EFFECT OF SOIL HEATING BY ^{239}Pu ON FIELD FAUNA*

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This paper presents continued studies on the effect of radioactive heating of a medium on soil fauna (Gilyarov, Krivolutskii, 1971). Plutonium-239 was selected for study because of its high radiotoxicity and because the effects of heating of a medium by alpha radiation on the animal population had not been previously observed.

To create experimental field districts, heated by ^{239}Pu, a field was selected which consisted of a highly leached chernozem, characterized agrochemically as follows: 8.2% humus; total absorbing bases, 45 meq per 100 g; hydrolytic acidity, 0.83 meq per 100 g; V = 98%; pH, KCl - 5.5 and H_2O - 6.65; K, 0.67; Na, 0.57; Sr, 0.24; Ca, 44.5; Cs, 3×10^{-5}; Rb, 1.6×10^{-3}.

Before spring plowing in 1968, 300 kg of superphosphate, 200 kg of ammonium nitrate, and 100 kg of potassium chloride per hectare were added to the soil, which was plowed to a depth of 25-30 cm and harrowed. The field was separated into 200-m^2 (5 by 40 m) plots. Two grams of ^{239}Pu metal dissolved in nitric acid was placed in the tank of a tractor-drawn sprayer, with water, and the plutonium was uniformly sprayed on the surface of the soil (calculated 0.6 liter per m^2 of soil). Calculations indicated that the plutonium on the soil was 1780 $\mu Ci/m^2$. The plots were then plowed again to a depth of 25-30 cm and planted with wheat. Wheat was sown again in 2 years, samples having already been taken of the microfauna, and standard mesofauna digging carried out.

For calculating the microfauna in September 1971, 20 samples, 0.5 dm^3 (10x10x5 cm) in volume, were taken from the surface soil layers in the heated section and in the control. Microarthropods were removed with a modified Berleze-Tullgren eclector . The results are shown in Table 1. As is seen, the number of microarthropods in the heated part decreased 7-fold, and the number of species of mites (8 species in the control vs 5 in the heated) decreased. The numbers were reduced even more in the Collembola---7.5 fold---and in the small acariform mites (especially prostigmats and tuboficids), 18 fold. Hamazids were not found in the heated soil samples. In the heated soil the uniformity of the population of arthropods was decreased: 15% of the control samples contained no microarthropods, while 45% of the samples from the heated soil contained no . This was shown in a large number of samples.

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Table 1. Microarthropods in Field Soil Containing ^{239}Pu and in Control (avg. No./m^2, 0- to 5-cm layer

Organism	Control	Exptl.
Oribatei	110	70
Liochthonius sellnicki	5	—
Brachychthonius berlesei	—	5
Oppia nova	40	5
Oppia unicarinata	5	35
Oppia bicarinata	5	—
Suctobelba hammeri	10	20
Tectocepheus velatus	30	5
Scheloribates laevigatus	10	—
Oppia minus	5	—
Gamasida	50	—
Acarina	630	35
Collembola	150	20
All microarthropods	930	125
Species of mites	8	5
% samples w. microarthropods	85	55
No. microarthropods per dm^2	9,3±3,2	1,2±0,3

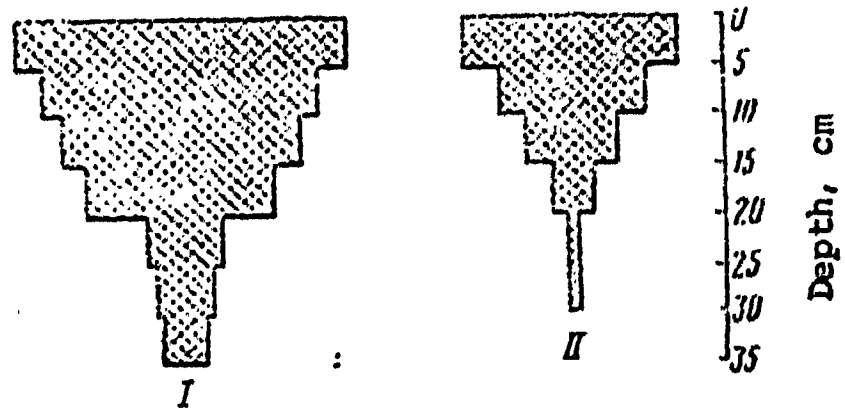
Confidence limit of difference in numbers of microarthropods in control and experimental; td = 2.5, where td > t_1

