SCIENTIFIC NOTE

CHROMOSOMES OF THE SOCKEYE SALMON (*ONCORHYNCHUS NERKA*)

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Older literature refers to several reports of interspecific and intraspecific differences of the chromosomes in fishes (Wickbom 1943; Svårdson 1945; Boothroyd 1959; Nogusa 1960; Roberts 1964), suggesting that fishes are likely to have more intraspecific chromosome variations than other vertebrates (Roberts 1967). Ohno *et al.* (1965) provided some evidence that chromosome variations occurred in every growing stage of a normal organ as well as in varying tissue samples of the rainbow trout (*Salmo irideus*).

Since the work of Prokofieva (1934), cytogenetic studies of salmonoid fishes have been carried out by many investigators (*cf.* Makino's list, 1956; Altman and Dittmer 1962; Roberts 1967).

The chromosomes of the land-locked form of *O. nerka* have been studied by Nogusa (1960) and Sasaki *et al.* (1968) and those of the Canadian sea-run form by Simon (1963). Information has never been given on the chromosome variation in *O. nerka*. The present study deals with a chromosome variation in somatic and germinal cells of *O. nerka*.

MATERIALS AND METHODS

The sockeye salmon (*Oncorhynchus nerka* var. *nerka* (Walbaum)) for this study were collected by gill nets at three stations in the Bering Sea (Table 1). All were in the mature stage following the final spawning migration. The fresh animals received a single intraperitoneal injection of colchicine solution (10-15 μ g/ml/g body weight) 6-12 hours prior to sacrifice. After treatment, fresh tissues, 5 mm cubes, were removed from the kidney and testes. They were minced with scissors, incubated in a 0.075 M KCl solution for 30-50 minutes at room temperature in fixing tubes, and then placed in a 1:3 acetic methanol fixative at least for 30 minutes. The chromosome slides were prepared from those samples by means of the routine air-drying method with Giemsa staining.

RESULTS

Somatic cells: The somatic chromosome number obtained in seven specimens collected at the first and second stations was $2n$, 58 at mode, while two of three obtained at the third station showed a modal number of 57, leaving the one having $2n$, 58

Table 1. Collection localities and fork length of animals

Fix. No.	Sex	Fork length (mm)	Collection locality	Date
1	♀	532	7002*	Jun. 15, 1970
2	♀	562	"	"
3	♂	565	"	"
4	♂	559	"	"
5	♂	557	"	"
6	♀	562	7005	Jun. 21, 1970
7	♂	500	"	"
21	♂	520	7007	Jun. 28, 1970
22	♂	511	"	"
23	♀	536	"	"

* 7002 (56°-16'N, 162°-35'W), 7005 (55°-58'N, 165°-48'W), 7007 (58°-00'N, 165°-00'W).

Table 2. Distribution of modal chromosome numbers in kidney and testis

Fix. No.	Sex	Tissues	Number of chromosome counts							Total cell counts
			54	55	56	57	58	59	60	
1	♀	kidney		2	1	3	42	2		50
2	♀	kidney				1	45	1	3	50
3	♂	kidney		1	1	4	10			16
		testis					7			7
4	♂	kidney			1		4			5
		testis			1		3			4
5	♂	kidney	1	1	7	7	33	1		50
		testis			2	2	7			11
6	♀	kidney			1	5	43	1		50
7	♂	kidney		1	7	8	32	1	1	50
		testis			3	1	10	1		15
21	♂	kidney		2	7	23	8			40
		testis				1	2			3
22	♂	kidney		3	5	42				50
		testis		1	7	46	19			73
23	♀	kidney		1	1	3	44	1		50
Total cell counts			1	12	44	146	316	8	4	568

(Table 2).

Detailed karyotype analysis indicated that cells with 58 chromosomes consisted of 44 meta- and submetacentrics, 2 subtelocentrics and 12 telocentrics (Fig. 1). Hence the total number of chromosome arms was calculated as 104. On the other hand, cells with 57 chromosomes showed 45 meta- and submetacentrics, 2 subtelocentrics and 10 telocentrics (Fig. 2). In those cells the total number of arms was also 104. Comparison between the two karyotypes indicated that one of the bi-armed chromosomes in the

Figs. 1-4. Karyotypes from four cells of *Oncorhynchus nerka*. 1. Karyotype of 58 chromosomes. 2. Karyotype of 57 chromosomes. 3. Karyotype of 56 chromosomes. 4. Karyotype of 55 chromosomes.

