Study of vertebrate animal's heredity under radioactive contamination

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Abstract. The paper describes the results of cytogenetic analysis of vertebrates for 2013-2015. To study the effect of radioactive contamination on the heredity of vertebrates, a cytogenetic analysis of some vertebrates living near radon sources in Jeti-Ögüz district of Issyk-Kul region was carried out.
Keywords: karyotype, chromosomes, mutations, physical environmental factors

1 Introduction

In Kyrgyzstan, uranium tailings and dumps are of particular concern; they are not reinforced with technical structures, are located near populated areas and pose a certain danger to the population and wild and farm animals living in these places. Tailings are destroyed by precipitation and landslides, radioactive substances get into water and soil, and along with this, the possibility of contact between biological objects and radioactive substances increases. Expansion of contacts of the population and all living things with ionizing radiation makes it relevant to study the biological effects of radiation, especially of its low doses which include radiation levels one to two orders of magnitude higher than the natural background [1-5].

In addition to tailings dams on the territory of Kyrgyzstan in Jeti-Ögüz, there are areas of increased radioactivity due to a number of uranium deposits which, when destroyed, form radon – the radioactive gas contained in the sources [6].

Therefore, the study of heredity in natural populations of various organisms exposed to radioactive contamination and chemical pollution will allow identifying the mechanisms of genetic adaptation of populations and developing methods for predicting the genetic consequences of the effects that ionizing radiation and chemicals as a mutagenic factor have on natural communities of the environment – in this regard, the work is relevant.

Purpose of the study: analyze the effect of radioactive contamination on the heredity of vertebrates.

2 Materials and methods

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The authors conducted a cytogenetic analysis of vertebrates caught in Jeti-Ögüz district of Issyk-Kul region in 2013-2015. At least 30 chromosome preparations from each species were obtained using the standard method by Ford and Hamerton (1956) from bone marrow with preliminary colchicization and hypotonic treatment. The preparations were stained with azure eosin (Romanowsky staining). Chromosomal preparations were analyzed under an MBI-11 microscope (objective 90, eyepiece 7^x and 10^x). Metaphase plates were photographed with a Canon Power Shot S5IS digital camera with a special attachment, and karyograms were compiled for final identification of chromosomes [7].

3 Results

Jeti-Ögüz waters are a source of groundwater discharge in the eastern part of Issyk-Kul artesian basin. The radon content in the thermal waters of Jeti-Ögüz resort reaches 120-1320 eman, that of uranium 3.2 10^{-7} – 1.0 10^{-6} g/l and that of radium 2.26 10^{-6} – 6.11 10^{-6} g/l [8].

Water from radon sources constantly flows into the Jeti-Ögüz River, making its level higher in such places. The strong current mainly carries pollutants away, and further from the radon source area, the water is cleaner, but the river floodplains have swampy areas where pollutants can settle, and the radon content increases accordingly.

Rana ridibunda Pallas is one of the most common species of amphibians in Kyrgyzstan. The marsh frog is found in intermountain valleys and depressions, and is localized near springs and in swampy areas at the altitude of 650-2200 m above sea level [9].

For cytogenetic analysis, the marsh frog was caught near the village of Chyrak, where the Jeti-Ögüz River flows into Lake Issyk-Kul.

The authors studied the karyotype of the marsh frog of the Jeti-Ögüz population. The diploid number of chromosomes is 2n = 26, the number of arms is NF = 52. There are 5 pairs of large and 8 pairs of small chromosomes, of which 3 pairs are metacentric, 6 pairs are submetacentric and 4 pairs are subtelocentric. However, in the 1st pair of large metacentric chromosomes, secondary constrictions were found, and in the 2nd pair of small subtelocentric chromosomes, a chromosome break was found (Fig. 1).

Based on the data obtained, it can be assumed that in marsh frogs, the high background radiation of radon waters contributed to a peculiar change in the chromosome structure in ontogenetic development [10, 11].

Chromosomal aberrations (rearrangements) are a classic manifestation of radiation damage to cells; they were discovered at the very beginning of radiobiological research, and their number corresponds to the radiation dose used in biological dosimetry. The emergence of aberrations reflects the formation of breaks in the DNA molecule, and its reparation defects; breaks lead to chromosome fragmentation.

The steppe rat snake (*Elaphe dione*) belongs to the genus of climbing snakes. In Kyrgyzstan, it is widespread in river valleys, on plains and in foothills, mainly near water – a very diverse habitat [12].

