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ABOUT RADIONUCLIDE TRANSFER ON BATS (CHIROPTERA) IN SOUTHERN URALS

Species composition of bats (Chiroptera) inhabiting the Southern Urals has been examined in the context of their role in forming local radioactive spots far from possible sources of radiation. Radionuclide isotopic composition has also been determined.

Key words: radionuclide migration, waste storage reservoirs, bats.

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О ПЕРЕНОСЕ РАДИОНУКЛИДОВ ЛЕТУЧИМИ МЫШАМИ (CHIROPTERA) НА ЮЖНОМ УРАЛЕ

Исследован видовой состава рукокрылых (Chiroptera), обитающих на Южном Урале, и феномен формирования ими локальных радиоактивных очагов, расположенных в отдалении от возможных источников радиации. Определён изотопный состав радионуклидов.

Ключевые слова: миграция радионуклидов, водоёмы хранилища отходов, рукокрылые.

For the first time radioactive contamination in residential dwellings by the lake Akakul located far from any potential sources of radiation was detected in 1993. Dosimetry service of the Mayak PA experimental research station found out that the source of ionizing radiation was bats' dung (guano), the animals in the order Chiroptera [1, 2]. The area of Mayak PA impact is inhabited by 8 species of bats [3, 4]. Species of the most frequent occurrence are *Myotis dasycneme, Eptesicus nilssonii, Vespertilio murinus, Myotis brandtii, Myotis mystacinus* and their counterparts *Myotis daubentonii*, *Plecotus auritus*, *Pipistrellus nathusii*.

The trunks of trapped animals were measured by dosimeter that revealed higher levels of radionuclide specific activity. It should be noted that the values of β-particle flux density and specific activity of ^{90}Sr were significantly higher in *Myotis dasycneme* than in *Eptesicus nilssonii* (table 1).

Table 1

Evaluation of levels of β-particle flux density (β-particles/*sm*^{2}·min), exposure dose rate (*microroentgen*/*h*) and specific activity of ^{90}Sr (*Bq*/*kg* of air-dry weight) in bats

Species		External dosimetry measurements		^{90}Sr *Bq*/*g*
		β-particle flux density	Exposure dose rate	
Myotis dasycneme	Min	19	12	10
	Max	2896	257	1098
	Average	451	34	279
	n	47	46	46
Eptesicus nilssonii	Min	12	11	2
	Max	114	26	178
	Average	47	20	24
	n	13	8	14

Note: *n* is the number of animals measured

The lake Akakul is located at a distance of 8-15 *km* south-west from the main Mayak PA industrial water reservoirs [5], therefore, its basin and coastal territories were not adversely affected by the accidents in Mayak PA [6] (Fig. 1). The lake is nowadays the recreational area for the residents of Ozyorsk and adjacent cities: Kyshtym, Chelyabinsk, Ekaterinburg.

