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Introduction of two Chromosomal Translocations of *Sus scrofa nigripes* and *Sus scrofa scrofa* into the Genome of *Sus scrofa domestica*

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Summary. Hybrids between wild and domestic pigs with two types of translocations in the karyotype were studied. The translocations of type I were first detected in a population of the Middle Asian wild boars. Type II was identified in a populations of the Central European subspecies. A large number of Middle Asian and Central European hybrids and their F_1-F_3 hybrids from crosses with domestic pigs were viable. By means of differential chromosome staining, the mechanism of the formation of 'synthetic' karyotypes, as well as some features of translocation inheritance, were established.

The introduction of two translocations into a single genome and the same chromosome set of these hybrids not only modified chromosome number, but also the composition of the linkage groups. The hybrids heterozygous for two translocations and their hybrid progeny are characterized by an obligatory heterozygozity for a large number of genes, gene complexes and linked genes. It is suggested that this heterozygozity may be associated with heterotic events. The use of such hybrids in pig breeding may provide heterosis for viability and productivity.

Key words: Robertsonian translocations – *Sus scrofa* sp. – Hybridization

Introduction

Karyotype polymorphism resulting from two types of Robertsonian translocations has been established cytogenetically in some subspecies of wild boars from different regions of the USSR (Tikhonov and Troshina 1972, 1975). This polymorphism is specific to wild boars and does not occur in domestic pigs (Tikhonov and Troshina 1971). Crosses between wild and domestic pigs have yielded large numbers of viable and fertile hybrids during the first four generations. Some of these hybrids have rearrangements of the first and second types in the heterozygous condition (Tikhonov and Troshina 1977).

To estimate the viability of hybrids carrying simultaneous translocations of both types and to elucidate the genetic role of chromosomes involved in these translocations, we used a new approach of hybridization of two subspecies of wild boars. These were *Sus scrofa nigripes* from Middle Asia (translocation type I) and *Sus scrofa scrofa* from Central Europe (translocation type II).

Middle Asian and European boars were first cytogenetically studied and then selected on the basis of their karyotypes. These boars were caught in the Sary-Chelek reservation (Kirghiz SSR) and in the Byelovezhskaya reservation (Byelorussian SSR) and maintained in the Experimental Farm of this Institute of Cytology and Genetics (near Novosibirsk).

A female, homozygous for translocation type I, 2n = 36 (T_1T_1) *Sus scrofa nigripes* and a male, homozygous for translocation type II, 2n = 36 (T_2T_2) *Sus scrofa scrofa*, were involved in hybridization.

Furthermore, double translocations were introduced into the genome of domestic pigs by crossing domestic pigs and wild ones carrying two different translocations for four generations. This introduction was performed with a view to obtain a basis for studying the genetic effect of double translocations in the genomes of hybrids and to assess the use of these hybrids in pig breeding.

Materials and Methods

European and Asian pigs of Landrace and Vietnames black breeds were used as mediators of translocations. As a result of hybridization of a European boar with 8 F_1 hybrid females (obtained by crossing Landrace and Vietnamees females with a *Sus scrofa nigripes* male) 91 hybrids were obtained, 56 of these hybrids were investigated karyologically.

Cytological studies were carried out in 23 hybrids obtained by crossing F_1 males (♀ Landrace × ♂ European boar) with F_{2b}

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females obtained by backcrossing hybrid females (♀ Landrace × ♂ European boar) crossed with a Landrace male.

Chromosome studies of hybrids during the first days of postnatal life were performed on preparations of bone marrow and spleen cells. The piglets were given intraperitoneal injections of colchicine (1 ml of 0.4% solution per kg body weight) two hours before sacrifice. The subsequent treatment of the material, including hypotonic solution, fixation and obtainment of preparations, was done according to the method of (Ford and Hamerton 1956). The preparations were stained in Giemsa by C – and G – band methods.

Karyotype analysis of piglets older than two month was performed on metaphase plates. These were obtained from a culture of peripheral blood lymphocytes with added phytoheamagglutinin and colchicine (Moorhead et al. 1960).

Results

The cytological study of F_1 hybrids obtained from the *Sus scrofa nigripes* female and a *Sus scrofa scrofa* male established that all have a 2n = 36. Their chromosome sets contained both types of Robertsonian rearrangement characteristic of the forms involved in the crosses (Figs. 1, 2). One translocated chromosome was regularly derived from the mother and the other was derived from the father irrespective of whether the parents were wild or domestic (Table 1).

