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REDISTRIBUTION OF ^{137}CS IN TROPHIC CHAINS OF INSECTS-HERPETOBIONS

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Annotation. *We review the questions of redistribution of ^{137}Cs in trophic chain, based on the study of radioactivity of insects-herpetobions exoskeletons, sampled in Drevlanskiy Natural Reservation (the density of radioactive contamination is above 555 kBq/m^2). To simplify the model, only obligatory phytophagous, zoophagous and necrophagous were used. Calculated accumulation coefficients (T_F) for each unit of chain give an ability to define theunit with the maximal accumulation of radioactive element - secondary consumers (zoophagous), where T_F is 6 time higher than in other units which proves known standard trend.*

However, draws attention the fact that TF for insects-predators is almost 3 times higher than for the predators from other taxonomical groups. Comparison of measured accumulation coefficients of insects-herpetobions to already published data allows us to make an assumption about the domination of insects in biogenic transformation of radionuclides, at least in forest ecosystems. This domination can be based on the higher biomass and density of population of invertebrates from one side and on the high level of radioactive contamination of these animals.

Keywords: insects-herpetobions, radionuclides, ^{137}Cs, trophic chain, accumulation coefficient, primary and secondary consumers

Even since the 30 years after the Chornobyl accident, the problem of presence of radioactive compounds in animal and human habitants is still actual. Post-accident high-scale studies of the impact of radioactive contamination on the flora and fauna of whole regions gave an opportunity to estimate radiobiological and radioecological effect on the plant and animal communities. The features of accumulation and redistribution of radionuclides in the animalswhose lifecycle is strongly connected to the soil surface is the important point of these studies.

Soil surface is the main source of radionuclides in terrestrial trophic chains. Radioactive compounds fall onto the soil surface, accumulate in the soil and after get included into biochemical cycles and became part of soil composition. Soil is the most important inertial chain and allover speed of migration of radionuclides through trophic chains is strongly dependent on the speed of radionuclides movement inside the soil. As the result of relocation in soil and subsequent sorption through the roots radioactive agents get into the parts of plants that have nutritional value or used as fodder [11].

On the assumption of biochemical cycle of elements in the landscape [1], migration of the majority of chemical compounds in the elemental landscape is a cycle, where elements repeatedly participate the composition of living organism (“organization”) and leave it (“mineralization”) [2; 3]. Such cycles are different in the time for each compound and each landscape; the cycles can never be inversed and landscape never goes to its previous state but can only be evolved with obtaining of some new properties. Development of landscape mainly emerges as the system of such cycles, and the soil, as the main consumer of primary and secondary production of biocenosis production, has the main role in it.

As it is known from the works of Hyliarov [4; 5], Zonn[6] and others, terrestrial and soil fauna have strong direct and indirect (through litter) impact on the cycle of matter. Soil invertebrates is an important factor of soil genesis and increasing of the quality of soil, and by so – the main element in the chain of biochemical relations [2; 7]. It can be concluded from the studies of Kryvolutskyi [8] and Pokarzhevskyi [9] that the role of soil animals in the accumulation and migration of chemical elements is significant. The long-term study of the role of different groups of litter mezofauna in the cycle of the mater in the conditions of the short-hawn oak forests and arena oak forests of steppe zone of Ukraine [10] can be used as an example. It was shown that the main participant to the process of the litter decomposition are Diplopoda, Siphidae,Scarabaeidae, Oniscidea, caterpillars of Noctuidae, Diptera larvae and Gastropoda in the short-hawn oak forest and Julida, Coleoptera, and Diptera in arena oak forests.

Invertebrates that live in the upper soil horizon – litter, from one side, are strongly linked to the plants, that, as well as animals, accumulate contaminants (including radioactive onea)and are the objects of feeding interest for the phytophagous. From the other side, these invertebrates are strongly linked to the litter which has barrier-function on the way of contaminants to enter the soil. Hence, the litter became not only the matrix for living of animals, but the object of destructive impact on saprophagous as well [13].

Thus, all vital processes in the population of animals of upper soil horizon come about the context of changing of chemical composition of their environment. Macro- and micro elements get to the body of animals and accumulate there in the process of feeding. Thereby, the features of accumulation of pollutants in invertebrates has an interest not only in the taxonomic, but on the trophic level as well. Redistribution of contaminants in case of radioactive contamination of any ecosystem elementhappen due to its (compound) active participation to the biogenic and abiogenic cycles of matter. The biogenic cycle is the most important, since radioactive compound actively include itself to the processes of exchange that have place in the living beings [15; 16].

Entrance of radionuclides in to the animal organisms depends on the ecology of different species and their feeding preferences and distribution at biocenosis, as well as on the chemical and physical properties of radionuclides [17]. For some groups of animals with the same feeding preferences the same trends in concentration of radionuclides while they migrate through trophic chain are observed.

