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CHROMOSOMAL VARIABILITY IN RAINBOW TROUT STOCKS IN ESTONIA

Rainbow trout (*Salmo gairdneri Richardson*) is an important farmed fish species. Numerous domestic strains of this fish have been developed. To characterize these strains genetically and to estimate the differences between them or between domestic and wild forms, the variability of the karyotype of rainbow trout has been studied in many countries. Numerous authors have published data about the chromosome number or karyotype of this fish (Ohno et al., 1965; Fukuoka, 1972; Cuellar, Uyeno, 1972; Кайданова, 1974, 1976; Thorgaard, 1983; Sofradzija, 1982; Hartley, Horne, 1984). An extremely high level of variability resulting mainly from Robertsonian translocations (centric fusions of two acrocentric chromosomes to one metacentric, or fission of one metacentric to two acrocentrics) has been revealed. The number of chromosomes of rainbow trout may vary from 57 to 65. The most common numbers are 58—62. At the same time the number of chromosome arms remains uninfluenced. H. Fukuoka (1972) identified the chromosome arm number (NF) of rainbow trout as 104. As intraindividual variability in the chromosome number is significant, the specimens are usually characterized by the modal chromosome number of metaphases with 104 chromosome arms.

G. H. Thorgaard (1983) tried to reveal regularities in the geographical distribution of populations with different chromosome numbers in native populations of wild rainbow trout. In the northern part of the distribution area of rainbow trout in North America populations with predominantly 58 chromosomes were found. In the southern regions this number was higher (60—64). In North California from where the domestic form originates (MacCrimmon, 1971) 60-chromosome karyotype prevails. In stocks cultivated in Europe and Japan the karyotype varies significantly (58—64), but karyotypes with higher numbers of chromosomes are more frequent than in America (Thorgaard, 1983; Ueda et al., 1983; Hartley, Horne, 1984; Кайданова, 1974, 1976). T. Ueda and Y. Ojima (1984) explained the high variability of domesticated rainbow trout chromosome number with its mixed origin. The crossing of parents with different karyotypes brings about an increase in variability (for example, parents with 61 and 62 chromosomes may give progeny with 60—63 chromosomes).

The purpose of our study was to establish the karyotype of the rainbow trout strains, reared in Estonian fish hatcheries, and to estimate their level of variability. There are two main strains of trout in Estonia — the local strain of German origin imported in the 1950s, and Donaldson strain, imported in 1981. Some fish farms cultivate also mixed stocks.

Material and methods

The data about the date and place of sampling, strain origin and number of specimens and concentration of colchicine solution injected are shown in Table 1. All the fish studied were yearlings or younger.

Table 1

Basic data for fish used for chromosome analysis

Hatchery	Strain	Number of specimens	Date	Colchicine contcentration, %
Roosna-Alliku	Donaldson	21	different times from 1985 to 1987	0.2
Roosna-Alliku	F1 hybrid between Donaldson and local strain	2	07. 1988	0.2
Pähkla	probably mixture of Donaldson and local strain	4	04. 1989	0.3
Põlula	local strain of German origin	5	06. 1989	0.3

The fish were injected with 0.2 or 0.3% colchicine solution (1 ml per 1000 g of fish weight) 2—17 hours before killing them. Pieces of kidney tissue were removed from fish, pretreated in 0.85% Na citrate solution for 30—40 min, and fixed in Carnoy solution. Chromosome slides were made following the routine air drying method with Giemsa staining.

Results

Mainly 58—60 chromosomes were found in Estonian stocks of rainbow trout (Table 2, Figs. 1—2). There were also a few metaphases with 61 and 62 chromosomes. The predominant number of chromosomes found in Donaldson trout was 60 (53.3% of all metaphases with 104 chromosome arms). In the local Estonian strain mainly metaphases with 58 chromosomes were detected (74.3%). In both mixed stocks karyotypes with 58 chromosomes predominated. Metaphases with 59 chromosomes were met with similar frequencies in all populations (Table 3). Numerous aneuploid metaphases containing 14—57 chromosomes were found in all populations (more than 20% of the metaphases screened). There was also significant intraindividual variation of chromosome numbers in all samples. For example, metaphases with 58—62 chromosomes could be found in the cells of one Donaldson trout (fish № 4).