The diploid set of chromosomes is 2n = 36, the number of arms NF = 56. In the karyotype, 8 pairs of macrochromosomes and 10 pairs of microchromosomes are clearly distinguished. Of these, 6 pairs are metacentric, 3 pairs are submetacentric, 1 pair is subtelocentric and 10 pairs are acrocentric chromosomes. The study showed that the 1st pair of large metacentric chromosomes clearly has secondary constrictions – dicentric figures (Fig. 2).

Aneuploidy and secondary constrictions were discovered in the previously studied Osh and Dzhumgal populations, in the vicinity of the urban settlement of Kara-Balta. The authors associate such changes with radioactive contamination [13, 14].

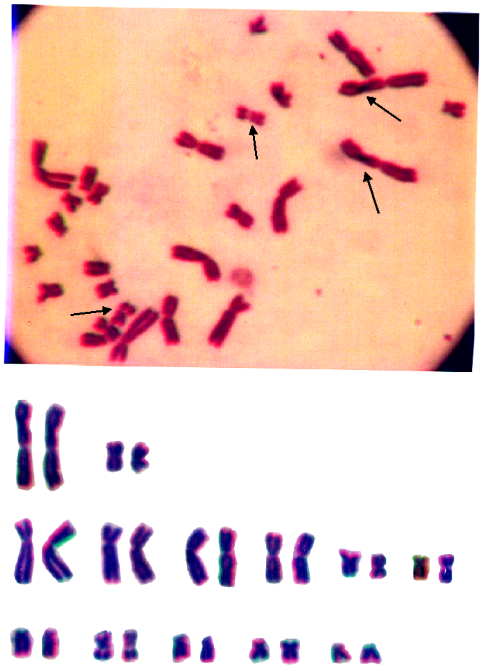

Fig. 1. Metaphase plate and karyogram of the marsh frog (R.ridibunda Pallas) of the Jeti-Ögüz population

Fig. 2. Metaphase plate and karyogram of the steppe rat snake (E.dione Pallas) of the Jeti-Ögüz population

The multi-ocellated racerunner (*Eremias multiocellata*) is widely distributed in Kyrgyzstan on mountain slopes at the altitude of 1400-4000 m above sea level. Its habitat is desertified and steppe mountain slopes and intermountain valleys [12].

The diploid number of chromosomes is 2n=38, the number of arms is NF=38. All the chromosomes are acrocentric, smoothly decreasing in size. No quantitative or morphological changes were found in the karotype (Fig. 3).

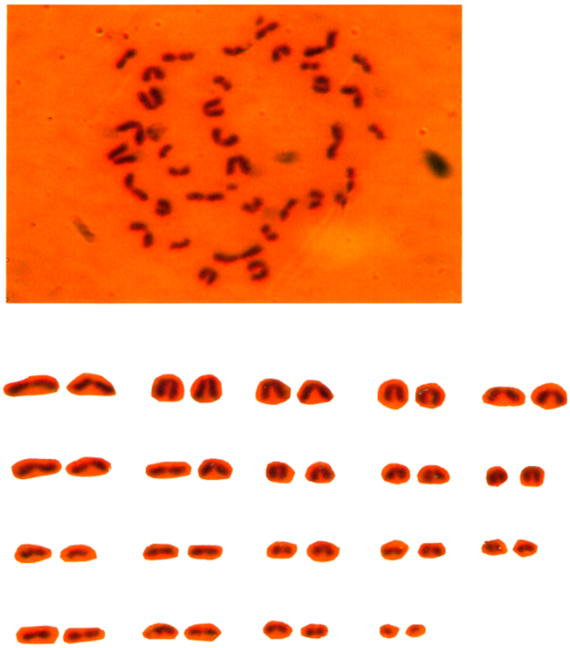

Fig. 3. Metaphase plate and karyogram of the multi-ocellated racerunner (E.multiocellata Gunther)

The relict ground squirrel (*Spermophilus relictus*) is distributed in the Issyk-Kul basin from east to west. It is found in the fescue semi-desert but also inhabits low-mountain fescue-feather grass steppes and high-mountain steppes with feather grass and cereal-forb vegetation of the alpine belt, at the altitude of 3000 m and more [15].

Specimen of the relict ground squirrel were caught in the coastal zones of the the Jeti-Ögüz River and in the forestry area. The ground squirrels do not penetrate deep into the gorge, sticking to open and dry places in its foothill zone instead, usually building holes near water. Ground squirrels live where the current of the the Jeti-Ögüz River is strong.