Figs. 5-6. First meiotic metaphases from the testis of No. 22 specimen.

cells with 57 chromosomes had been produced through the fusion of certain two un-armed chromosomes, or by a so-called Robertsonian mechanism. The karyotypes of cells with 57 chromosomes observed in different specimens (nos. 1, 2, 3, 5, 6, 7, 21, 22, and 23) were the same. There were some cells showing a deviation of chromosome numbers, such as 54, 55, 56, 59 and 60, in addition to the basic karyotype. Those chromosomal changes were not explained by a simple Robertsonian system. For example, the karyotype of cells with 56 chromosomes was represented by 44 meta- and submetacentrics, 2 subtelocentrics and 10 telocentric chromosomes (Fig. 3), and cells having $2n$, 55 chromosomes showed 45 meta- and submetacentrics and 8 telocentrics (Fig. 4).

Germinal cells: Due to the season-off for spermatogenesis, a few mitotic pictures of spermatogonia were available for study. As shown in Table 2, cells of the basic karyotype with 58 chromosomes were observed in nos. 3, 4, 5, and 21 specimens: they showed the same karyotype as that observed in the somatic cells. The karyotype of $2n$, 57 observed in nos. 5, 7, and 21 specimens showed the Robertsonian translocation. The mode of the chromosome number of no. 22 specimen was $2n$, 57 (Table 2): 63 per cent of cells observed was $2n$, 57, 26 per cent, 58 and 11 per cent $2n$, 55-56.

At diakinesis, some spermatocytes with multivalent-like structure were observed in some testicular samples (Figs. 5-6). The significance of the occurrence of such chromosomes has remained unknown at the present status of our knowledge. Further studies are requested for the interpretation of the feature.

DISCUSSION

Out of ten animals here under study, eight individuals gave a modal chromosome number of 58 in both somatic and germinal cells (Table 2). In the remaining two (nos. 21 and 22), the modal counts were 57. Especially in the specimen no. 22 no cells with 58 chromosomes were observed in its somatic cells. Further, 68 per cent of the

spermatogonia also contained 57 chromosomes. The arm-number was 104 in both cells having 57 and 58 chromosomes. This suggests that the variation is caused by a Robertsonian translocation.

It was found that no. 21 and 22 specimens had a modal chromosome-number of 57 and that they had none or only a few somatic cells with 58 chromosomes. This suggests that at least one of their parents might have 57 chromosomes. Hence a few cells with 58 chromosomes seem to be derived from the cells with 57 chromosomes by means of the Robertsonian translocation. The feature indicates that the Robertsonian translocation occurs also in the direction toward the addition of two uni-armed chromosomes through dissociation of one bi-armed chromosome. A similar feature has been presented by Ohno *et al.* (1965) in the rainbow trout.

It was shown that cells of $2n$, 56 and 55 had an arm-number of 102, and that a Robertsonian correlation existed between cells of $2n$, 56 and those of $2n$, 55.

The haploid number of *Oncorhynchus nerka* of the Japanese land-locked form was first recorded as 54 by Nogusa (1960) according to the older testis-section method. Recently, Sasaki *et al.* (1968) reported the diploid number as 58 in the same species. The diploid number and basic karyotype of *O. nerka* reported in this paper is compatible with the results of Sasaki *et al.* (1968). Cells with 56 chromosomes, 102 in arm number, were rarely observed in the present materials (Table 2). The same finding was presented in the Canadian sockeye salmon by Simon (1963). It seems very probable that the population with the arm-number of 102 seems to differentiate from the population with the arm-number of 104.

Ohno (1970) emphasized that in tetraploid species, the individual which chromosome set reduced such as trisomic (actually pentasomic) and monosomic (actually trisomic) chromosomes might be tolerated.

SUMMARY

The somatic and germinal chromosomes of the sockeye salmon (*Oncorhynchus nerka*) from three stations in the Bering Sea are studied by the routine air-drying method.

The chromosome number is $2n$, 58 for eight individuals and $2n$, 57 for two. Based on the arm-number is 104 in 57- and 58-cells, the variation is interpreted by a Robertsonian mechanism. There are some cells showing a deviation of chromosome numbers, such as 54, 55, 56, 59 and 60, in addition to the basic karyotype. Those chromosomal changes are not explained by a simple Robertsonian system.

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