

## CYTOGENETIC EXAMINATION OF BULLS. VARIANTS OF THE Y CHROMOSOME<sup>1</sup>

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**Summary.** Genetic studies of 238 bulls were performed. All the animals had a normal karyotype. Measurements of metaphase chromosomes were made in the case of 72 bulls. They were used for calculations of the parameters characterizing sex chromosomes: the relative chromosome length, centric index and the arm length ratio. On the basis of the performed one-step analysis of variance significant variation in the relative *Y* chromosome length was found among the studied 72 bulls. Eight individuals with untypical size of the *Y* chromosome were separated in the group under study. No relationship was detected between the size of the *Y* chromosome and some semen traits in bulls.

A wide-scale application of artificial insemination for reproduction of bulls causes that before mating bulls are subjected to a thorough estimation of their breeding value and on that basis they are then strictly selected. One of the aspects of their breeding value should be the estimation of their karyotype. Such estimation is already obligatory in some countries and the detection of chromosome aberration does not permit a bull to be accepted for reproduction.

Besides chromosome aberrations, karyotypes are frequently observed to have various forms of chromosome polymorphism associated for example with centric fusion, the size of heterochromatin blocks (C bands), with manifestation of NOR areas (silver staining) or with the size of *Y* chromosome. There is however, no explicit answer to the question what phenotypic effects are caused by polymorphism.

The occurrence of polymorphic forms of the *Y* chromosome in bulls was described several times (Sysa 1982, Zhivalev, Goldman 1973, Haln: n, Watson 1982, Eldridge et al. 1983).

The purpose of the present paper was to estimate the karyotype of bulls intended for artificial insemination with particular reference to variation of the *Y* chromosome size in relation with some semen traits of bulls.

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## MATERIAL AND METHODS

The studies covered totally 238 bulls of the Black-and-White breed from the Stations of Animal Breeding and Insemination (88 individuals) and from the State Bull Breeding (150 individuals).

The chromosome preparations were obtained on the basis of standard technique of lymphocyte culture and were Giemsa-stained afterwards.

Measurements of metaphase chromosomes were performed on photographs  $18 \times 24$  cm in size in the case of 72 individuals (60 bulls from The State Bull Breeding and 12 from the Station of Animal Breeding and Insemination). Totally 197 metaphase plates were analysed, from 2 to 4 photographs being taken for a single animal.

On the basis of the performed measurements the following parameters characterizing sex chromosomes were calculated for each metaphase plate: relative length (expressed as percentage of the length of autosomal haploid set + the length of the X chromosome), the length ratio of long to short arms and the centric index. Besides, that, regarding bulls originating from the State Bull Breeding Station (60 animals), the information concerning the following semen traits was used from the breeding data: the volume of ejaculate, percentage of mobile spermatozoons, concentration of spermatozoons in  $1 \text{ mm}^3$ , percentage of spermatozoons with the major morphological changes and percentage of spermatozoons with minor morphological changes.

The collected material was statistically treated using a unifactorial analysis of variance. Grouping of means of the objects into internally homogenic groups was also applied (Caliński, Wagner 1974).

## RESULTS

All the bulls covered by the present studies had a normal karyotype ( $2n=60$ ).

The mean values of individual parameters (calculated on the basis of all 197 measurements), as well as minimum and maximum values of the same parameters (calculated for particular bulls) and variation coefficients are given in Table 1. As

Table 1. Mean ( $\bar{x}$ ), minimum ( $x_{\min}$ ) and maximum ( $x_{\max}$ ) values and variation coefficients ( $V$ ) of parameters characterizing morphology of sex chromosomes

Sex chromosomes	Relative length (%)	Centric index	Ratio of arm lengths
chromosome X			
$\bar{x}$	5.52	0.34	1.99
$x_{\min}$	4.90	0.29	1.51
$x_{\max}$	6.00	0.41	2.53
$V$ (%)	7.2	8.5	13.5
chromosome Y			
$\bar{x}$	2.08	0.43	1.37
$x_{\min}$	1.37	0.36	1.05
$x_{\max}$	2.75	0.49	1.78
$V$ (%)	17.3	9.7	18.0

follows from Table 1, the mean relative length of sex chromosomes was 5.52% and 2.08%, respectively, for *X* and *Y*.

The performed analysis of variance of the parameters, characterizing sex chromosomes showed significant (on the level of  $\alpha=0.01$ ) variation between the bulls for the parameter of the relative length of the *Y* chromosome ( $F_{\text{calc}}=2.65$ ,  $F_{0.01}=1.61$ ).

