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^{40}K, ^{3}H, and ^{14}C levels in dark-striped field mice, *Apodemus agrarius*, as a potential radio-environmental and ecological monitoring system

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1. Introduction

Social concerns over radiation safety remain a very important issue in the management of nuclear power plants and the installation of facilities for radiation waste storage. To understand how environmental effects of radionucleus from radiation facilities relate to human beings, the development of an unmanned monitoring system is required. The IAEA suggests a method to evaluate the effects of radiation emitted from radiation facilities on marine water, freshwater, and habitats for land animals and plants on its Technical Report Series 190 , 288, and 332. Recently, (IAEA-TECDOC-1270, 2002), ICRP Publication No. 91 (2003) was consecutively published to protect non-human animals and plants from environmental radiation and radioactive materials. In particular, ^{3}H and ^{14}C, types of radionucleides that are emitted from nuclear power plants, are mostly emitted from heavy-water reactor and ^{3}H also from light-water reactor to affect surrounding environments (Jeong et al. 2005). As these radionucleides exist in nature and become the major cause of environmental exposure (Koarashi et al. 2005; Levin et al. 1988), we need to have an accurate understanding of their dynamic movements to evaluate the surrounding environments of radiation facilities. Nevertheless, not many studies have been done on this topic.

This study sets up the following requirements to select a biological indicator: 1) it must be an animal species that is clearly classified from other species (Cobert 1978); 2) it must have a consistent ecological characterization; 3) it must inhabit areas that are also livable for humans; 4) its habitat must be limited; 5) it must eat and drink from its habitat; 6) it must have a considerable length of lifespan; and 7) it must provide information on the radioactivity of natural radionucleides in its bodies (Mihok et al. 1989). This study compared the external appearances and enzyme types in the livers of dark-striped field mice to classify them and only selected middle-aged mice to measure the radionuclides in their whole bodies and each organ.

2. Methods and Results

For this study, dark-striped field mice were sampled from three regions in Korea (Kyonggi, Chungchong, Cholla, and Kangwon province), using Sherman traps (H.B. Sherman trap, USA) in spring. The dark-striped field mice inhabited farmlands, rice fields, and scattered habitats throughout the foothills of mountains.

2.1 Morphological external characters.

The coat colors were studied to determine the exact species of the dark-striped field mice and to measure their external characteristics. The fur color of the mice used for this study was dark brown and the abdominal hair color was white-gray. On the ventral part, a dark-colored stripe runs from the head to the basal part of tail. The length of the tails was shorter than the length from head to the basal part. The ears were so small that they could not reach the eyes even when folded.

2.2 Age classification

We selected middle-aged mice in adult pelage phase with wear on the cups of the upper molars, lake condition. Seven middle-aged-adult mice were donated to measure radioactivities in whole body and their organs.

2.3 Analysis of isoenzymes

Analyzing the LDH, G6PDH, and AAT patterns in the liver of the mice whose hair colors and external characteristics matched those of *A. agrarius* showed only one type of isoenzyme. However, one type each of the G6PDH and AAT were slower in movement than those of ICR mice.

2.4 Analysis of γ-ray radionuclides

The activities of natural radionuclides were measured by gamma ray-spectrometry. The gamma-spectrometry system consists of a lead-shielded Ge(Li)-detector with an anticoincidence plastic detector for additional background reduction and a lead-shielded hyper pure Ge-detector for low energy regions. Seven of the mice classified as middle-age classed measured 18,000 sec. An automatic spectrum evaluation was performed with the aid of software, Ginie 2000. The result shows that qualitatively identified nuclide was ^{40}K with activity of 17Bq from whole body.

2.5 Analysis of organic β-ray radionuclides

After measurement for γ-ray radionuclides, about 100mg of organs were collected. The collected organs were weighed and dissolved in a tissue solublizer (Soluene-350, Packard) and an aliquot portion of the solution was mixed with Hionic-Fluor (Parkard) for measurement of the radioactivity. Samples were counted for one hour using a liquid scintillation spectrophotometer (2500TR, Parkard). The result shows that the radioactivity of ^{3}H and ^{14}C was higher in the liver, lung, heart, and kidney than in the spleen, thymus, adrenal gland in descending orders (Table 1).

2.6 *Biokinetic activity of ^{14}C in ICR mice*

To compare biokinetic activity of ^{14}C between organs of *A. agrarius* and ICR mice, we administrated ^{14}C into ICR mice (6weeks old, female) via oral and intravenous routes. The samples were combusted in a sample oxidizer (B-306, Parkard Instrument Co., USA). The radioactivity of the samples was measured by a liquid scintillation counter. The radioactivity was expressed as a relative concentration (RC), which was calculated by the formula as follows: RC=[(Radioactivity in tissue/weight of tissue at sacrifice)/(Radioactivity administrated to mice/weight of mice at administration)]×100. The result shows that about 20% was distributed ^{14}C in the organs and excreta 24hrs after administration. The radioactivity in liver, lung, kidney, spleen, and digestive tracks was high in descending order.

Organs	Activity (Bq/gm) of	
	^{3}H	^{14}C
Liver	59±17	28±2.6
Lung	61±12	24±0.9
Heart	43±10	25±1.5
Kidney	46±17	26±3.2
Spleen	23±0.6	21±0.2
Thymus	21±3.5	20±1
Adrenal gland	22±3.2	21±1

Table 1. Radionuclides in organs of dark-striped field mice, *Apodemus agrarius* (Mean±SD, n=7).

3. Conclusion

This study found the following characters of dark-striped mice as a biological indicator to evaluate the effect of environmental radioactivity. First, the species of field mice was identified to be *A. agrarius* based on their fur color, external morphology, and liver enzymes. Second, a statistically significant number of field mice could be collected to evaluate the radioactivity of low-level regions as a great number of field mice are scattered in broad habitats. Third, as they eat and drink within the spheres of life of men, we could calculate the radioactive concentration of restricted areas. Fourth, as they live up to three years and breed four times a year, they were used to study the long-term effects and genetic effects of radioactivity. Fifth, as dark-striped mice are genetically very similar to men, we could apply the data on the distribution and movement of radionuclides in bodies to human bodies. Sixth, this study identified the natural concentration of ^{40}K, ^{3}H and ^{14}C in the whole body and each organ of dark-striped mice and built a base to interpret the movement of radionuclides in environment. In other words, this study understood the ecological characters of dark-striped mice and allowed us to investigate the movement of environmental radionuclides around nuclear power plants or radiation facilities and their effects on human beings. In the future, the radionuclide concentration of dark-striped mice that inhabit areas around nuclear power plants or radioactivity waste storage facilities and non-radiation facilities must be measured to accumulate basic data to evaluate the level of contamination in case of leakages.

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