In F_2 hybrids between *Sus scrofa* boars and Landrace sows, the ratio of 36- to 37-chromosome individuals was 1:1.1 in newborn piglets. The high fertility of sows (10 piglets per liter) and the low number of still-born piglets in these crosses demonstrate that embryonic development in 36-chromosome hybrids carrying two translocations is not impaired. This conclusion is supported by cytological observations made on 2.5 – 3 month old embryos from a female obtained in the second cross scheme. Of 8 embryos, 6 had a 2n = 36 karyotype, i.e. they each had both types of translocations. The high embryonic viability of hybrids with double translocations additionally confirmed that the presence of these chromosome rearrangements in the hybrids' zygote does not interfere with mitotic division during embryonic development. It is noteworthy that the cytologically studied F_3 hybrids obtained by crossing hybrid sows (♂ *S.s. nigripes* × ♀ Landrace) with an F_1 male (♀ Landrace × ♂ *S.s. scrofa*) had high embryonic viability (12 piglets per litter) and high postnatal viability (96% of the piglets attained 2 months of age) – Table 2. Two litters were obtained from the above mentioned crosses; there were 12 piglets in one litter and 11 piglets in the other. In the former litter, the ratio of 36-, 37- and 38-chromosome hybrids conformed to the 1:1 expected ratio. The latter did not contain any 36-chromosome individuals and the ratio 37- to 38-chromosome individuals and the ratio of 37- to 38-chromosome individuals was 1.75:1.

Hybrid forms with a 2n = 36 and two different Robertsonian rearrangements have not been, so far, described in the literature. Their karyotypes are 'synthetic' in that they possess Robertsonian rearrangements of both types, characteristic of the chromosome sets of two subspecies of wild boars (Fig. 3). These hybrids may be regarded as heterozygous for two types of Robertsonian rearrangements, in the formation of which chromosomes of three pair of acrocentrics are involved. In the group of acrocentric chromosomes of these hybrids, 8 chromosomes are present, as in the 36-chromosome hybrids we have de-

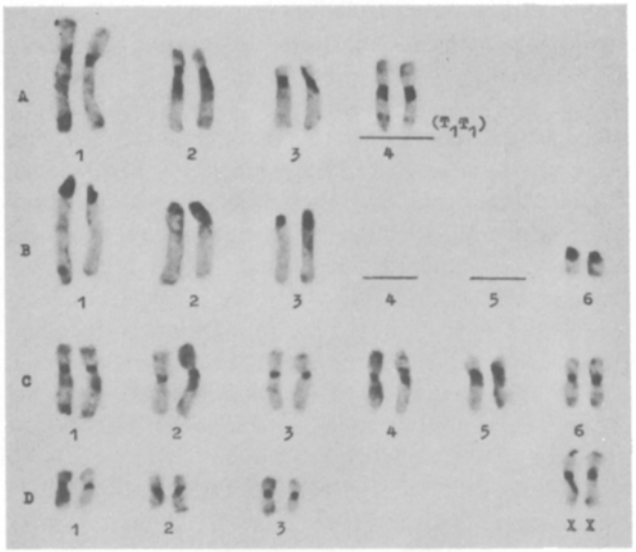

Fig. 1. C – banded chromosomes of a female 2n = 36 *Sus scrofa nigripes* with Robertsonian rearrangement of type I (2n = 34 + T_1 + T_1)

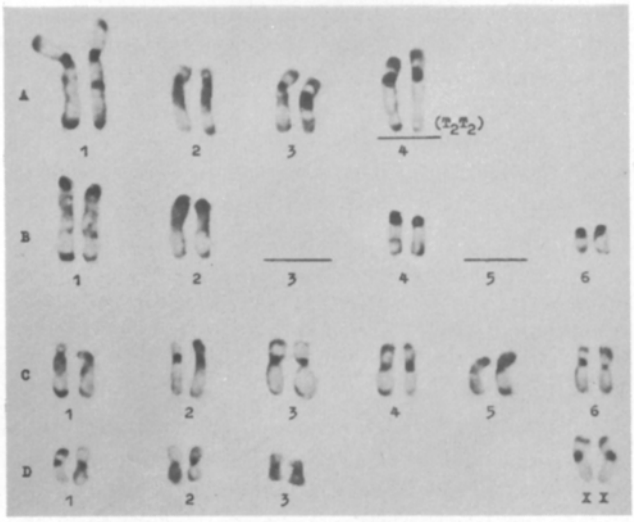

Fig. 2. C – banded chromosomes of a female 2n = 36 *Sus scrofa scrofa* with Robertsonian rearrangement of type II (2n = 34 + T_2 + T_2)

Table 1. Inheritance of chromosome number and male to female ratios in hybrids between wild and domestic pigs in different cross schemes

Diploid chromosome number (2n)		No. of karyologically studied piglets	No. of offsprings with different chromosome number			No. of males and females with different chromosome number (2n)					
						Females			Males		
Father	Mother		2n = 36	2n = 37	2n = 38	2n = 36	2n = 37	2n = 38	2n = 36	2n = 37	2n = 38
36 (T_2T_2)	36(T_1T_1)	4	4	–	–	2	–	–	2	–	–
36(T_2T_2)	37(T_1 –)	56	26	30	–	11	14	–	15	16	–
37(T_2 –)	37(T_1 –)	23[a]	3	13	7	0	7	3	3	6	4

