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CHROMOSOMAL ABNORMALITIES IN QUAILS SELECTED FOR A HIGH AND LOW BODY WEIGHT[1]

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Summary. The frequency of chromosomal abnormalities was studied in quails selected for a high and low body weight. The control group consisted of Japanese quails of the "Standard" type grown without selection for the body weight. Karyotypes were determined in the cells of embryonic disc after 16-18 hour incubation. They were taken from individuals of the 4th and 5th generations of a line selected for a high body weight and from the 9th and 10th generations of a line selected for a low body weight. Totally 923 embryos were examined. The largest percentage — 5.31 of embryos with abnormal karyotype was found in the line selected for a high body weight. In the line selected for a low body weight only 3.6% of the embryos, and in the control group — 1.43%, had abnormal karyotype. Among embryos with abnormal karyotype we have noted 7 kinds of chromosomal aberrations. The results obtained in the studied groups of quails indicate that selection for the body weight causes increase of chromosomal abnormalities in embryos. In the discussion attention is paid to the role of these abnormalities in reproduction, as well to the use of cytogenetic studies in flocks of birds intensively selected for the body weight. This would make it possible to eliminate from parental populations of individuals carrying chromosomal aberrations and genetically predisposed for their transmission to the progeny.

Selection as a basic method commonly used in animal breeding is at the same time a subject of many theoretical studies. From a number of studies carried out on model animals it follows, however, that there is a biological limit of that kind of improvement of production animals traits (Roberts 1966, Wilson et al. 1971, Al-Murani 1974, Orozco 1979). It is considered that in some domestic animals, such as fowl, for example, the achieved selection limit of some useful traits is so high, that gains from further selection progress are unprofitable not only from the economic but also biological point of view (Clayton 1972, Nordskog 1975). Selection for one trait also leads to changes, not always positive in other traits as a result of their genetic correlation. The relationship between selection for a high and low body weight and changes in reproduction was pointed out by many authors (Legates 1969,

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Baker, Chapman 1975, Eisen 1975). It was also found that selected animals distinguish by a lower activity of some enzymes in comparison with unselected animals (Kownacki et al. 1976). Hens of lines selected for a high body weight display not only a lower fertility and hatchability of eggs, but an increase in chromosomal aberrations (Reddy, Siegel 1977).

Spontaneous chromosome aberrations in birds are encountered quite frequently. Their harmful effect is a decrease of hatchability of fertilized eggs. Particularly different kinds of heteroploid states are responsible for the embryo death at the initial and final periods of incubation (Bloom 1969, 1974, Miller et al. 1971, Smith 1974).

The purpose of the present studies was to determine the frequency of chromosomal abnormalities in quails selected for a high and low body weight as well as in populations not selected for that trait.

MATERIAL AND METHODS

Material for the studies were embryos of two quail lines selected for a high and low body weight at the 3rd week of life. The control group was presented by Japanese quails of the "Standard" type, not selected for that trait. The studied material originated from the farm of the Fowl Genetics Laboratory of the Institute of Genetics and Animal Breeding in Jastrzębiec. In the line selected for a high body weight the studies covered F_4 and F_5 generations, and in the line selected for a low body weight — F_9 and F_{10} generations. The mean body weight of birds at the 5th week of life in the studied generations was 138 and 143 g, respectively in males and females in the line of quails selected for a high body weight, and 72 and 76 g in the line selected for a low body weight, whereas in the control group it was 89 and 96 g. The parental flock in the selected lines consisted of 35 males and 70 females. One male was mated with two females, avoiding relationship. Eggs for the studies were collected each day without storing them at lower temperatures. Incubation lasted for 16 - 18 hours at 38°C. Then, isolated embryonic discs were incubated for 3 hours in the Parker medium added with colchicine at 37.5°C. The tissue material and chromosome preparations were performed according to the method of Zartman,

Table 1. The number and percentage of embryos with chromosome aberrations in the studied groups of quails

Group	Number of studied embryos	Embryos with chromosome aberrations	
		number	percentage
Quails selected for high body weight	376	20	5.31*
Quails selected for low body weight	250	9	3.60
Control group	297	4	1.34*

* $P \leqslant 0.01$

Jaszczak (1980). The karyotype of each embryo was determined only on the basis of the longest 5 autosome pairs and 1 pair of sex chromosomes. Microchromosomes in view of their difficult identification were not taken into consideration in the analysis. At least 10 metaphases were analysed for each embryo. Differences between the studied groups were estimated by the *Chi*-square test.