As the number of metaphases with 104 chromosome arms was small in many individual fish (Table 2) we could not determine the modal number of chromosomes for every specimen. Therefore, the fish with different karyotypes could not be counted. But it is evident that the difference between Donaldson and local strain results from the different proportion of fish with predominantly 58 and 60 chromosomes in these stocks. In fact, all the local strain fish and hybrids had the modal number of chromosomes of 58, and most of the Donaldson trouts were 60-chromosome specimens.

Discussion

The native populations of rainbow trout in North America have mainly 58, 60 or even more chromosomes (Thorgaard, 1983). The domestic form of rainbow trout, cultivated in ponds all over the world originates mainly from the region where 60-chromosome karyotype predominates. The Donaldson trout was developed in the area where 58-chromosome set is

Table 2

Chromosome number (NF=104) distribution in Donaldson trout, Estonian local trout and their hybrids

№	Number of metaphases with					
	58 chr	59 chr	60 chr	61 chr	62 chr	Total
			Donaldson trout			
1.	1	—	2	—	—	3
2.	3	—	7	—	—	10
3.	—	—	1	—	—	1
4.	1	—	4	1	2	8
5.	—	1	5	—	—	6
6.	—	—	—	—	1	1
7.	—	—	2	—	—	2
8.	1	—	—	1	—	2
9.	—	—	2	—	—	2
10.	1	—	—	—	—	1
11.	—	—	1	—	—	1
12.	—	1	1	—	1	3
13.	—	—	—	1	—	1
14.	—	—	—	1	—	1
15.	5	2	4	—	—	11
16.	—	1	1	1	—	3
17.	—	—	4	—	1	5
18.	1	3	1	—	1	6
19.	1	2	3	—	—	6
20.	—	—	1	—	—	1
21.	—	—	1	—	—	1
Total	14	10	40	5	6	75
			Hybrids from Roosna-Alliku hatchery			
1.	9	—	4	—	1	14
2.	9	4	6	—	—	19
Total	18	4	10	—	1	33
			Mixed stock from Pähkla hatchery			
1.	14	3	8	—	—	25
2.	3	1	2	—	—	6
3.	5	2	2	—	—	9
4.	10	3	—	—	—	13
Total	32	9	12	—	—	53
			Estonian local strain			
1.	9	—	1	—	—	10
2.	5	1	1	—	—	7
3.	12	1	2	—	—	15
4.	8	2	3	—	—	13
5.	18	2	4	1	—	25
Total	52	6	11	1	—	70

Table 3

STRAIN (hatchery)	Number of meta-phases	Proportions of metaphases with different karyotypes, %				
		58 chr	59 chr	60 chr	61 chr	62 chr
Donaldson (Roosna-Alliku)	75	18.7	13.3	53.3	6.7	8.0
F1 hybrids (Roosna-Alliku)	33	54.6	12.1	30.3	3.0	—
Mixed (Pähkla)	53	60.4	17.0	22.6	—	—
Local (Põlula)	70	74.3	8.6	15.7	1.4	—

more frequent. The same chromosome number was expected for this strain in Estonia. However, mainly 60 chromosomes were found in our sample. The Estonian local strain has been imported from Germany over Russian fish farm Ropsha, where 60—62-chromosome karyotype prevails (Schniedewind et al., 1985b; Кайданова, 1974, 1976). But we found mainly 58 chromosomes in this stock. We may conclude that the chromosome number of Estonian rainbow trout stocks is lower than in most European and Japanese stocks. The range of variation of karyotype is also wider in West-European trouts. Unfortunately, the intra- and interindividual variation in the stocks of Estonian fish farms is too high to use this difference as a genetic marker and distinguish the specimens from different strains on the basis of their karyotype.