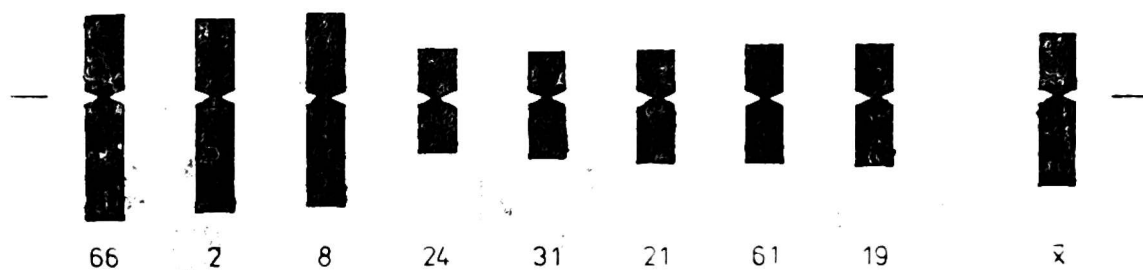


Fig. 1. An idiogram of *Y* chromosomes of eight bulls in comparison with that presenting the mean size and morphology of the *Y*-chromosome in the studied group of bulls

Taking into account the least significant differences (LSD) (*t*-Student's test), 8 bulls with especially distinguishing *Y* chromosome were separated. Parameters characterizing morphology of sex chromosomes in these bulls are summarized in Table 2. Fig. 1 presents an idiogram of *Y* chromosomes of 8 bulls in comparison

Table 2. Parameters characterizing morphology of sex chromosomes in bulls with untypical *Y* chromosome

Number of individuals	No. of analyzed pictures	Relative length	Centric index	Ratio of arm lengths
66	2	2.75	0.41	1.50
2	3	2.57	0.41	1.45
8	3	2.57	0.44	1.32
24	3	1.37	0.48	1.07
31	3	1.45	0.46	1.22
21	3	1.50	0.46	1.33
62	2	1.55	0.47	1.17
19	3	1.63	0.45	1.26

with the *Y* chromosome of an average size for the group under study. Fig. 2 presents sex chromosomes from the analysed metaphase plates of bulls with a distinguishing *Y* chromosome. As follows from Table 2, three bulls were characterized by a long *Y* chromosome and five bulls — by a short *Y* chromosome. Attention is drawn by the fact that an increase or a decrease of the *Y* chromosome size was principally a result of proportional changes in the length of both long (*q*) and short (*p*) arm.

Using the method of grouping object means into internally homogenic groups, the studied bulls were divided into two groups on account of the *Y* chromosome size. In the first group (I) consisting of 35 bulls the mean relative length of the *Y* chromosome was 1.84%, whereas in the second group consisting of 37 bulls it was 2.31%.

The separated groups of bulls were compared with regard to some semen traits, i.e. the volume of ejaculate, percentage of mobile spermatozoons, the number of spermatozoons in 1 mm<sup>3</sup> of sperm, percentage of spermatozoons with major morpho-

