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LIFE DURATION OF INBRED AND OUTBREED RABBITS, IRRADIATED WITH GAMMA RAYS

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Abstract

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The life expectancy of inbred and outbreed rabbits irradiated with gamma rays at a dose 4 Gy has been studied. It was found that the average life duration of inbred groups is less than that of the outbreed animals, as the differences were statistically significant. It was viewed that the animal produced from inbred strains and inbred lines are at risk from the harmful effects of environmental factors (specific gamma-radiation) compared to heterozygous hybrids and animals from populations with high heterogeneity.

Key words: life duration, gamma rays, inbreeding, outbreeding, homogenic animals, heterogenic animals, rabbits

Introduction

Ionizing radiation including gamma radiation is characterized by high biological activity. When interacting with living cells, it causes ionization of different chemical compounds and bio substrates, which leads to complex reactions and processes in the cells and tissues (Auerbach, 1976).

A large amount of research in this area focus on the harmful effects of gamma radiation on the genetic structure and biochemical and physiological processes in various species and humans (Georgiev et al., 1996; Georgieva and Georgiev, 2003; Ginsberg, 2003; Carnes et al., 2003; Georgiev et al., 2005; Tanchev et al., 2004; Georgieva et al., 2005a; Georgieva et al., 2005b; Tanchev et al., 2005; Popov et al., 2007; Sasaki and Fukuda, 2008).

Other scientists have turned their attention to research opportunities for positive and stimulating effects of low doses of gamma rays on the physiological condition and life expectancy of the studied biological objects (Thomson et al., 1986; Thomson and Grahn, 1989; Furuno - Fukushi et al., 1993; Hsie et al., 1996; Calabrese and Baldwin, 2000; Parsons, 2002; Cameron, 2003; Tanaka et al., 2003; Cameron, 2005; Kumar et al., 2006; Mitchel, 2006; Ito et al., 2007; Le Bourg, 2007; Moskalev, 2007; Tanaka et al., 2007; Aloy et al., 2008; Moskalev, 2008).

Few studies have been devoted to the effects of gamma rays on life duration of different species - representatives of heterogeneous and homogeneous populations (Moskalev and Zainullin, 2006; Sasaki and Fukuda, 2006; Moskalev, 2008).

This study is a result of our other study, where we did comparative chromosome analysis in inbred and outbreed rabbits irradiated with gamma rays (Tanchev et al., 2006). Subsequently raised the idea to investigate the influence of the factors genotype /homozygous and heterozygous/ and inbreeding on survival of irradiated with gamma rays rabbit has become a major objective of the present study.

Materials and Methods

Twenty four female rabbits, aged 8 to 12 months were allocated into two main groups: Group I – 12 rabbits irradiated with gamma rays and Group II – 12 rabbits – sham irradiated

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(control) group. First group was divided into two subgroups – 6 inbred rabbits (Fx = 0.25) and 6 outbreed rabbits. Additionally, depending on the origin and the degree of inbreeding these subgroups were divided as follows:

- 3 homogeneous outbreed rabbits representatives of genetic consolidated breed California rabbit;
- 3 homogeneous inbred rabbits representatives of the same breed;
- 3 heterogeneous outbreed rabbits – hybrid forms produced by crossing the breeds Californian rabbit and chinchilla;
- 3 heterogeneous inbred rabbits with the same hybrid origin.

In the second (control) group, rabbits were allocated in the same manner as in Group I. The degree of inbreeding was considered by the classic method of Wright (Wright, 1937).

Rabbits of Group I were exposed to a single whole body irradiation with gamma rays at a dose of 4 Gy, at a dose rate 24 Gy/min with a source of radiation ^{60}Co. Exposure was calculated according to the geometry parameters of the power source, its distance and capacity.

The experimental protocol was approved by the Department of Animal Care and adhered to the European Community Guiding Principles for the Care and Use of Animals. During the study, all rabbits were raised under identical conditions of feeding and rearing. The life duration after irradiation with gamma rays was calculated in days.

Data from observations of irradiated animals was processed by analysis of variance. During the processing, we used additive model with fixed effects – ANOVA. The mean values for days of life duration in rabbits and Standard Deviation were calculated by Descriptive Statistics and for evaluation of the P-values was used ANOVA Single Factor (MS Excel 7.0). Statistically significant effects of the studied factors were reported with the critical level $P < 0.05$.