The diploid set of chromosomes is 2n=36, the number of arms is NF=72. In the karyotype, 4 pairs in the 1st row of chromosomes are metacentric, 6 pairs in the 2nd row are submetacentric, 7 pairs in the 3rd row are subtelocentric chromosomes, and sex chromosomes consist of one large submetacentric X chromosome and a smaller submetacentric X chromosome (Fig. 4).

Morphological changes or structural destruction of chromosomes are not observed, but one of the 5th pair of subtelocentric chromosomes has a small break. Unlike other studied populations, 6 pairs of chromosomes are closer to subtelocentric than submetacentric. In previously studied populations, chromosomal changes were observed in the Toktogul population – a heteroploid set of chromosomes was revealed, clearly due to the high seismicity of the region where ground squirrels live (25).

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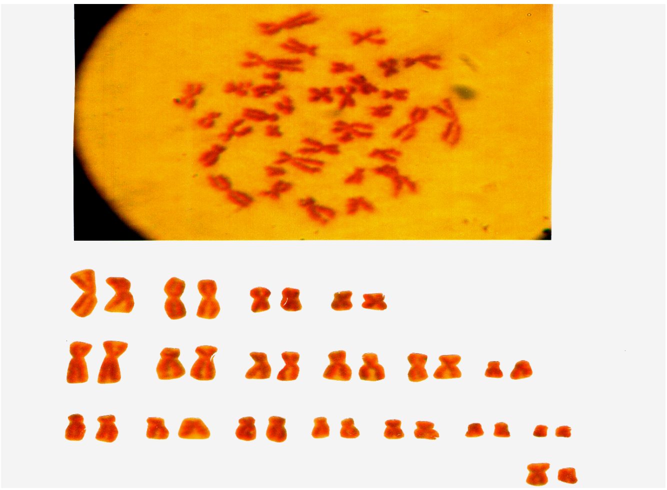

Fig. 4. Metaphase plate and karyogram of the relict ground squirrel (S.relictus Kaschkarov) of the Jeti-Ögüz population

4 Conclusion

The obtained data on cytogenetic analysis show that the marsh frog from the amphibian class caught near the radon sources of the Jeti-Ögüz region has significant mutations in the chromosome sets, expressed chromosome breaks and secondary constrictions, but the number of chromosomes remains unchanged. Dicentric figures were found in the chromosome sets of the steppe rat snake, but the number of chromosomes remains unchanged.

We associate this phenomenon, manifested in structural change in chromosomes, with the habitation of the frog and the snake in places with increased radiation due to radon sources.

When radionuclides enter the body of animals, they cause mutations, changing heredity and damaging chromosomes; this is expressed in the emergence of dicentric figures, arms breaks and translocation mutations.

References

1. V.V. Kovalskii, et al., Proc. Biogeochem. Lab. USSR Acad. Sci. **12**, 5-122 (1968)
2. I. A. Torgoev, V. P. Charskii, Ecological consequences of radioactive ore mining in Kyrgyzstan (Ilim, Bishkek, 1998)
3. N. I. Kataeva, Z. I. Melnikova, Underground mineral waters of the Kyrgyz SSR (Frunze, 1969)
4. A. M. Kuzmin, Natural radioactive background and its significance for the Earth's biosphere (Nauka, Moscow, 1991)
5. S. G. Neruchaev, Uranium in the life and history of the Earth (Nedra, Leningrad, 1982)
6. V. N. Vasilyeva, *Features of the formation of Jeti-Ögüz thermal waters*, in Problems of the formation and distribution of mineral waters of the USSR (Nedra, Moscow, 1960)
7. C. E. Ford, J. L. Hamerton, Stain Tech. **31**, 247-351 (1956)

8. Yu. P. Bulashevich, et al., Geochem. **54**, 490-496 (1976)
9. A.T. Toktosunov, V.I. Portnyagina, Iss. Biol. Fac. KSU **12**, 20-25 (1971)
10. T. A. Toktosunov, The *influence of radon waters on amphibian karyotypes*, in The influence of environmental factors on the organism (1997), pp. 223-226
11. A. T. Toktosunov, T. A. Toktosunov, Ecological cytogenetics of Tian Shan animals. Part 2 (Bishkek, 2010)
12. I. Yakovleva, Reptiles of Kyrgyzstan (Frunze, 1964)
13. A. T. Toktosunov, E. Yu. Mazik, et al., Zool. J. **71(5)**, 118-127 (1992)
14. T. A. Toktosunov, Ecological factors determining karyotypic changes in animals. Abstract of PhD Thesis (Bishkek, 2001)
15. A. T. Toktosunov, Rodents of Kyrgyzstan (Frunze, 1958)