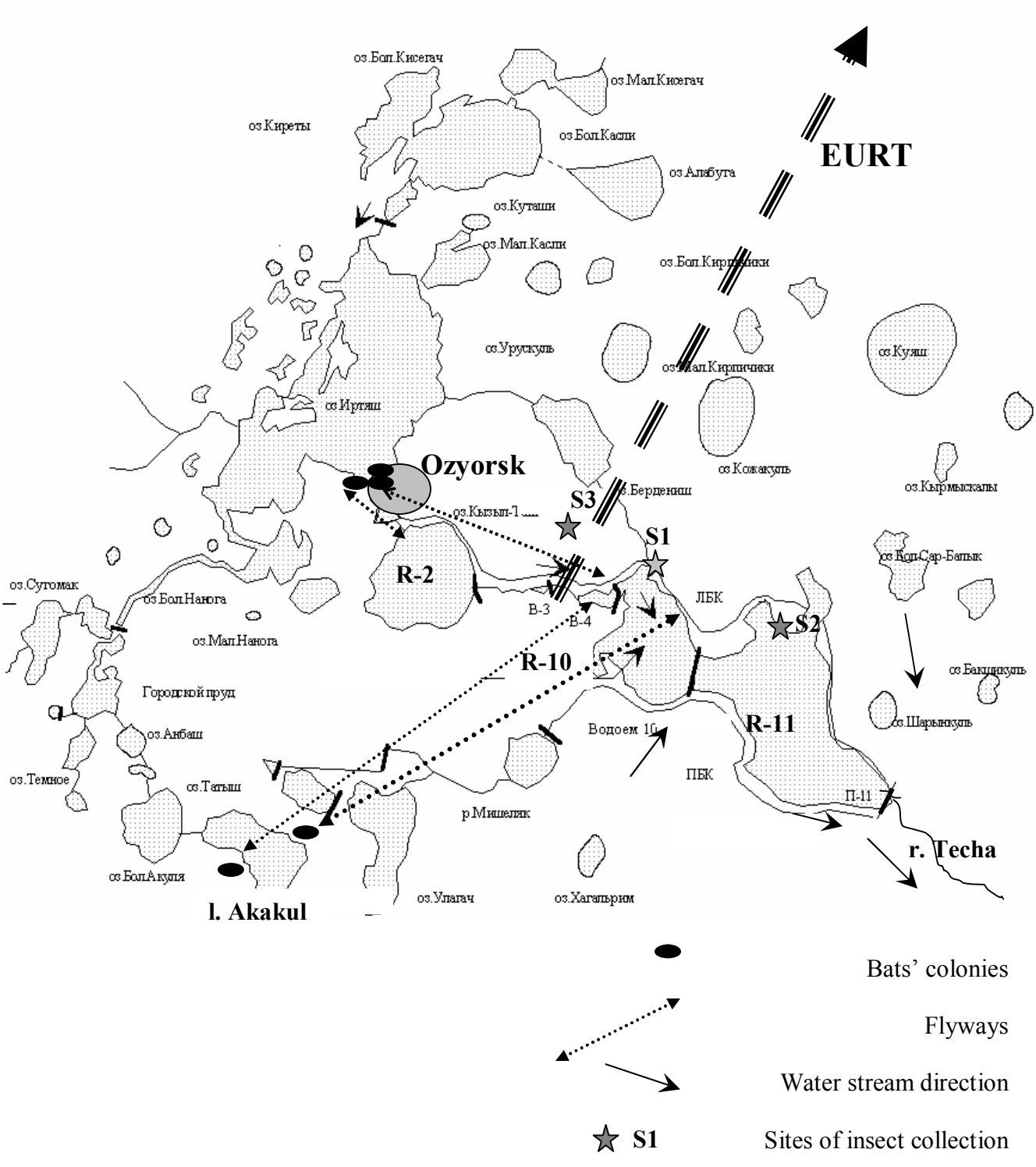

Fig. 1. Map of the region under investigation

Levels of β-particle flux density and specific activity of ^{90}Sr in adults are significantly higher than in youngsters (tables 2 and 3).

Table 2

Age differences in radionuclide accumulation based on external dosimetry data: β-particle flux density (β-particles/*sm*^{2}·min), exposure dose rate (*microroentgen*/*h*) and specific activity of ^{90}Sr and ^{137}Cs (of air-dry weight) in *Myotis dasycneme*

Age group		External dosimetry data		Radionuclide	
		β-particle flux density	exposure dose rate	^{90}Sr	^{137}Cs
Youngsters	Min	19	12	10	3
	Max	1748	32	661	44
	Average	196	20	130	115
	n	16	15	15	8
Adults	Min	40	12	15	1,5
	Max	2896	114	1098	17
	Average	583	41	351	8,6
	n	31	31	31	18

Table 3

Level of significance for external dosimetry data: β-particle flux density (β-particles/*sm*^{2}·min), exposure dose rate (*microroentgen*/*h*) and specific activity of ^{90}Sr and ^{137}Cs (dispersion analysis results) between two age groups for *Myotis dasycneme*

Parameters	MS		F (df 1, 2) 1.24	Level of significance
	Between groups	Among groups		
β-particle flux density	1583062	327350	4,8	0,03
Exposure dose rate	4828	425	11,4	0,002
^{90}Sr	553105	75075	7,4	0,009
^{137}Cs	211	83	2,6	0,123

These peculiarities in radionuclide accumulation by bats are associated with large distances the adult bats fly over for forage as opposed to youngsters who can not possibly fly far from their roosting.