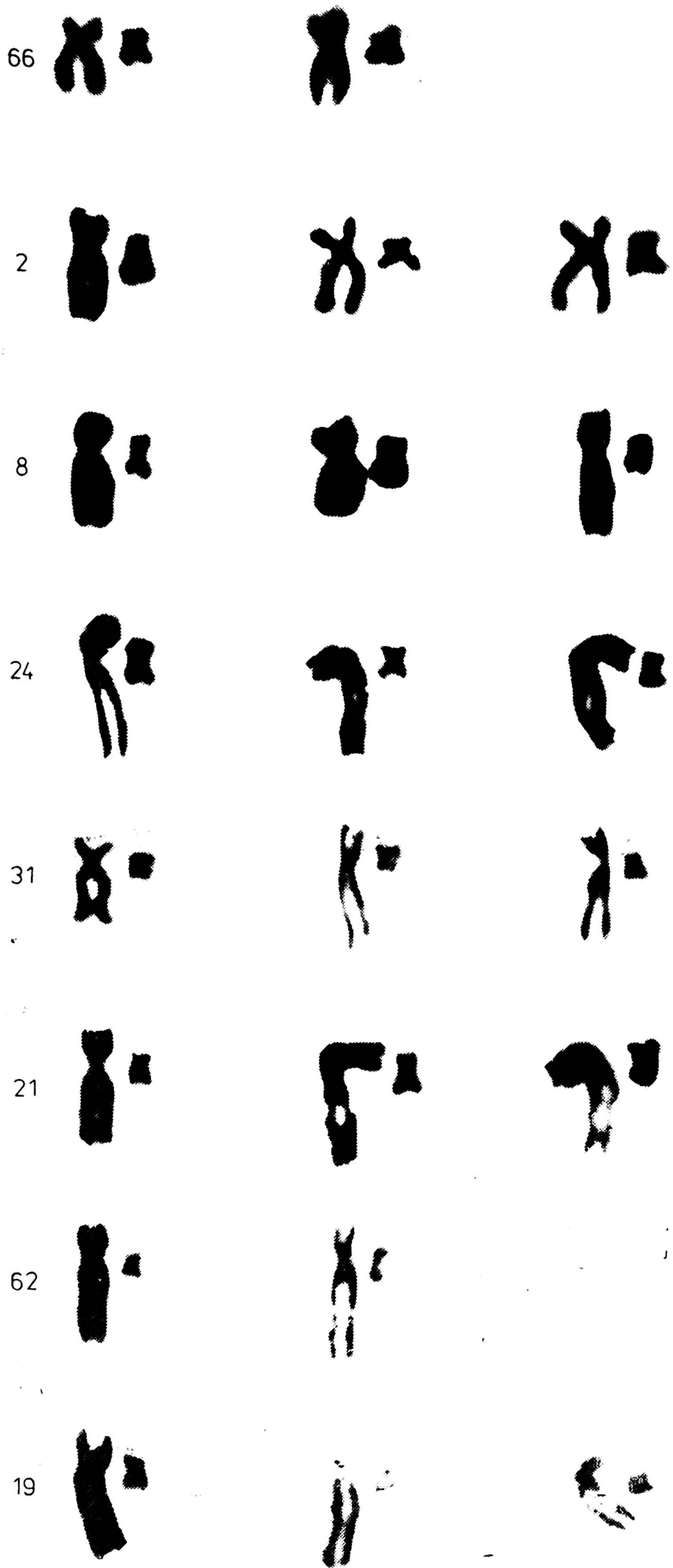


Fig. 2. Sex chromosomes of eight bulls with untypical Y chromosome  
(Nos. 66-19: bulls designation)

logical changes and percentage of spermatozoons with minor morphological changes. The mean value of the mentioned traits for the both groups are given in Table 3. It should be noticed that in this comparison we took into consideration only bulls from the State Bull Breeding (60 individuals). The omission of 12 bulls from the

Table 3. Development of some semen traits in two groups of bulls with different relative length of the Y chromosome

Group	No. of bulls	Mean relative length of Y-chromosome	Ejaculate volume	Per cent of mobile spermatozoans	Spermatozoan concentration (th./mm <sup>3</sup> )	Per cent of spermatozoans with morphological changes	
						major	minor
I	30	1.82	3.6	60	745	4.2	6.2
II	30	2.32	3.7	60	728	4.8	6.1

Stations of Animal Breeding and Insemination did not affect the means in two above groups. These values for group I and II were 1.82% and 2.32% respectively. No differences were found between these groups with regard to the mentioned semen traits.

## DISCUSSION

Cytogenetic studies of cattle in Poland were undertaken several times. Sysa (1976) found the 1/29 Robertsonian translocation in two young bulls of the Polish Red breed. The same aberration was also observed by Słota and Danielak (1984) in a cow of the Black-and-White breed. Jaszczak (1980) found a single individual, originating probably from a different-sex twin pregnancy, with a chimeric karyotype 60 XY/60 XX among the studied 160 little bulls of Black-and-White breed from bull breeding station. A similar case was observed by Słota and Janicka-Mazur (1982) among 47 little bulls of the Polish Red breed originating also from bull breeding station. Moreover, Słota et al. (1982) described the karyotype 60 XX/61 XXY in a bull originating from twins of different sex, and Słota (1984) found also a bull originating from bull breeding station, which had the karyotype 61 XXY.

As follows from the presented literature data the frequency of different chromosome aberrations in cattle in Poland is not low despite the fact that in the present paper all the studied bulls (238) had a normal karyotype.

