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Perspective

An Evolutionary Method for Pollution Control

Huiyu Dong*

Department of Environmental Science, Addis Ababa University, Addis Ababa, Ethiopia

*Corresponding Author's E-mail: hydon@rcees.ac.et

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INTRODUCTION

For conservation concerns, estimating the effects of environmental changes is crucial, especially in the context of global change. Since the 2000's, there has been increased interest in examining the effects of pollutants using an evolutionary method; nonetheless, these studies are still uncommon when compared to the characterization of direct effects on individual traits. We chose to concentrate on the study case of anthropogenic ionizing radiation because, although it may have a significant effect on evolution, there aren't many evolutionary methods available to examine the biological effects of this stressor.

DESCRIPTION

We propose that an evolutionary approach could contribute to the provision of an integrative perspective on the biological effects of ionizing radiation in this study by examining specific aspects of the stressor's biological effects and reviewing previous research on evolution under ionizing radiation. Our three main areas of interest were:

- The mutagenic characteristics of ionizing radiation and how it interferes with evolutionary processes.
- Exposures at different time scales, which result in an interaction between the evolution of the past and the present.
- The unique characteristics of contaminated areas known as exclusion zones and how evolution could correspond with effects observed in the field and in the lab.

This method can help address a number of important radio ecological questions, including how different species differ in how sensitive they are to ionizing radiation, how to better estimate how ionizing radiation affects populations and how to identify the environmental factors that affect organisms (such as interactions with other pollutants, population migration and anthropogenic environmental changes). It would be advantageous to incorporate the evolutionary approach into the ecological risk assessment procedure.

The comparatively recent advancements in nuclear energy and the expansion of radionuclide applications have resulted in multiple instances of environmental exposure to ionizing radiation from human sources. The most prominent and tragic instances are the nuclear accidents at Fukushima, Chernobyl and Kyshtym. In radioactively contaminated catastrophe sites, which are typically evacuated by people and known as "exclusion zones," surviving wild creatures may be subjected to ionizing radiation at relatively high dose rates for several decades. These human excluded areas are home to a few uncommon and charismatic species, which may indicate that the potential benefits of radiation protection may be outweighed by the decline in human activity. However, a number of studies continue to show that ionizing radiation has negative effects on specific organisms in these locations, sparking a scientific discussion about whether or not ionizing radiation effects may be applied to the entire biotic population following a nuclear accident. Along with the existence of a threshold beyond which no effect is anticipated, these problems also concern the linearity of the dose response relationship for a range of doses encountered in anthropogenic contaminated areas. Therefore, there are still significant cultural and scientific obstacles in the way of the study of ionizing radiation's impacts on the environment.

Since ionizing radiation is known to cause mutations, other pollutants like lead or benzo(a)pyrene are also problematic. An environment tainted with long lived radionuclides can be subjected to ionizing radiation for an extended period of time and experience the impacts of it. This makes anthropogenic ionizing radiation extremely persistent. Lastly, it is recognized that ionizing radiation may cause possible fitness deficits, particularly by disrupting oxidative state. The basic tenet of biological evolution is that changes in the transmitted variations across generations might result from all these particular aspects of the biological effects of ionizing radiation. However, research examining evolution and its processes are still rather rare, even with radioecology's interest in evolutionary notions. The

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underrepresentation of evolution in radioecology is consistent with ecotoxicology as a whole, where studies examining changes in the intensity of evolutionary processes faced with pollutants are still relatively rare compared to mechanistic studies examining effects at the individual scale. Since the 2000's, efforts have concentrated on the development of new molecular biological biomarkers, particularly employing "omics" technologies, in addition to physiological or biochemical data.

For example, studying the mechanism of action of contaminants or understanding how sensitive an organism is to them genetically has been made possible by the interest in molecular biology. The development of studies in "evolutionary ecotoxicology" has coincided with the integration of an evolutionary method to examine the impacts of contaminants on the environment. As a result of this method, assumptions regarding the strength of evolutionary processes were possible, which were particularly reinforced by the advancement of molecular biology.

CONCLUSION

An investigation on currently existing studies on the evolutionary consequences of ionizing radiation and by examining the specific biological consequences of ionizing radiation and how they could involve changes in the intensity of evolutionary processes of exposed organisms. We thus show that evolutionary questioning is indispensable to shed new light on scientific debates in radioecology. Indeed, ionizing radiation can disrupt evolution by their effect on genetic or non-genetic inheritance and populations, and consequently have an impact on organisms at ecological and geological time scales. In addition, evolution is necessary to apprehend the particular features of exclusion zones and make the link between laboratory and field studies.