[a] Litters with 12 piglets had no 36-chromosome individuals

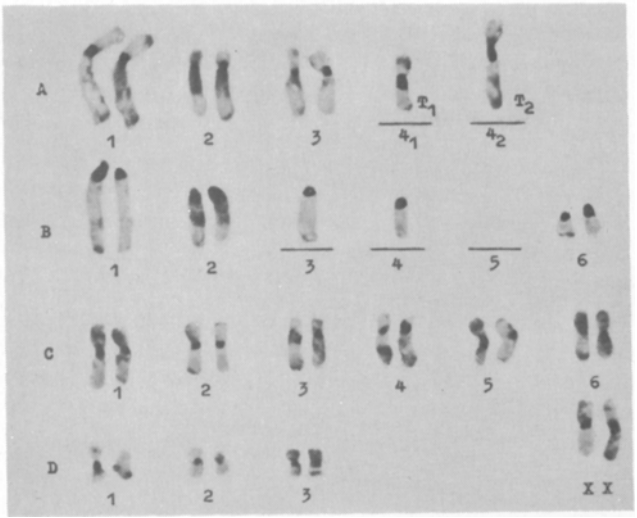

Fig. 3. C – banded chromosomes of a hybrid female 2n = 36 with Robertsonian rearrangements of types I and II (2n = 34 + T_1 + T_2)

Fig. 4. G – banded chromosomes of a hybrid femal 2n = 36 with Robertsonian rearrangements of types I and II (2n = 34 + T_1 + T_2)

scribed earlier (Tikhonov and Troshina 1975), but the set of acrocentrics is different. The first, second and sixth pairs of acrocentric homologues (B1, B2 and B6) are usually observed in the karyotypes of wild and domestic pigs, while the chromosomes of the third and fourth pairs are in a heterozygous condition.

This means that their genetic equivalents participate in translocations and are members of other linked groups ($A4_1$ and $A4_2$). As to the fifth pair of acrocentrics (B5), it is absent as an independent linkage group which is always present in 38-chromosome individuals (Fig. 4).

Conclusions

As a result of double translocations simultaneously present in chromosomes sets, the pig hybrids studied showed karyotype changes not only with respect to chromosome number, but also to linkage groups.

Thus, it is possible to obtain viable domestic hybrids pigs with 'synthetic' karyotypes containing translocated chromosomes from the genomes of the *S.s. nigripes* and *S.s. scrofa*.

Further, studies of the reproductive capacities of these hybrids and their cytogenetic features are of interest. Crosses between 2n = 36 hybrids (T_1T_2, T_1T_1 and T_2T_2) and domestic pigs 2n = 38 (T_1-T_2-) should yield offspring heterozygous for a large number of interacting genes, gene complexes and even linkage groups (all offsprings having a 37-chromosome karyotype, heterozygotes for two chromosomes.)

It is pertinent to recall that Robertsonian translocations are not rare in mice, cattle, sheep and other mammalian species (Gropp et al. 1972; Gustavsson 1969; Bruer 1974). Moreover, sheep heterozygous for two translocations develope normally and even show increased fertility (Bruer and Chapman 1974). Heterozygosity in pigs described in this paper is possibly related to heterosis for viability and fertility.

Table 2. Cross scheme, fertility and viability in relation to chromosome number in different parental forms

Generation	Cross scheme		Karyotype (2n)		No. of sows	Number of hybrids			No. of 2-month old piglets		Sex of new-born pliglets	
	Father	Mother	Father	Mother		Total	Alive	Still-born	No.	%	♂	♀
F_1	S.s.s.	S.s.n.	$36(T_2T_2)$	$36(T_1T_1)$	1	5	4	1	4	80	2	2
F_2	S.s.s.	F_1 (Ssn × L)	$36(T_2T_2)$	$37(T_1 -)$	4	41	10	0.25	16	39.02	36	34
	S.s.s.	F_1 (Ssn × V)	$36(T_2T_2)$	$37(T_1 -)$	4	40	10	0.	10	25		
F_3	F_1 (Sss × L)	$F_{2b}(F_1$ Ssn × L) × L	$37(T_2 -)$	$37(T_1 -)$	2	24	23	1	22	95.65	11	13

S.s.n. = Middle Asian boars (*Sus scorfa nigripes*, Blanf.)
S.s.s. = Central European boars (*Sus scorfa scrofa* L.)
T_1 = Robertsonian rearrangement of type I identified in *Sus scrofa nigripes* population
T_2 = Robertsonian rearrangement of type II identified in *Sus scrofa scrofa* population
L = Landrace and V = Vietnames breeds

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