Review papers of many authors (Gustavsson 1979, Fechhaimer 1979, Gustavsson 1980, Sysa, Sławomirski 1979 a, 1979 b, Świtoński 1980) point out to the diversity of chromosome aberrations in cattle and their distribution, underlining at the same time the necessity of systematic cytogenetic studies in that species. The mean values of the studied parameters for sex chromosomes obtained in the present paper are similar to the values obtained by other authors (Gustavsson 1969, Zhivalev, Goldman 1973, Cribeu, Popescu 1974, Sławomirski et al. 1979, Arruga, Zarazaga 1981-82, Świtoński, Pordąb 1983). The relative length of sex chromosomes observed by the mentioned authors ranged from 5.4% to 5.6% for the X chromosome and from 1.8% to 2.8% for the Y chromosome.



Significant variation in the size of the *Y* chromosome was detected among the studied bulls in the present paper. Variation of that type in cattle was already described in two aspects, i.e. (1) in the aspect of interbred differences and (2) in the aspect of the presence of individuals with atypical *Y* chromosome within the breed. Interbred differences were studied by Zhivalev, Goldman (1973), Cribiu (1975), Giovanni, Cribiu (1977), Halnan, Watson (1982), Stranzinger (unpublished). Sysa (1976) and Eldridge et al. (1983) observed the occurrence of individuals with a long *Y* chromosome, the first of the mentioned papers finding the same *Y* form in both father and sons.

Polymorphism of the *Y* chromosome was frequently described in man (Hübner 1971 a, 1971 b, Bratkowska, Hübner 1981, Wiśniewski et al. 1981, Parcheta et al. 1983). There are few papers, however, discussing phenotypic effects of that type of polymorphism. Hübner (1971 b) found more frequent occurrence of various somatic and psychic defects in men with a long *Y* chromosome. Wiśniewski et al. (1981) found that a group of men with adversities in reproduction had an increased frequency of polymorphic forms of the *Y* chromosome ( $Y_q+$  and  $Y_q-$ ) in comparison with the control group, which consisted of men with a healthy progeny. In the present paper the development of five semen traits in two homogenetic groups of bulls differing by the relative length of the *Y* chromosome was compared. The obtained results suggest the lack of interrelationship between the size of the *Y* chromosome and the studied semen traits.

An important problem is the elucidation of causes of the *Y* chromosome polymorphism. The observed variation of that chromosome may be a result of different phenomena, for instance, changes in the process of chromatin spiralization, structural aberrations or polymorphism of C-bands, which frequently occur in the *Y* chromosome. Results of the present paper indicate that variation of the *Y* chromosome length is a result of changes in the length of the both chromosome arms, which could suggest that the basic role in that case is played by processes associated with chromatin spiralization. Studies by Parcheta et al. (1983) show that variation of the *Y* chromosome size in man is closely correlated with the DNA content in that chromosome. This finding indicates a doubtful importance of variation in spiralization process for the development of that polymorphism. Maybe, therefore, the phenomenon of variation of the *Y* chromosome size should have been considered in the categories of C-band polymorphism, the importance of which has not been elucidated until now. On the other hand, however, there are communications (Parcheta 1983), which point out that variation of the *Y* chromosome size depends on the length of both heterochromatin and euchromatin.

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## BADANIA CYTOGENETYCZNE BUHAJÓW. WARIANTY CHROMOSOMU Y

### Streszczenie

Przeprowadzono badania cytogenetyczne 238 buhajów. Wszystkie zwierzęta miały kariotyp prawidłowy. W przypadku 72 buhajów dokonano pomiarów chromosomów metafazalnych, a następnie wyliczono parametry charakteryzujące chromosomy płci: długość względna chromosomu, indeks centryczny oraz stosunek długości ramion. Na podstawie przeprowadzonej analizy wariancji jednostopniowej stwierdzono występowanie, w obrębie 72 buhajów istotnej zmienności długości względnej chromosomu Y. W badanej grupie wyróżniono 8 osobników o nietypowej wielkości chromosomu Y. Nie stwierdzono współzależności pomiędzy wielkością chromosomu Y a niektórymi cechami nasienia buhajów.

## ЦИТОГЕНЕТИЧЕСКИЕ ИССЛЕДОВАНИЯ БЫКОВ. ВАРИАНТЫ ХРОМОСОМЫ Y

### Резюме

Произведены цитогенетические исследования 238 быков. Все животные имели нормальный карิโอтип. На 72 быках были произведены измерения метафазных хромосом, а затем были вычислены параметры, характеризующие половые хромосомы: относительная длина хромосомы, центрический индекс и отношение длины плечей. На основании проведённого анализа одноступенчатой вариации обнаружено выступление в пределах 72 быков существенной изменчивости относительной длины хромосомы Y. Не обнаружено взаимозависимости между величиной хромосомы Y и некоторыми признаками спермы у быков.