

KAARYOTYPE CHARACTERISTICS OF *CYPRINUS CARPIO* L. (PISCES) INDIVIDUALS CAUGHT
IN THE DANUBE BE ZEMUN TOWN

SVETLANA FIŠTER* and P. ČAKIĆ**

*Faculty of Veterinary Medicine, University of Belgrade, 11000 Belgrade, Yugoslavia **Institute for
Biological Research, 11000 Belgrade, Yugoslavia

(Received, 16. January 1998.)

*The karyotype of the species *Cyprinus carpio* L. (Cyprinidae, Pisces) was analysed by a cytogenetical approach in 39 fish specimens caught in the Danube by Zemun town. All individuals had a diploid chromosome number $2n=104$. Out of this number 24 chromosomes were metacentric (M), 12 submetacentric (SM), 12 subacrocentric (SA) and 44 acrocentric (A). The results obtained in this study are discussed in relation to relevant data from the available literature.*

*Key words: Karyotype, *Cyprinus carpio*, chromosome aberrations, tetraploid origin*

INTRODUCTION

It is known that the fish species *Cyprinus carpio* L. from the family Cyprinidae has a tetraploid origin (Ohno et al., 1968; Bender and Ohno, 1968; Kirpichnikov, 1973). It seems that tetraploidization of the entire genome within the frame of the Cyprinidae family occurred independently in the genera *Cyprinus*, *Carassius* and *Barbus*. This is supported by the fact that some related species with a simple-diploid ($2n$) and multiplied - tetraploid ($4n$) chromosome number appear within the above genera. Also numerous authors reported data which are agreement with the hypothesis on the tetraploid origin of the species *Cyprinus carpio*. For instance, doubled amounts of nuclear DNA were observed (Ohno and Atkin, 1966; Ohno et al., 1968; Bender and Ohno, 1977), duplicate gene expression was revealed by electrophoretic analyses (Bender and Ohno, 1968; Klose et al., 1969; Ferris and Whitt, 1977) and cytogenetical data pointed to the doubling of the chromosome set (Ohno et al., 1967; Wolf et al., 1969).

The number of chromosomes in the karyotype of the carp (*Cyprinus carpio*, L.) varies somtimes between 98 and 104 chromosomes. However, this variation produces no obvious phenotype effect. Possible differences related to varying chromosome number have not been studied in detail, although some authors reported the findings of carp individuals with a diploid chromosome $2n=98$ number (Szolar et al., 1972; Al-Sabti, 1986a, 1986b and 1987) and this difference

amounts to three chromosome pairs (6 chromosomes in relation to $2n=104$) in comparison with the data of others (Table 1).

Table 1. Data on the karyotype of the species *Cyprinus carpio* L.

Source	2n	Karyotype	NF
Makino (1939)	100	12M + 36SM, SA + 52A	148
Ojima and Hitotsumachi (1967)	100	12M + 63SM, SA + 52A	148
Ohno et al. (1967, 1968)	104	46M, SM + 18SA + 36A + 4min	168
Szollar et al. (1971)	98		
Raicu et al. (1972)	100	24M + 24SM, SA + 52A	148
Nygren et al. (1875)	100		
Marian and Krasznai (1978)	104		
Sola et al. (1981)	104	46M, SM + 28SA + 30A	150
Al-Sabti (1987)	98	50M, SM + 48SA, A	
Fišter (1992)	104	24M + 12SM + 24SA + 44A	164

Among all cytogenetic results supporting the idea about the tetraploid origin of the carp, the most interesting findings were reported by Ohno et al. (1968). These authors observed the formation of synapses during meiosis of the last and the tiniest acrocentrics designated as minutes into a quadrivalent complex. This phenomenon demonstrated without any doubt that these four chromosomes represent the last remains of the original tetraploidy, i. e. of the original four homologues.

Since the number of chromosomes in the carp varies just in relation to the last few pairs of acrocentrics, the aim of the present studies was to investigate the karyotype of carp individuals caught in the Danube by Zemun town. Special attention was paid to possible variation in the number of chromosomes of this fish species.

MATERIALS AND METHODS

Thirty carp individuals (*Cyprinus carpio* L.) caught in the Danube by Zemun town were studied.

Each individual was injected with colchicine (1/ug/mg b. w.) and sacrificed three hours later. Metaphase chromosome figures were obtained by preparation of the kidney tissue by a modification of the procedure of Fontana et al. (1970).

The number and morphology of the chromosomes were determined (these values together with NF values are listed in Table 1.).