On the basis of data analysis it can be inferred that insects whose larval stage is under the water of reservoirs – Mayak PA radioactive waste storages – are the source of radionulclides accumulated in animals (Fig. 1). Analysis results on radioactivity in insects collected alongshore are presented in table 4.

Table 4

Radionuclide specific activity in insects (*Bq*/*g* of air-dry weight) collected alongshore the water reservoirs used as storages by Mayak PA

Sites of insect collection	Specific activity					
	^{137}Cs			^{90}Sr		
	Min	Max	Average	Min	Max	Average
S1	3	489	130	8	71	43
S2	1	3	2,3	35	113	77
S3			1,6*			2,1*

Note: From S3 "terrestrial site" a single sample of different species was collected

A.A. Peredelsky and I.O. Bogatyryov [7] determined, that considerable transfer of radioactivity from contaminated water reservoirs occurs. Radionuclides are likely to be incorporated in bats through their food chain: Mayak PA industrial water reservoirs – insects – bats – bats' dung (Fig. 2).

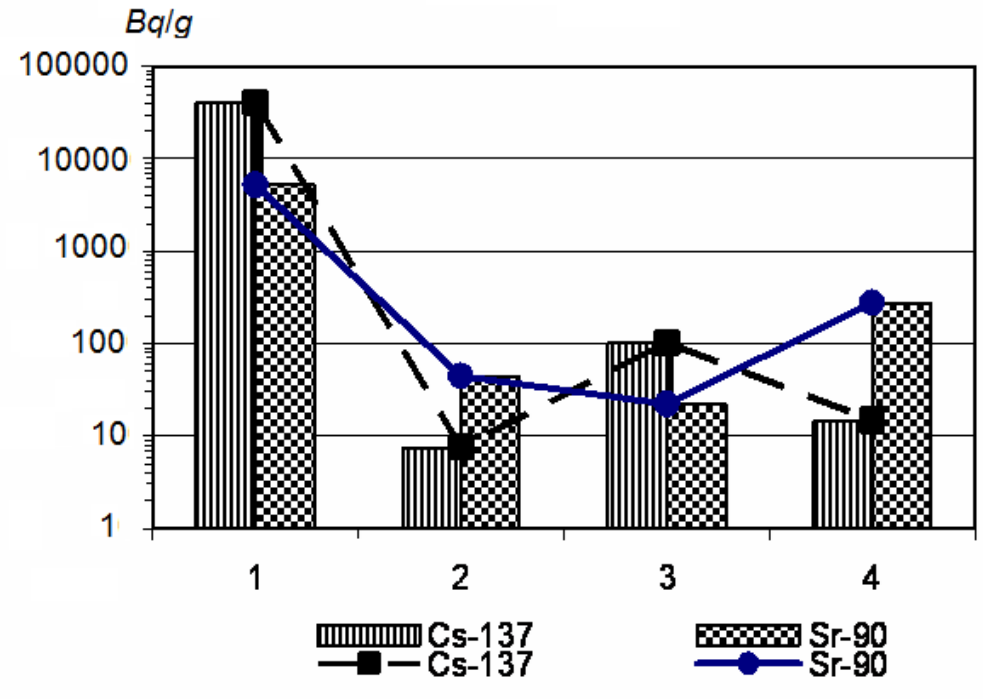

Fig. 2. Specific activity of water and bottom sediments in R3, insects and bats:
1 – bottom sediments, *Bq*/*g*; 2 – water, *Bq*/*ml*;
3 – insects, *Bq*/*g* of dry weight; 4 – bats (trunk), *Bq*/*g* of dry weight

Bats' seasonal migrations to winter hibernation sites are distances of hundreds of kilometers, therefore, the Arakayevskaya and Smolinskaya caves in Sverdlosk region and Sugomak cave in Chelyabinsk region (a distance of several kilometers from the lake Irtyash) were examined including radioactivity survey. There was no radioactivity in bats or their dung revealed.