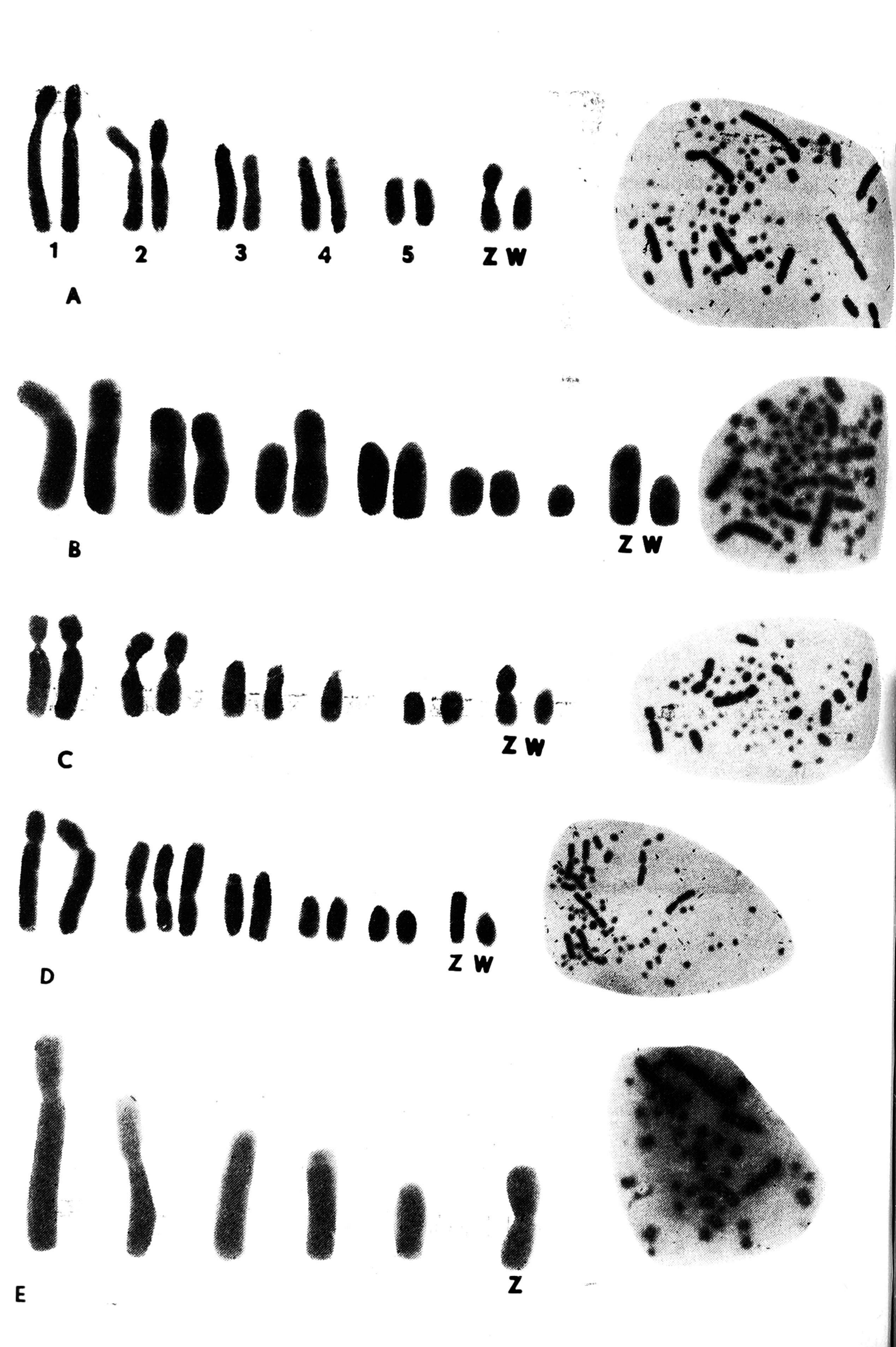
RESULTS AND DISCUSSION

Results of the karyotype analysis of three studied groups of quails are given in Table 1. It was found that 20 individuals in the group of 376 studied embryos from the quail line selected for a high body weight have abnormal karyotype, which constitutes 5.31% of the studied embryos in that group. In the line selected for a low body weight, 9 individuals in the group of 250 examined embryos were found to have chromosomal aberrations, which made 3.6%. In the third group of quails, not selected for the body weight, only 4 (1.34%) out 297 embryos analysed cytogenetically had abnormal karyotype. Difference in the number of chromosomal aberrations was statistically significant only between the embryo group of the line selected for a high body weight and the control ($P \leqslant 0.01$). A similar kind of dependence between chro-