RESULTS

In all 30 specimens of the species *Cyprinus carpio* L. examined a diploid number $2n=104$ of the chromosomes representing the karyotype of this fish

species was found. Based on the position of the centromeres, i. e. morphology, the chromosomes were classified into the following groups: 12 pairs of metacentrics, i. e. 24 metacentric chromosomes (M), 6 pairs submetacentrics, i. e. 12 submetacentrics (SM), 12 pairs of subacrocentrics, i. e. 24 subacrocentric chromosomes (SA) and 22 pairs of acrocentrics, i. e. 44 acrocentric (A) chromosomes (Figure 1. and Figure 2.). Thus the total number of arms (NF) is 164.

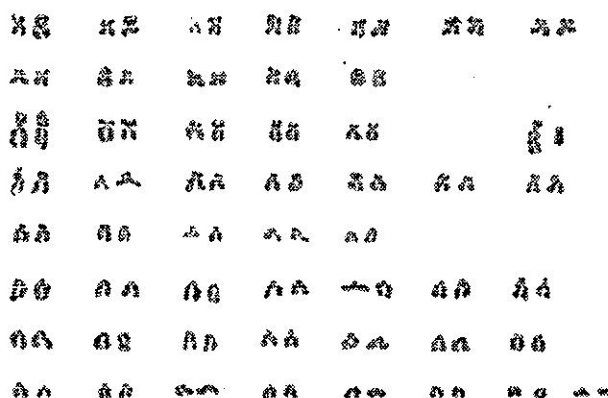


Figure 1. Karyotype of the carp (*Cyprinus carpio* L.)

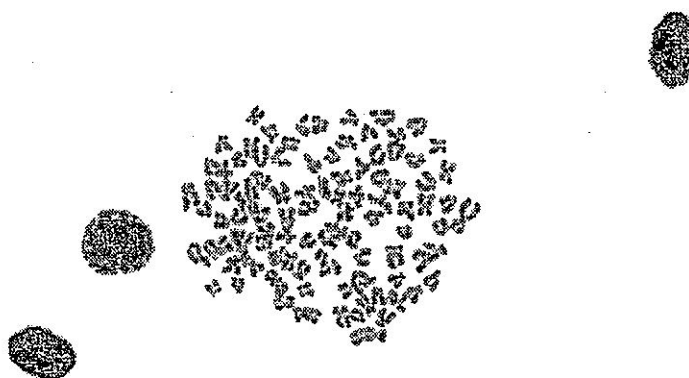


Figure 2. Metaphase figure of the carp chromosomes from kidney tissue

DISCUSSION

Similarly to the differences in number of chromosomes recorded by numerous authors (Table 1.), *Cyprinus carpio* L. is characterized by differences in the number of acrocentric chromosomes and connected to that, differences in the NF value were evident.

Our data on the number of acrocentrics in this fish species are similar to those previously observed by Ohno et al. (1967, 1968). These authors found that specimens with the chromosome number of $2n=104$ had 40 acrocentrics, including the four last acrocentrics designated as minutes. Our findings, however, showed that for $2n=100$, the number of acrocentrics was 40, while individuals with $2n=104$ had 44 acrocentric chromosomes, including the last four acrocentrics which were the tiniest ones. This is the reason why Ohno et al. (1967, 1968) found an NF value of 168 for the specimens with $2n=104$, while in our study the NF value was found to be 164 for the same group of individuals.

As seen in Table 1. conspicuous differences were also found in relation to the number of chromosomes belonging to other groups. It is still unclear whether these differences reflect the lack of precise procedures for determination of the ratio of the arms in some submetacentric and subacrocentric pairs or whether there are real differences between carp populations originating from different habitats along the range of distribution of this fish species.

The data presented in this work are in accordance with our previous studies (Fišter, 1992) demonstrating that all carp specimens caught in the Danube, which belong to the so - called wild type carp, had a diploid chromosome number $2n=104$ in the karyotype.

