teleost species the existence of possible heteromorphic sex chromosomes has been reported by several investigators. The situation seems to deal with the sexual difference of chromosomes in teleost fishes. However, the literature refers to no such picture

Fig. 4. C-banding karyotype of *C. a. buergeri* (the lower row).

Fig. 5. C-banding karyotype of a female of *C. a. subsp.* (the lower row).

The arrows denote two large submetacentrics having intensely C-banded short arms.

in the larger part of teleosts. For understanding of sex determination in teleosts the following items of elucidation would be required: 1) the cytogenetic mechanism, 2) morphophysiological process, and 3) hormonal control. In teleosts, our knowledge is very poor on these three aspects in comparison with other animals (Vanyakia 1972). Svårdson and Wickbom (1942) have mentioned that the cytological identification of the sex chromosomes in teleosts is impossible even though the existence of such features were proven by genetic methods. Makino (1932) and Galgano (1938) are of opinion that inasmuch as

teleosts occupy a rather low position on the evolutionary ladder, the degree of difference between their sex chromosomes and autosomes being very negligible. On the basis of a consensus of estimates through the facts and views as mentioned above, the statements may be available that the fish group is now being in the course of evolution, and that the sexual differentiation is still in unstable condition.

Fig. 6. C-banding karyotype of a male of *C. a.* subsp. (the lower row). The arrow denotes one large submetacentrics having intensely C-banded short arms.

According to Gosline (1971), the teleostean fishes are classified into the following three groups: lower (Salmoniformes, Cypriniformes, etc.), intermediate (Cyprinodontiformes, etc.), and higher groups (Perciformes, etc.). According to this view, the Cyprinidae belongs to the lower group. The fact showing that the sexual difference for the C-banded marker chromosomes occurs in certain subspecies of *Carassius* would be suggestive of sex differentiation in the lower teleostean group.

Summary. In five subspecies of *Carassius auratus*, such as *C. a. langsdorfi*, *C. a. cuvieri*, *C. a. grandoculis*, *C. a. buergeri*, and *C. a.* subsp., the C-banding patterns of chromosomes are comparatively investigated. *C. a. langsdorfi* is characterized by a pair of markers with remarkable C-bands on the short arms of the second largest submetacentrics. In *C. a.* subsp. there are two such markers in the female and one in the male.

Our particular thanks are due to Emeritus Professor Sajiyo Makino, M. J. A., for his invaluable advice and revision of the manuscripts.

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