Such the features can explain why the majority of publications that deal with the biogenic transformation of radionuclides in trophic chains devoted to the study of accumulation of radioactive isotopes in the chains that finally leads to the human or in the trophic chains of vertebrates which have specific feeding specialization [18-21]. Trophic specialization of the majority of insects are not studied so deeply yet. Segregation of insects according to their feeding character on to trophic groups more or less relative since the degree of this specificity is differ from species to species; for example, some insect species might be zoophagous, phytophagous, saprophagous and necrophages at the same time [23].

The goal of this work is the study of the redistribution of ^{137}Cs in the trophic chain of insects-herpetobions: plants – phytophagous – zoophagous – necrophagous. It is obvious that such a simplified model is not able to represent all details of redistribution of radionuclides, but it allows to take into consideration some features of trophic links of herpetobions. The next objects were chosen for the study: *Zabrus tenebrioides Goese*as the obligatory phytophagous, *Calosoma sycophanta* as the obligatory zoophagous, *Nicrophorus vespillo* as a necrophagous. All chosen modeling species has short lifecycle which strongly simplify the interpretation of obtained data.

Material and methods. Material for the study has been taken in the Drevlanskiy Natural Reservation by using Berber's traps, in the pine forest 60+ years old with the density of soil contamination by ^{137}Cs was above 555 kBq/m^2. Radioactivity of exoskeletons of collected insects has been defined by using gamma – ray spectrometer with Ge(Li) semi conductive detector of GEM-30185, GMX series (EG&G ORTEC) and multichannel analyzer (ADAM-300, USA, IN-1200, France) in measuring reservoirs "Denta" fabricated in the shape of a frustum 3.3 cm high and with the diameters of base 6.3 and 7.3 cm respectively in the Institute of Agricultural Radiology of NULES of Ukraine.

The coefficient of accumulation of radionuclides in each unit of the trophic chain has been defined by using common-known formula: the ration of the specific activity of the linker-acceptor to the donor unit.

Results and discussion. The simplified trophic chain started from the wild-growing cereals was used to perform the study (Fig. 1)

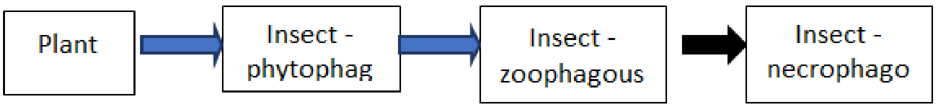

Fig.1. Simplified model of trophic chain

Such a simplified model allows to take into account redistribution of radionuclide by representatives of each ecological group, starting from the primary consumers and until the decomposers. Activity of the first unit (plant) has been considered as 1.

As it was predicted, radioactivity of each unit of trophic chain has not shown any significant deviation from the general trend – thesecondary consumers (zoophagous) has the highest value (Tab. 1).

1. Radioactivity of units of trophic chain

Trophic level	Radioactivity (Bq/kg)
Herbivore	1327 ± 240
Primary consumer (*Zabrus tenebrioides Goese*)	520 ± 104
Secondary consumer (*Calosoma sycophanta*)	3283 ± 33
Necrophagous (*Nicrophorus vespillo*)	525 ± 92

As it was already shown, the main parameter that characterizes degree of biogenic redistribution between the units of trophic chain is the transfer factor (T_F). Computation showi that on the stage of migration "plant – primary consumer" significant decreasing of T_F is clearly traced, what is in agreement with the data from literature [24-26] – the decreasing of the concentration of radionuclide in the first stage of trophic chain.

Totally different situation appears in the second unit – "phytophagous – zoophagous" (Tab. 2). T_F in this unit is 16 times higher, what has never been reported before for any studied group of animals.

2. Transfer factor in the units of trophic chains

Trophic level	T_F
Herbivore	-
Primary consumer (*Zabrus tenebrioides Goese*)	0.39
Secondary consumer (*Calosoma sycophanta*)	6.31
Necrophagous (*Nicrophorus vespillo*)	0.16

It might be likely explained by the specificity of lifestyle of selected species, that is characterized by high mobility and aggressivity, short lifecycle and feeding features of larva, which is obligatory zoophagous [27].

Third unit of trophic chain – necrophagous has, compare to zoophagous, much lower coefficient of accumulation. However, since the trophic specialization of *Nicrophorus vespillo* tends to include the consumption of vertebrate animals, the result is not in disagreement with the data obtained before.

Another point of interest is the data about the second trophic unit – secondary consumers. Comparison of T_F for zoophagous of different systematic groups (Tab. 3) allows to say that among all zoophagous the insects have the highest coefficient of accumulation of ^{137}Cs, which probably can be explained though the specificity of ecology of these animals.