Table 2. Kind of aberrations in embryos and the number of embryos with definite aberrations in the studied groups of quails

Group	Kind of aberrations		Number of embryos with aberrations
Quails selected for a high body weight	Monosomy	2A, *ZZ*, −4	2
	Trisomy	2A, *ZZ*, +2	1
	Triploidy	3A, *ZZW*	4
		3A, *ZZZ*	2
		3A, *ZWW*	1
	Mosaicism	2A, *ZW*/4A, *ZZWW*	1
	Chimerism	2A, *ZW*/1A, *Z*	2
		2A, *ZZ*/2A *ZW*	2
	Translocation	2A, *ZW*, t/3; 6/	5
Quails selected for a low body weight	Haploidy	1A, *Z*	2
	Monosomy	2A, *ZW*, −3	2
	Chimerism	2A, *ZW*/1A, *W*	2
		2A, *ZW*/2A, *ZZ*	2
	Mosaicism	2A, *ZW*/4A, *ZZWW*	1
Control group	Triploidy	3A, *ZZZ*	1
		3A, *ZZW*	1
	Haploidy	1A, *Z*	1
	Mosaicism	1A, *Z*/2A, *ZZ*/3A, *ZZZ*	1

A — complex of somatic chromosomes
Z and *W* — sex chromosomes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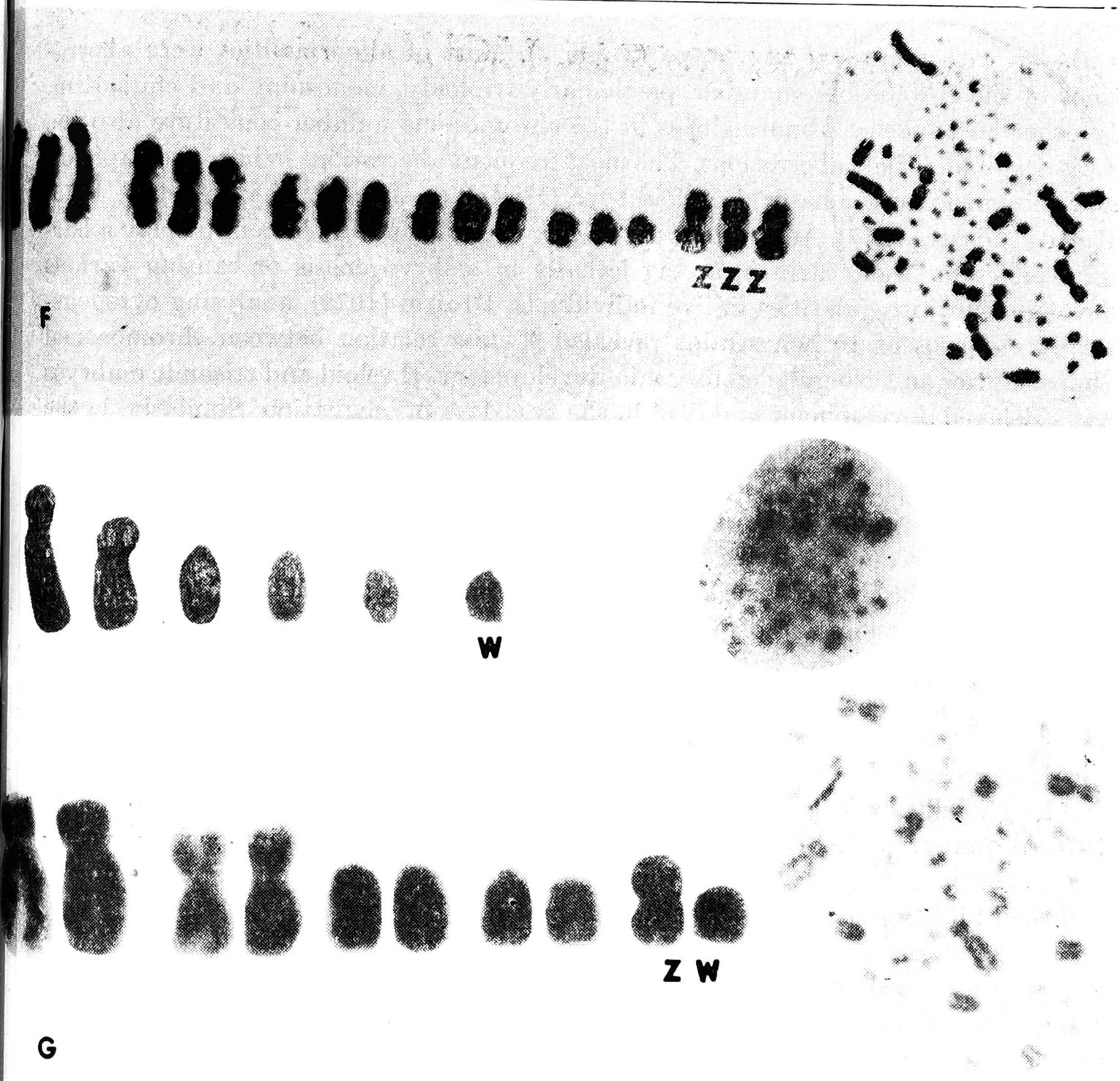