Table 2. Microfauna in Soil Containing ^{239}Pu and in Control (avg. No./m^2 Counted in 15 1-m^2 Areas)

Organism	Control	Exptl.
Lumbricidae	0,1	0,2
Enchytraeidae	2,5	2,0
Mermithida	3,5	1,1
Geophilidae	0,1	0,3
Aranea	0,1	—
Insecta		
Staphylinidae i.	1,5	0,2
Carabidae i.	3,2	1
Carabidae l.	1,2	0,7
Diptera l.	3,3	1,2
Elateridae l.	0,1	0,2
Curculionidae l.	0,2	—
Avg. No./m^2	15.8±1	6.9±0,9
All mesofauna collected	238	102

Confidence limit of difference in numbers in experimental and control 99.9%; td = d/md = 6.3, where td > t_3 (t_3 = 3.7 at V = 29)

The information presented indicates a sharp decrease in the number of soil organisms as a result of heating the medium with ^{239}Pu. This is quite marked in all indexes despite the very low number of organisms, as is always the case in plowed soils. The negative effect of heating is much stronger than observed in the heating of a medium with gamma or beta radiation with about the same heat density (Krivolutskii,1970; Krivolutskii, Kozhevnikova,1972). This may be explained, in our opinion, by several conditions. Probably ^{239}Pu is much more radiotoxic to microarthropods than ^{90}Sr, ^{137}Cs, ^{144}Ce, ^{106}Ru, ^{95}Zr, whose action we studied earlier. Also, the large area of the experimental plot excludes transfer of the animal population by horizontal migration, the more so that in the surface areas there are almost no inhabitants among the microarthropods and the migration capability of essentially surface dwelling forms is small. This conclusion is verified by observation of the species make-up of the inhabitants (Table 1), where out of 9 species there is not one surface type and 7 species are characteristic inhabitants of the smallest pores of the substrate layer. However, despite the considerable non-homogeneity of the soil microarthropod population, the differences in numbers in the heated portion and the control has a confidence limit of 95%.



Vertical distribution of mesofauna in (I) control and (II) soil heated by ^{239}Pu.

Observations verified that radioactive heating of soil results in a more rapid death rate of microarthropods. In soil heated by ^{239}Pu there is complete absence of gamazovye [not in dictionary] and grain ticks, and a sharp decrease in the number of Collembola (all these groups have a short post-embryonic development period). At the same time, the population of the armored mites, whose development is a factor of 3 to 10 slower, was not so seriously affected.

In the same sections, counts were made of the soil mesofauna in the period before sowing of wheat (May 15-20, 1971). Samples of soil with an area of 1 m^2 each were examined by 5-cm layers to a depth where organisms were found, but to at least 20 cm. In each section, 15 soil samples were taken. The results of mesofauna counting are shown in Table 2 and in the figure. As we see, the number of mesofauna in the heated sections was lower than in the control by a factor of 2.3. The decrease in numbers was statistically significant. The presence only in the control of spiders and weevil larvae and in the heated section of a somewhat larger number of earthworms, geophilids, and click beetles is fortuitous since all these organisms are found singly and the observed difference is not statistically significant. In the heated portions, especially markedly decreased is the number of invertebrates in the deeper layers. This was also noted in portions heated by ^{90}Sr (Gilyarov, Krivolytskii, 1971). The number of mesofauna in the 15- to 35-cm layer was 4.8 times as high in the control section as in the heated.

Thus, ^{239}Pu has a marked depressing action on all groups of soil organisms in the meso- and microfauna groups.

References

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