3. Transfer factor for different groups of zoophagous

Secondary consumers	T_F
Insecta (*Calosoma sycophanta*)	6.31
Reptilia [21, 25, 26]	3.4, 2.5
Mammalia [21, 25, 26]	1.3
Aves [21, 25, 26]	0.53

The results of the study proved known trend of concentration of ^{137}Cs in the second unit of trophic chain. However, it needs to be noticed that such high values of T_F (two times higher) that were observed for insects-predators allows us to make an assumption about dominating position of insects in the biogenic transformation of radionuclides, at least in forest ecosystems. This assumption is based on the high biomass and density of invertebrates compare to vertebrates on the one side and high level of contamination of invertebrates on another.

As it was mentioned before, the exoskeletons with the removed soft tissues were used for the study, thus only contamination of chitinous cover was analyzed.Comparison of this data with the radioactivity of whole body of animals, sampled in the same biocenosis allows to assume that the coefficients of accumulation can be significantly higher for other units of trophic chain. The basis for this assumption is the comparison of radioactivity of phytophagous *Zabrus tenebrioides* exoskeletons (520±104 Bq/kg) and radioactivity of Melolontha melolontha (1500±14 Bq/kg), which is approximately 3 times higher for the second species.Additionally, it indirectly proves an assumption about the leading role of invertebrates and particularly insects in the trophic transformation of radionuclides in natural ecosystems.

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ПЕРЕРОЗПОДІЛ ^{137}CS В ТРОФІЧНОМУ ЛАНЦЮГУ КОМАХ-ГЕРПЕТОБІОНТІВ

В. Гайченко, Д. Моношин

***Анотація**. На прикладі вивчення питомої радіоактивності екзоскелетів комах-герпетобіонтов, відловлених у Древлянському заповіднику (щільність забруднення понад 555 кБк / м^2) розглядаються питання перерозподілу 137Cs в трофічному ланцюгу пасовищного типу. Для побудови спрощеної моделі трофічного ланцюга використовувалися облігатні фітофаг, хижак і детритофаг. Розраховані коефіцієнти накопичення (КН) для окремих ланок ланцюга дають можливість виявити ланку з максимальним накопиченням радіонукліда - консументи II порядку (зоофаги) - в якій КН у 6 разів вище, ніж в інших ланках, що підтверджує відому закономірність. Разом з тим, звертає на себе увагу високий коефіцієнт накопичення у хижих комах, який майже втричі вищий, ніж для відомих хижаків різного систематичного положення з наземних екосистем. Проведене порівняння коефіцієнтів накопичення в трофічному ланцюгу комах-герпетобіонтов з літературними даними дозволяє* *висловити обґрунтоване припущення про домінуюче положення комах в біогенній трансформації радіонукліда, хочаб в лісових екосистемах. Підставою для цього, з одного боку, є більша ніж у хребетних тварин біомаса і щільність безхребетних в наземних ценозах, а з іншого – значне радіоактивне забруднення цих тварин.*

Ключові слова: комахи-герпетобіонти, радіонукліди, 137Cs, трофічні ланцюги, коефіцієнт накопичення, консументи I, II порядку.

ПЕРЕРАСПРЕДЕЛЕНИЕ ^{137}CS В ТРОФИЧЕСКОЙ ЦЕПИ НАСЕКОМЫХ-ГЕРПЕТОБИОНТОВ

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Аннотация. *На основании изучения удельной радиоактивности экзоскелетов насекомых-герпетобионтов, отловленных в Древлянском заповеднике (плотность загрязнения свыше 555 кБк/м^2) рассматриваются вопросы перераспределения ^{137}Cs в трофической цепи пастбищного типа. Для построения упрощенной модели трофической цепи использовались облигатные фитофаг, хищник и детритофаг. Рассчитанные коэффициенты накопления ($К_Н$) для отдельных звеньев цепи дают возможность выявить звено с максимальным накоплением радионуклида – консументы II порядка (зоофаги) – в котором $К_Н$ в 6 раз выше, чем в других звеньях, что подтверждает известную закономерность. Вместе с тем, обращает на себя внимание высокий коэффициент накопления у хищных насекомых, который почти в три раза выше известных для хищников различного систематического положения из наземных экосистем. Проведенное сравнение коэффициентов накопления в трофической цепи насекомых-герпетобионтов с литературными данным позволяет высказать обоснованное предположение о доминирующем положении насекомых в биогенной трансформации радионуклида, по крайней мере, в лесных экосистемах. Основанием для этого является, с одной стороны, бóльшая, чем у позвоночных животных биомасса и плотность беспозвоночных в наземных ценозах, а с другой – значительное радиоактивное загрязнение этих животных.*

Ключевые слова:насекомые-герпетобионты, радионуклиды, ^{137}Cs, трофические цепи, коэффициент накопления, консументы I, II порядка.