Fig. 1. Karyotypes of selected quail embryos (the photographs show a karyogram consisting os the longest 5 pairs of the autosome complex — A and of the sex chromosome Z and W, as well af a metaphase plate)

A — An embryo with the normal karyotype (2A, ZW), B — An embryo with autosome translocation (2A, ZW, t/3.6), C — A monosomic embryo (2A, ZW, —4), D — A trisomic embryo (2A, ZW, +2), E — Haploid embryo (1A, Z), F — triploid embryo (3A, ZZZ), G — A chimera embryo with diploid and haploid cell lines (2A, ZW/1A, W)

mosomal abnormalities and selection for a rapid growth and body weight was found in hens (Miller et al. 1971, Reddy, Siegel 1977). The level of chromosomal aberrations in the analysed lines of hens was much higher than in the case of the studied quail lines. These differences may result from the intensity of selection and from the number of generations. In hens there occurs also a large variation in the frequency of chromosomal aberrations resulting from genetic differences of the studied strains (Bloom 1974).

Totally 7 different kinds of chromosomal aberrations were revealed among 33

embryos with abnormal karyotype (Table 2). Most of abnormalities were aberrations of the chromosome number, particularly triploidy, monosomy and chimerism. In other bird species, abnormalities in the chromosome number constitute also the majority of identified aberrations. The most frequent aberrations in hens are haploidy and chimerism of the haploid-diploid type (Miller et al. 1971, Snyder et al. 1975, Reddy, Siegel 1977). Aberrations of the chromosome number in hens display a harmful effect for their carriers, acting lethally in embryogenesis or causing various developmental irregularities in live individuals. Bloom (1972), analysing cytogenetically embryos of 10 hen strains revealed a close relation between chromosomal abnormalities and irregular embryonic development. Haploid and trisomic embryos has a delayed development and died in the first days of incubation. Similarly, in the case of triploid embryos, 90% of them died before the 4th day of incubation. On the other hand, born triploid chickens are characterized by a number of developmental defects and are infertile (Donner et al. 1969, Abdel Hamed, Shoffner 1971).

In the line of quails selected for a high body weight 5 embryos were found to have aberrations of the chromosome structure. These aberrations in all the cases concerned chromosome translocation of pair 3 with one of the microchromosomes.

Relatively rare in fowl were spontaneous chromosomal translocations (Ryan, Bernier 1968, Jaszczak, Zartman 1979). Most of the described chromosome mutations of translocation type were induced by X-rays or chemical mutagens (Zartman 1971, Shoffner 1972, Wooster et al. 1977). A negative mutation effect on fertilization and hatchability was thoroughly studied in chicken (Zartman 1971, Tellani et al. 1976, Wooster et al. 1977). A decreased laying of fertilized eggs in hens of translocation heterozygotes is a result of formation of chromosomally unbalanced embryos and their higher mortality (Blazak, Fechheimer 1979, 1981).

In the studied groups of quails, the hatchability of eggs was lower in those groups, which had a higher percent of chromosomal abnormalities, the lowest hatching from set eggs (53.6%) was in quails selected for a low body weight. A somewhat higher hatching was in quails selected for a high body weight — 58.5%. For comparison, the per cent of hatching from set eggs in the group of quails not selected for the body weight was 75.9.

The sex ratio of the studied groups of quail embryos showed no statistically significant deviations. It was found that embryos with the sex chromosomes *ZZ* were slightly predominant in the group of quails selected for a low body weight and in the control group (53.5% and 51.1%, respectively). On the other hand, the group of embryos from the line selected for a high body weight was found to have a nearly equal sex distribution — 49.5% *ZZ* and 50.5% with the sex chromosomes *ZW*.

Differences in the number of karyotypically abnormal embryos between the studied lines would indicate that with selection for the body weight the frequency of chromosomal aberrations increases in their progeny.