REFERENCES

1. Al-Sabti, K. 1986a. Karyotypes of *Cyprinus carpio* 47, 19-25.
2. Al-Sabti, K. 1986b. Chromosome complements of the goldfish (*Carassius auratus*) and common carp (*Cyprinus carpio*). *Cytobios*, 49, 143-150.
3. Al-Sabti, K. 1987. Cytogenetic studies of five species of Pisces from Yugoslavia. *Cytobios*, 49, 175-188.
4. Bender, K. and Ohno, S. 1968. Duplication of the autonomally inherited 6-phosphogluconate dehydrogenase gene locus in tetraploid species of cyprinid fish. *Biochem. Genet.*, 2, 101-107.
5. Ferris, S. D. and Whitt, G. S. 1977. Loss of duplicate gene expression after polyploidisation. *Nature*, 265, 258-260.
6. Fišter, S. 1992. Genetičko-populaciona analiza kariotipa nekih vrsta riba familije Cyprinidae. Doktorska disertacija, Veterinarski fakultet Univerziteta u Beogradu.
7. Fontana, F. B., Chiarelli and Rosi, A. 1970. Il cariotipo di alcune specie di Cyprinidae, Centrarchidae, Characidae. Studi sulle colture in vitro. *Carologia*, 23, 549-564.
8. Kirpichnikov, V. S. 1973. On karyotype evolution in Cyclostomata and Pisces. *Ichthyologia*, 5, 55-77.
9. Klose, J., Wolf, V., Hitzler, H. and Ritter, H. 1969. Polyploidization in the fish family Cypriniformes II. Duplication of the gene loci coding for lactate dehydrogenase (E. C.: 1.1.1.27) and

- 6-phosphogluconate dehydrogenase (E. C.:1.1.1.440) in various species of Cyprinidae. *Humangenetic*, 7, 245-250.
10. Makino, S. 1939. The chromosomes of the carp, *Cyprinus carpio*, including those of some related species of Cyprinidae for comparison. *Cytologia*, 9, 430-440
 11. Marian, T. and Krasznai, Z. 1987. Cytologische Untersuchung bei der Familie Cyprinidae (Pisces). *Biol. Zool.*, 97, 194-205.
 12. Nygren, A., Anderson, J., Jonsson, L. and Jahnke, G. 1975. Cytological studies in Cyprinidae (Pisces). *Hereditas*, 81, 165-172.
 13. Ohua, S. and Atkin, N. B. 1966. Comparative DNA values and Chromosome complements of light species of fishes. *Chromosome (Berl.)*, 18, 455-466.
 14. Ohno, S., Muramoto, J. and Christian, L. 1967. Diploid-tetraploid relationship among Old-World members of the fish species Cyprinidae. *Chroosoma*, 23, 1-9.
 15. Ohno, S., Wolf, U. and Atkin, N. B. 1968. Evolution from fishes to mammals by gene duplication. *Hereditas*, 59, 169-187.
 16. Ojima, Y. and Hitotsumachi, S. 1967. Cytogenetic studies in lower vertebrates. IV. A note on the chromosomes of the carp (*Cyprinus carpio*) in comparison with those of the tuna and goldfish. *Jap. J. Genet.*, 42, 163-167.
 17. Raicu, P., Taisescu, E. and Cristian, A. 1972. Diploid chromosome complement of the carp. *Cytologia*, 37, 355-358.
 18. Sola, L. S., Cataudella, S. and Capanna, E. 1981. New developments in vertebrate cytotoxonomy. III. Karyology of bony fishes. - A review. *Genetics*, 54, 285-239.
 19. Szollar, J. and Hobor, M. 1972. Shades on the somatic chromosomes of the carp (*Cyprinus carpio*). *Acta Morpholog. Hung.*, 20, 185-189.
 20. Wolf, U., Ritter, H., Atkin, N. and Ohno, S. 1969. Polyploidization in the fish family Cyprinidae, order Cypriniformes. I. DNA content and chromosome set in various species of Cyprinidae. *Human-genetic*, 7, 240-244.

KARAKTERISTIKE KARIOTIPA VRSTE: *Cyprinus carpio* L. (Pisces) JEDINKI UHVAĆENIH U DUNAVU KOD ZEMUNA

SVETLANA FIŠTER I P. CAKIĆ

SADRŽAJ

Citogenetički je analiziran kariotip šarana - vrste *Cyprinus carpio* L. (Cyprinidae, Pisces), primerka riba uhvaćenih u Dunavu kod Zemuna. Dobijeni rezultati pokazuju da su sve jedinke sadržale diploidan broj hromozoma $2n=104$ i to: 24 metacentrika (M), 12 submetacentrika (SM), 24 subakrocentrika (SA) i 44 akrocentrika (A). Dobijeni rezultati su diskutovani u odnosu na postojeće u literaturi, specijalno u odnosu na mogućnost variranja broja i morfologije hromozoma kod divljeg tipa šarana s obzirom na tetraploidno poreklo ove vrste.