Results and Discussion

The analysis of the influence of the studied factors on survival of rabbits after irradiation with gamma rays (4Gy) are presented in Table 1. Statistically significant impact on life expectancy of female rabbits have both the studied factors separately.

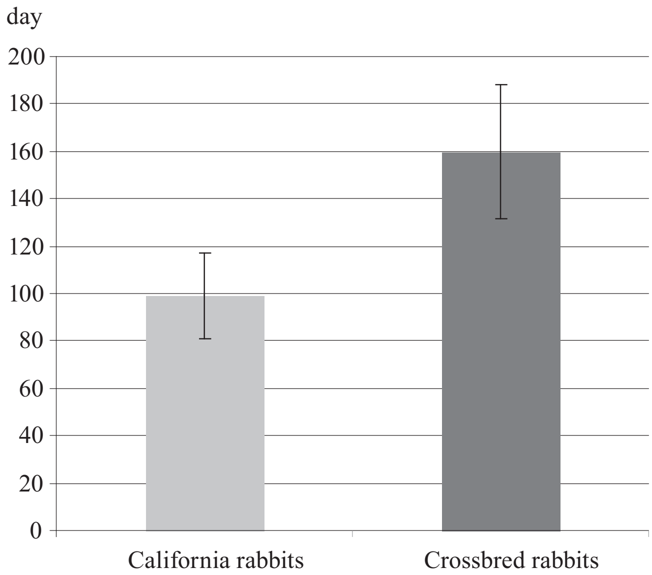

Fig. 1. Life duration of rabbits after irradiation with gamma rays at a dose of 4 Gy, depending on the origin. Identical letters mark statistically significant differences (P = 0.001)

Figure 1 shows the life expectancy of rabbits after irradiation, according to the origin. Heterogeneous animals statistically significantly outperform their homogeneous coevals. Most likely this is the result of retained heterosis effects in crosses in terms of resistance to gamma radiation.

Figure 2 presents the average life duration of rabbits after irradiation with a dose of 4 Gy, depending on the inbred level. Outbreed rabbits statistically significantly outperform their inbred coevals in life duration. This is confirmed by the fact that 90 days after irradiation homogeneous inbred rabbits are losing 20–25% of their live weight, while in heterogeneous inbred rabbits that loss is in the range of 5–10% (Figures 4 and 5). Increasing the level of homozygous inbreeding leads to increased sensitivity to negative effects of various environmental factors in our case – gamma rays, the most likely cause for the observed results, depending on inbred level /Fx/.

Although we found no statistically significant effect of the combination of the two factors examined (Table 1), the

Table 1
Influence of origin and level of inbreeding on survival of rabbits irradiated with gamma rays at a dose of 4 Gy

Factors of influence	df Effect	MS Effect	df Error	MS Error	F	p-level
Breed	1*	10266.75*	8*	118.4684*	86.4684*	0.000015*
Level of inbreeding	1*	6120.08*	8*	118.7500*	51.53754*	0.000094*
Both together	1	310.08	8	118.75	2.61123	0.144772

*statistical significance

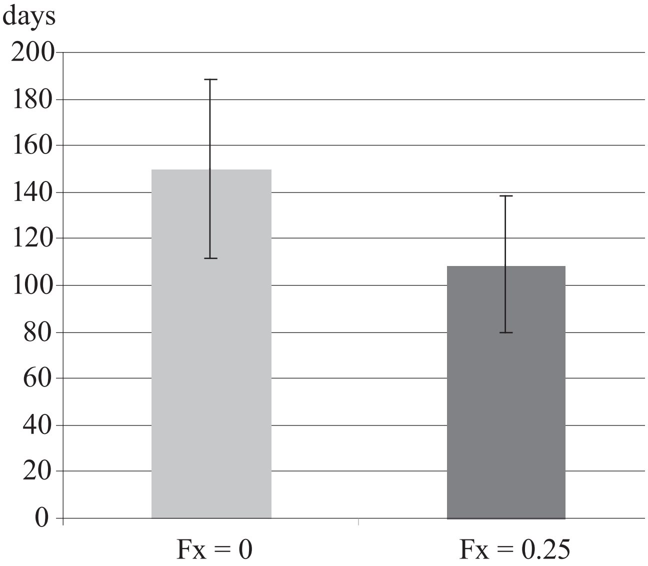

Fig. 2. Life expectancy of rabbits after irradiation with gamma rays at a dose of 4 Gy, depending on the inbreed level. Identical letters mark statistically significant differences (P = 0.064)