The winter hibernation sites for contaminated bats were not specified. They are assumed to be Mayak PA industrial buildings where bats can get additional radiation doses.

The study of bat fauna in exclusion zone of nuclear power station in Chernobyl conducted by the Ukrainian scientists in 2007-2009 has revealed that about 12 species of bats inhabit this territory: *M. dasycneme, M. daubentonii, M. mystacinus, Pl. auritus, N. leisleri, N. noctula, N. lasiopterus, P. pygmaeus, P. nathusii, P. kuhlii, V. murinus* and *E. serotinus* [8]. Due to the variety of populations researchers came to the conclusion that environmental conditions are favorable for their growth. Specific activity levels of ^{90}Sr and ^{137}Cs in bats trapped in the area of Chernobyl nuclear power station were amounted to 10-64 *Bq*/*g* and 10-150 *Bq*/*g*, respectively, thus being in compliance with radioactivity levels in bats inhabiting the area of Mayak PA

impact. Specific activity in bats of Chernobyl nuclear power station district, like in the area of Mayak PA impact, is varied over a wide range: 2-3 orders of magnitude. As opposed to the bats of Mayak PA area the youngsters of Chernobyl district accumulate more amounts of radionuclides than adults. This fact is explained by the food habit peculiarities. Senior age groups are capable for long-lasting flights. Bats inhabiting the area of Mayak PA influence flight for forage to the water reservoirs used as waste storages while bats inhabiting districts of Chernobyl nuclear power station impact flight outside the zones of radioactive contamination. The researchers conclude that Chernobyl zone should be considered as a valuable natural reserve necessary for keeping and increasing of biological diversity.

Similar studies were performed by D.B. Hall et al [9]. Sampling was conducted at a pond which collects and holds water that percolates through fractures in a tunnel system constructed to test nuclear weapons on the U.S. Department of Energy's (DOE's) Nevada Test Site. Water and sediment samples, 29 bats (7 species), and 10,3 *grams* (wet weight) of flying insects (7 Orders) were collected from the pond. An additional 8 bats were collected from a control site. Man-made radionuclides in the contaminated pond water and sediment were tritium (3H), ^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239+240}$Pu, and ^{241}Am. Tritium, ^{137}Cs, $^{239+240}$Pu, and ^{241}Am were detected in bats and flying insects from the radioactive pond with little difference between bats or flying insects. Internal dose rates to bats from man-made radionuclides ranged from 6,7 10^{7} *Rad*/*day* to 2,3 10^{5} *Rad*/*day* (mean 9.0 x 10^{6} rad/day; median 7.0 x 10^{6} rad/day) and were predominantly from tritium. These levels are less than 1 % of the DOE recommended dose limit of 0,1 *Rad*/*day* for the protection of terrestrial biota.

Conclusion

All the bats collected in sites of their summer colonies in the area of Mayak PA influence had higher levels of radionuclide contamination. Specific activity of ^{90}Sr and β-particle flux density in bats are significantly higher in *Myotis dasycneme* than in *Eptesicus nilssonii* that can be explained by the food habit differences. The youngsters of *Myotis dasycneme* inhabiting zones of Mayak PA impact have lower levels of specific activity of ^{90}Sr and β-particle flux density than adults. An inverse effect is observed in the area of Chernobyl accident impact. Radionuclides in bats inhabiting Southern Urals are incorporated through the food chain: Mayak PA industrial water reservoirs – bats – bats' dung.

Investigations of the bat colonies in the area of Mayak PA impact indicate that due to zoogenic transfer the amount of sites inhabited by animals with higher levels of radionuclide contamination is increasing.

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