The hybrids of fish with 60 and 58 chromosomes must have 59 chromosomes, and segregation has to take place in following generations. The proportion of metaphases with 59 chromosomes was not higher either in F1 hybrids or in the mixed stock of Pähkla hatchery. However, the frequencies of 58- and 60-chromosome metaphases in mixed stocks were intermediate between parental forms (Table 3). The modal number of chromosomes was 58 for all hybrid specimens. To explain why 59-chromosome karyotypes are not frequent in mixed stocks we must propose that the modal number of chromosomes in somatic cells does not reflect adequately the karyotypes of the gametes. H. Schniedewind and co-authors (1985a, b) showed that in the rainbow trout stock where the modal number of somatic cell chromosomes was 62, the spermatocytes contained in the first meiotic metaphase 30 bivalents. Another explanation can be that although 60-chromosome karyotypes prevail in Donaldson trout mainly 58-chromosome specimens were used in crossings producing hybrids.

Intraindividual variation of the chromosome number is common for fishes. It can be treated as an artefact, resulting from the treatment of cells when making slides, or as a reflection of natural variability which occurs also in intact cells. S. Ohno and co-authors (1965) explained this with differentiation of cells during differentiation of tissues. However, intraindividual polymorphism has been found in lymphocyte culture, too (Hartley, Horne, 1984). G. Svärdson (1945) suggested that the chromatids of some metacentric chromosomes may segregate before anaphase. It can be also proposed that hypotonic treatment breaks the centromere region of some metacentrics. We suggest that the chromosomes have to be counted in meiotic metaphases to estimate the karyotypic differences between Donaldson and local strain trouts as it was done by H. Schniedewind and co-authors (1985a) and A. Sofradzija (1982) in case of other strains. The analysis of the segregation of chromosomes in the anaphase can probably help find out the causes of intraindividual variation.

Conclusions

58—62 chromosomes were found in rainbow trout stocks reared in Estonia. 60-chromosome metaphases predominated in Donaldson trout while 58 chromosomes were more frequent in the local strain. Intraindividual variation from 58 to 60 chromosomes was detected in all stocks. Meiotic chromosomes have to be studied to eliminate tissue differentiation effects on chromosome number variability.

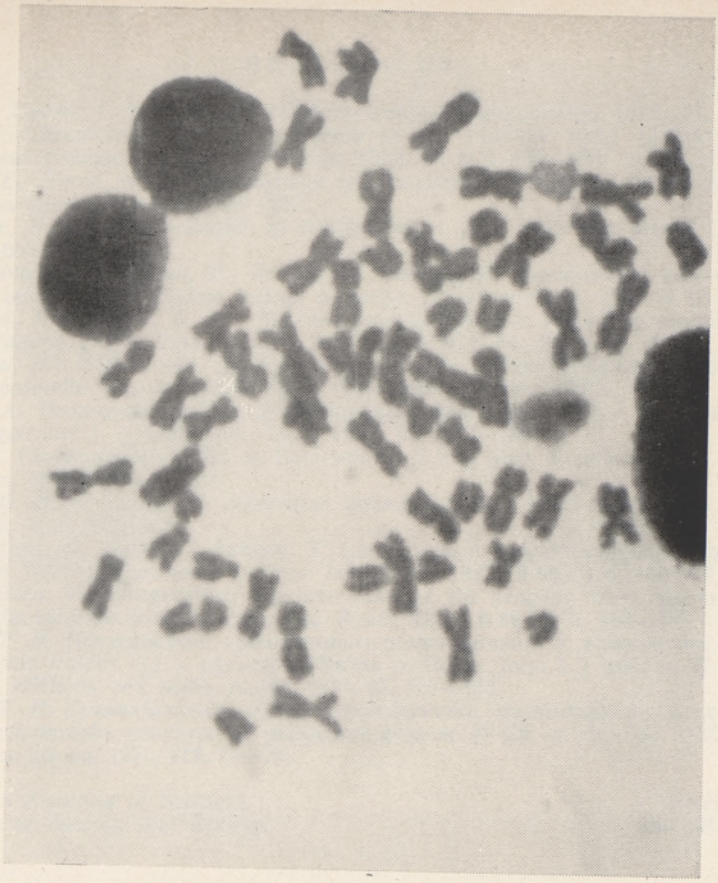

Fig. 1. Metaphase of Donaldson strain rainbow trout (2n = 60).