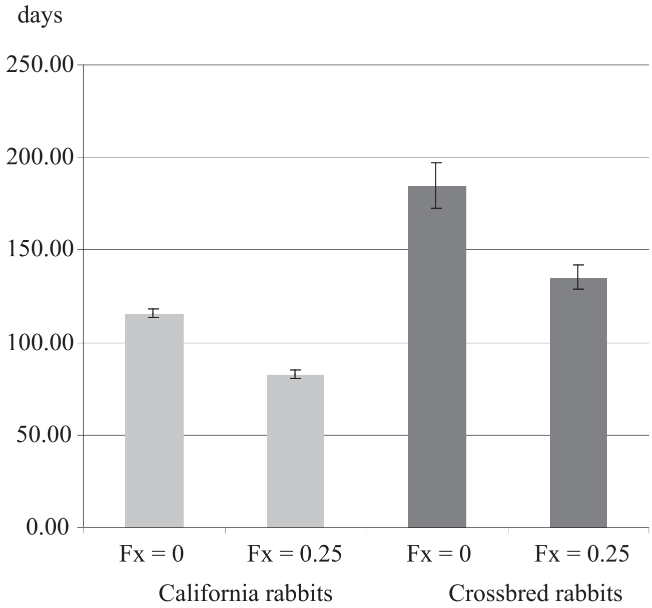

Fig. 3. Life expectancy of rabbits after irradiation with gamma rays at a dose of 4 Gy by origin and inbred level. Identical letters mark statistically significant differences (P = 0.000)

results of multiple comparisons between groups showed statistically significant superiority of outbreed compared to inbred rabbits (Figure 3). This confirms once again the above-mentioned findings that generally heterogeneous rabbits have higher adaptive capacity to ionizing radiation, which determines the longer life duration after irradiation with gamma rays compared to homogeneous group of rabbits. Body conditions of homogeneous and heterogeneous female rabbits after irradiation are presented in Figures 4 and 5.

The results of the research in this area are ambivalent. Some authors state that chronic exposure of biological objects with low doses of gamma rays increases the life duration (Calabrese and Baldwin, 2000; Parsons, 2002; Moskalev, 2008; Moskalev et al., 2009). Most researchers, however, contend that irradiation with gamma rays with both high and low doses adversely affects the life duration of irradiated organisms and cell populations (Thomson et al., 1986; Thomson et al., 1989; Furuno – Fukushi et al., 1993; Hsie et al., 1996; Tanaka et al., 2003; Kumar et al., 2006; Sasaki and Fukuda, 2006; Tanaka et al., 2007).

Our results show that the characteristics of individuals identified by the degree of inbreeding and origin are essential for the reactivity of the organism, its adaptability and consequently its survival in changing environmental conditions. Heterogeneous organisms are more adaptable and more resistant to environmental factors, while homogeneous individuals that arise through inbreeding are unstable and

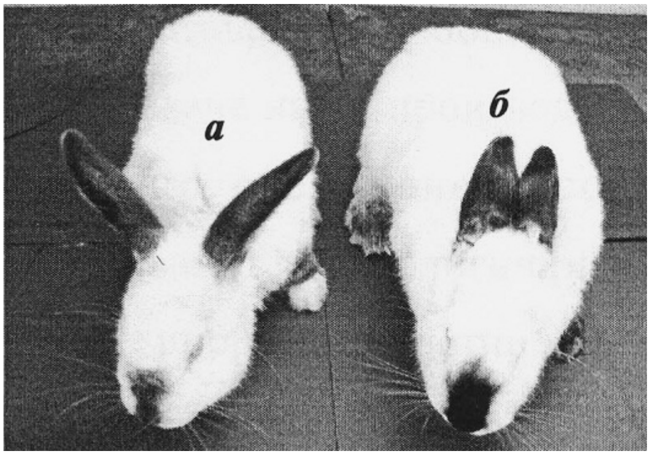

Fig. 4. Body condition of homogeneous female rabbits / California/ 90 days after irradiation with gamma rays at a dose of 4 Gy: a (Fx = 0.25), b (Fx = 0)

threatened by rapid and massive death. This is especially important for species and productive populations of laboratory animals where intensive selection in one or more directions and implementation of inbreeding in order to reinforce certain skills lead to higher homozygosity and high genetic similarity. Such inbred lines are used in livestock. Due to the high homozygosity achieved during intensive selection