For a complete confirmation of this hypothesis it is necessary to perform a secondary cytogenetic analysis in further generations of selected quail lines. Nevertheless, the obtained results concerning the frequency of chromosomal aberrations in the embryos of quails selected for the body weight, through not too high with regard

to per cent, support data obtained on other experimental material (domestic chicken), that in birds, together with selection for the body weight there occurs a tendency towards the increase of chromosomal abnormalities. In view of a harmful effect of these abnormalities in reproduction it is reasonable to test cytogenetically the flocks, in which intensive selection for a high body weight was performed to eliminate carriers of chromosomal aberrations, as well as individuals having genetic predisposition to their production, from a population.

CONCLUSIONS

1. Cytogenetically studied lines of quails selected for a high and low body weight were found to have the highest per cent of embryos with chromosomal abnormalities in the lines selected for a high body weight (5.31%). In the line selected for a low body weight 3.6% of the embryos had abnormal karyotype, whereas in the control group — 1.34% of the embryos.

2. Totally 7 different kinds of aberrations, of which triploidy and chimerism were most frequent, were identified in the group of 33 embryos with abnormal karyotype.

3. The obtained results indicate that selection for the body weight in quails also leads to an increase of chromosomal aberrations in embryos, which may be the cause of lower hatchability of fertile eggs. For that reason selected bird stocks should be cytogenetically tested each time throughout several generations with the aim to eliminate parents predisposed to production of karyotypically abnormal embryos.

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NIENORMALNOŚCI CHROMOSOMOWE U PRZEPIÓREK SELEKCJONOWANYCH NA WYSOKĄ I NISKĄ MASĘ CIAŁA

Streszczenie

Badano częstość występowania nienormalności chromosomowych u przepiórek selekcjonowanych na wysoką i niską masę ciała. Grupę kontrolną stanowiły przepiórki japońskie typu Standard hodowane bez selekcji na masę ciała. Kariotypy oceniano w komórkach tarczek zarodkowych po upływie 16 - 18 godz. inkubacji. Pobierano je od osobników czwartego i piątego pokolenia linii selekcjonowanej na wysoką masę ciała i z dziewiątego i dziesiątego pokolenia selekcjonowanej na niską masę ciała. Ogółem przebadano 923 zarodki. Najwyższy procent — 5,31 zarodków z nieprawidłowym kariotypem stwierdzono w linii selekcjonowanej na wysoką masę

ciała. W linii selekcjonowanej na niską masę ciała nienormalny kariotyp miało natomiast 3,6% zarodków, a w grupie kontrolnej 1,43%. Wśród zarodków z nieprawidłowym kariotypem zanotowano 7 rodzajów aberracji chromosomowych. Otrzymane wyniki w badanych grupach przepiórek wskazują, że selekcja na masę ciała powoduje wzrost nienormalności chromosomowych u zarodków. W dyskusji wskazano na rolę tych nienormalności w reprodukcji jak i na celowość prowadzenia badań cytogenetycznych w stadach ptaków intensywnie selekcjonowanych na masę ciała. Pozwoliłoby to na wyeliminowanie z populacji rodziców osobników — nosicieli aberracji chromosomowych jak i mających genetyczne predyspozycje do ich przekazywania potomstwu.

ХРОМОСОМНЫЕ АНОМАЛИИ У КУРОПАТОК СЕЛЕКТИРОВАННЫХ НА ВЫСОКУЮ И НИЗКУЮ МАССУ ТЕЛА

Резюме

В настоящей работе исследовалась частота появления хромосомных аномалий у куропаток, селектированных на высокую и низкую массу тела. Контрольную группу составляли японские куропатки типа „Стандарт", выращиваемые без селекции на массу тела. Кариотипы оценивались в клетках зародышевых дисков по 16 - 18-часовой инкубации. Брались они от особей 4-го и 5-го поколений линии, селектированной на высокую массу тела, и от особей 9-го и 10 поколений, селектированных на низкую массу тела. Всего было исследовано 923 зародыша. Наивысший процент — 5,31 зародыша с неправильным кариотипом обнаружен в линии, селектированной на высокую массу тела. В линии, селектированной на низкую массу тела, ненормальный кариотип имело 3,6% зародышей, а в контрольной группе — 1,43%. Среди зародышей с неправильным кариотипом обнаружено 7 видов хромосомных аберраций. Результаты, полученные в исследуемых группах куропаток, показывают, что селекции на массу тела вызывает рост хромосомных аномалий у зародышей. В дискуссии указывается на роль этих аномалий в репродукции, а также на важность проведения цитогенетических исследований в стадах птиц, интенсивно селектированных на массу тела. Это позволило бы устранить из популяции родителей особи, являющиеся носителями хромосомных аберраций и имеющих предиспозиции к передаче этих аберраций потомству.