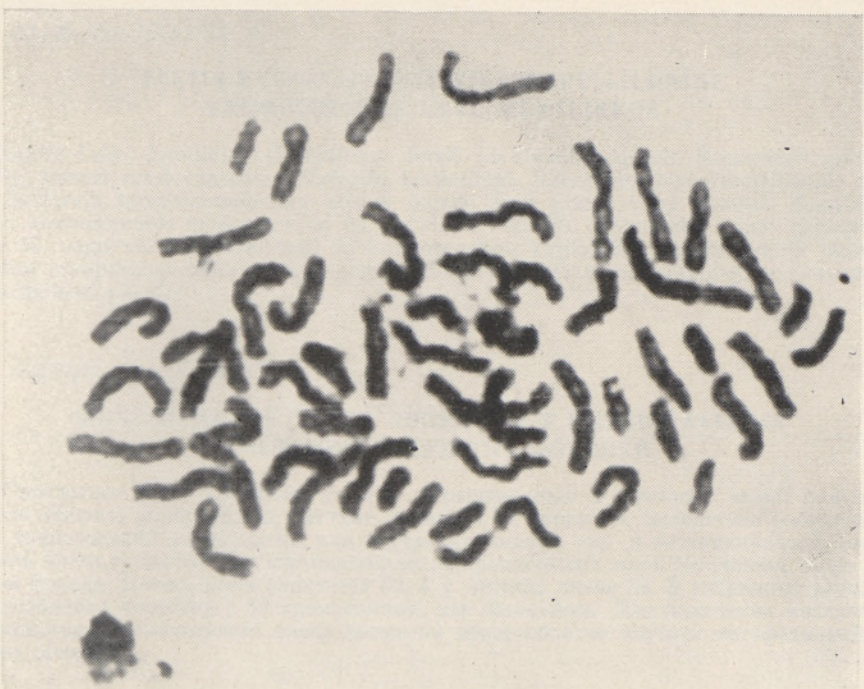

Fig. 2. Metaphase of local strain rainbow trout (2n = 58).

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EESTIS KASVATATAVATE VIKERFORELLILIINIDE KROMOSOOMIDE ARVU MUUTLIKKUS

Uuriti kahe forellilliini (Donaldsoni forell ja kohalik, algselt Saksamaalt pärinev forell), samuti nendevaheliste hübriidide karüotüüpi. Robertsoni translokatsioonide tõttu on vikerforelli kromosoomide arv püsiva õlgade arvu juures väga muutlik. Donaldsoni forelli kromosoomide modaalarv on 60, kohalikul liinil 58. Hübriididel esines sagedamini mitte 59, nagu võiks oodata, vaid 58 kromosoomiga karüotüüp. Isendisisese ja isenditevahelise muutlikkuse tekkepõhjuste selgitamiseks on vaja uurida rakujagunemiste metafaase meioosi puhul.

Ану ПАЛЬМ, Тийт ПААВЕР

ИЗМЕНЧИВОСТЬ ЧИСЛА ХРОМОСОМ У ВЫРАЩИВАЕМЫХ В ЭСТОНИИ РАДУЖНЫХ ФОРЕЛЕЙ

Определено число хромосом у двух выращиваемых в Эстонии линий радужной форели (форель Дональдсона, местная линия) и их гибридов. Вследствие робертсоновских транслокаций наблюдается как внутрииндивидная, так и межиндивидная изменчивость числа хромосом при постоянном числе хромосомных плеч. Модальное число хромосом форели Дональдсона равняется 60, а у местной линии 58. В гибридных отводках не преобладал кариотип с 59 хромосомами, как ожидалось. Для выяснения механизмов возникновения изменчивости числа хромосом целесообразно изучить метафазы мейотических делений.