IONIZING RADIATION EXPOSURE EFFECTS ACROSS MULTIPLE GENERATIONS IN NON-HUMAN BIOTA

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Background

The potential for radiation-induced deleterious effects in progeny, and thus, in next generations is a major concern for parents exposed to ionizing radiation from occupational, medical or environmental sources. To date, the systems of radiological protection do not quantify or consider the possibility for effects that may manifest subsequent generations following the initial exposure. A Task Group (TG121) of the International Commission on Radiological Protection (ICRP) Committee 1 was launched in 2021 to study the effects of ionizing radiation in offspring and next generations. One goal of TG121 was to review the literature on both multi-generational (in which the exposure continues across multiple generations) and trans-generational (in which later generations are not exposed during a recovery period) effects in non-human biota. With shorter generation times in these non-human species, they offer a unique tool to monitor and study generational effects following radiation exposure, although the underlying biological and physiological differences amongst these species must be carefully considered.

Methods

A review of multiple online databases (Google Scholar, PubMed, Scopus) was completed in 2022 by performing keyword searches related to the topics of multi- and trans-generational effects of ionizing radiation in non-human species. Both laboratory-controlled experiments and field studies were considered, with the latter typically containing ecological studies from either the Chernobyl Exclusion

Zone or the Fukushima-Daiichi prefecture. In addition to studies identified from online databases, we also considered published reviews, conference proceedings and expert reports within our review.

Results

Studies were grouped into categories based on the model organism used, which includes species of bacteria, nematodes and annelids (largely *Caenorhabditis elegans*), crustaceans (largely *Daphnia magna*), insects, amphibians, birds, fish, mammals and plants. Details regarding exposure schedule (multi-generational, trans-generational or environmental exposure), generation numbers studied, endpoints monitored and results were summarized into a table. Effects on altered reproductive parameters were reported in offspring, with this observation present in different study models. In some studies, decreased survival in offspring was also observed, however these studies typically involved chronic, persistent exposure of numerous generations to a radiation field or following very large acute doses in trans-generational studies. There was also a number of studies in different study species that reported changes in genetic and epigenetic endpoints, with transmission of epigenetic changes into subsequent generations previously described as a possible mechanism for multi- and trans-generational irradiation effects. Changes in genome methylation, histone modifications chromosomal aberrations and other mutations were reported in plants (*Arabidopsis thaliana* and flax), nematodes (*Caenorhabditis elegans*), insects (*Drosophila melanogaster*) and amphibian (Japanese tree frogs and Eastern tree frogs) species. Overall, the diversity of available non-human biota data brings complexities regarding the application of any reported results into the systems of radiological protection. We propose that differences in radiation sensitivity between species, transferability of data between different species, the presence of adaptation and adaptive responses, and dose reconstruction across subsequent generations and finally extending knowledge to humans represent key knowledge gaps within this field.

Conclusion

The goal of this paper was to perform a literature review of studies that investigated multi- and trans-generational effects in non-human biota, and to consider the incorporation of this evidence into the systems of radiological protection. The reported effects in altered reproduction represent an area of potential concern, due to the importance of population and ecosystem structure within ecological radiation protection. This is in contrast to human radiation protection, which considers effects at an individual level. Future work of ICRP Task Group 121 will continue to review this literature, with a final ICRP Publication that will be published for the radiation protection community.