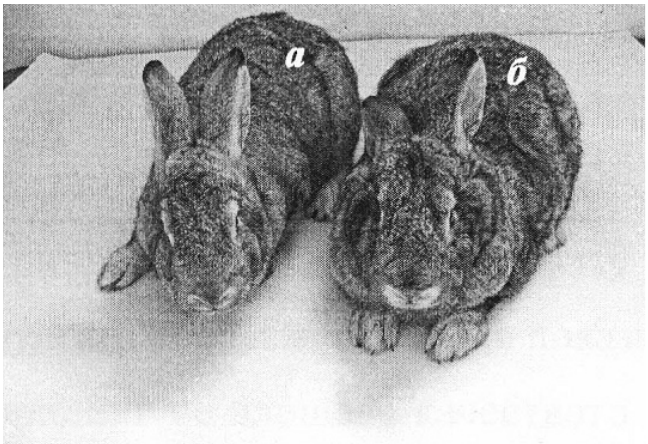

Fig. 5. Body condition of heterogeneous female rabbits /hybrid forms/ 90 days after irradiation with gamma rays at a dose of 4 Gy: a (Fx = 0.25), b (Fx = 0)

and inbreeding, individual representatives of the line will respond similarly to environmental factors. If the influence of these negatively factors arise there is danger of losing a large percentage of individuals and even the whole inbred line.

In a study of the life duration of isogenic and heterogeneous lines drosophila (wild-type) chronically exposed for 14 consecutive generations of low-dose gamma rays – 60 cGy (Moskalev and Zainullin, 2006) reported results that differ from our results. Their research showed that the life duration of the irradiated drosophila isogenic lines increased compared to non-irradiated isogenic control groups and heterogeneous line. The reason according to the authors was the increasing level of genetic heterogeneity effects induced by gamma rays in the isogenic line.

Despite the differences between the results of Moskalev and Zainullin with our results, we believe that there is a contradiction in our opinion. According to us, the main reason is the difference in the performance in the experiment and probably species-specific difference in response after irradiation with gamma rays (insects and mammals). On the other hand, the study of the Russian scientists on *Drosophila melanogaster* involves exposure to low doses of gamma rays for many generations, in which natural selection results in the preservation of those genotypes in isogenic populations providing the best adaptive qualities and best adaptability to specific environmental conditions.

This natural selection leads to strong reduction of genetic diversity and reduced variability of the quantities characterizing a sign. Opposite, the highest heterozygosity in heterogeneous populations determines large differences in the reaction of the various genotypes to gamma rays. This defines a large range of variation of a feature in heterogeneity populations, which is observed after the first hybrid generation.

In another review article, Moskalev (2008) notes that reducing the life duration of organisms irradiated with ionizing radiation is due to stress-induced premature aging of cells and increase - the stress-induced activation of transcription factor (FOXO). According to the author such a positive activation under the influence of low doses of radiation over a number of successive generations leads to a reduction of the harmful effects of depression in inbred populations of laboratory animals.

In our study, we monitored the reaction of rabbits after a single exposure to a significantly higher dose of gamma rays (4 Gy) and made a comparative analysis of the life of the irradiated inbred and outbreed individuals. Results and statistically found significant differences are in favor of the outbreed groups, primarily heterogeneous hybrid rabbits. This allows us to conclude that the probability of homogeneous populations – product of inbreeding to be at risk from the harmful effects of environmental factors is significantly greater than heterogeneous populations.

Without exploring the influence of ionizing radiation Lacy et al. (1996); Tanchev et al. (2006); Georgieva et al. (2012), noted that along with the negative impact on reproductive performance of animals increased inbreeding and homozygosity negatively affects the vitality and adaptive abilities.

By applying advanced mathematical models for accounting the fixed effects and integrated assessment of productivity, including lifetime productivity of inbred rabbits and pigs to similar conclusions came Poujardieu and Toure (1980); Farghaly (2000).

Conclusion

The results of this study show that after a single exposure to gamma rays (4 Gy) inbred rabbits have a shorter life duration than their outbreed coevals. This allows us to assume that animal product of inbreeding, respectively herds and highly inbred lines are at higher risk from harmful effects of environmental factors, specifically gamma rays, compared with heterozygous female hybrids and animals from populations with high heterogeneity.

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