Rigorous methodology for studies of effects of radiation from Chernobyl on animals and humans

Anders P. Møller, CNRS Researcher Timothy A. Mousseau
Université Paris-Sud XI

Wickliffe [1] recently criticized our research on the negative association between abundance of invertebrates and levels of radiation at Chernobyl [2], demanding information on (1) sampling locations and blind research protocols, and (2) underlying mechanisms that could account for the observed patterns.

We whole-heartedly subscribe to rigorous research approaches in any scientific endeavour. Our publication provided a map showing the general locations of our study sites [2], and we would be happy to provide GPS coordinates for the individual sites. We are unaware of any study reporting a large number of GPS coordinates for individual study sites [e.g. 3-5], and we note that Wickliffe and his collaborators do not do so either (six publications cited in Wickliffe [1]), although that of course should not prevent others from following rigorous research protocols. Wickliffe [1] suggests that our research findings may have been biased because they were not done blindly. We note that this equally applies to research by Wickliffe and co-workers (as cited in Wickliffe [1]), although their lack of rigour should not prevent others from adopting more rigorous methodology. For logistic reasons a double-blind approach would be impossible at Chernobyl, at least for persons familiar with the area. We have shown similar dose-dependent patterns of radiation among years [6], and we have reported a significant repeatability of census results among observers [7], suggesting that there is no bias in our census results.

Wickliffe [1] argues that their studies on rodents have shown no effects of radiation, prompting him to suggest that this should also imply to other taxa such as invertebrates. We note that Wickliffe [1] only cites his own work and that of his collaborators showing 'no effect' of radiation on rodents, while omitting to cite a single of the many publications by other scientists showing strongly negative effects on chromosomal aberrations, lethality, embryo mortality and sterility [8-12], thus providing a biased view of available evidence. How come that three different research groups working on rodents in areas contaminated by radiation from Chernobyl show strongly negative effects, while Wickliffe and collaborators show 'no effects'? Finally, we note that while scientists working on rodents in the wild adopt the internationally recognized rigorous approach of trap-lines...
followed for two consecutive nights [e. g. 13], Wickliffe and co-workers have not adopted this standard practice to assess abundance of rodents.

Finally, Wickliffe [1] suggests that without any knowledge of underlying mechanisms of radiation damage, there is no reason to consider dose-dependent relationships as those that we reported [2]. We take issue with this approach to scientific investigations because there is no priority when considering proximate and ultimate scientific approaches to science [14]. Both approaches are equally valid, and both are required for developing a comprehensive understanding of any biological or medical phenomenon. While Wickliffe [1] dismisses any effects of low-dose radiation at the levels we have investigated in Ukraine and Belarus, we notice that similar or lower levels of radiation from Chernobyl, but also from nuclear power plants in Germany, have had significant negative impacts on birth rate and sex ratio in Germany [15-17], and on high school attendance in Sweden [18].

To make progress on assessing the impacts of radiation from Chernobyl on animals and humans, but also on other organisms, it is imperative that we approach the questions while considering all available information, and not just what fits into a specific mould. Despite the Chernobyl accident happening 25 years ago, there is a dearth of scientific information available, and what is available is often not considered if it does not fit into a preconceived view of the effects of radiation. We strongly urge scientists to help break this mould.

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Conflict of Interest:

None declared

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Published February 7, 2011

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**Clarification and explanation of experimental design and mechanistic dose-response effects for significant radioecological impacts**

Jeffrey K. Wickliffe, Assistant Professor Robert J. Baker, Horn Professor
Tulane University, Texas Tech University

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The study on the detrimental effects of Chernobyl on insects by Moller and Mousseau represents a very interesting and unexpected conclusion, which conflicts with the vast knowledge regarding ionizing radiation effects and the principles of dose-response in the field of toxicology and radiation biology. In addition, the experimental design does not appear to hold to contemporary, rigorous standards.

As for the experimental design, two obvious problems are apparent to us. The first is that the scientific observations and data collected during the field sampling were carried out by an individual that had knowledge of the environmental conditions and "treatment" groups during those periods. Pre-selected plots were assessed for insect and avian presence and activity by a potentially biased observer instead of an individual blinded to the environmental conditions under study. This is particularly problematic in an ecological survey that relies so heavily on the observer for results. Perhaps concern for a blinded individual's safety and health was a primary concern. That said, the lack of potential objectivity or some real, independent measure to guard against such bias should have been explicitly declared. In addition, information required to allow independent replication of their study is inadequate. For example, no GPS or UTM coordinates are given for their field sites. Therefore, it would be impossible for an independent researcher to study these same sites. This would seem to be an obvious shortcoming especially in a field-based ecological survey study.

As for the conclusions regarding the biological and ecological impacts on insects, the authors should have explained the biological or radiotoxicological process by which such phenomenally low dose rates can produce such "significant" effects. Dose-rates reported in the published study are several orders of magnitude lower than those carefully reconstructed in several studies examining small mammals within the exclusion zone, which have not found evidence of biological, population genetic, or molecular genetic effects [1-6]. It is worth noting that the studies on mammals also find highly variable doses and dose-rates among specimens collected from the same location [7-8]. Moller and Mousseau report apparent "biologically effective" radiation dose-rates that are essentially equivalent to radiation dose-rates human populations might experience living along the Gulf Coast of the United States (their low radiation sites, 0.4uGy/hr) or those they may experience living on the Colorado plateau and in the Rocky Mountain West (their high radiation sites, 0.6uGy/hr). These dose-rate estimates for U.S. human population exposures are from the United States Nuclear Regulatory Commission and the National Council on Radiation Protection and Measurements. Recalling that insects, on average, are relatively radioresistant in comparison to humans, would this indicate that people living in high radiation sites in the U.S. are at a significantly elevated health risk because of this almost imperceptible increase in dose? The biological plausibility of this conclusion is not obvious and, therefore, the authors should provide a detailed, mechanism-based explanation for their findings. Is it possible the results are "statistical" findings and not truly "biological" findings? We feel this last question should be addressed in the context of the rich and deep scientific literature on radiation...
genetics, radiation biology, and radioecology that does not to
support their conclusions. It remains difficult to understand how the
dramatic ecological changes brought about by the disaster, and the
unprecedented exclusion of humans and human activity, do not
remain the best and strongest predictors of effects on invertebrate
and vertebrate populations. This is especially true in areas that
received negligible to very low levels of contamination.

For clearer answers to emerge from research conducted at
Chernobyl, rigorous experimental design and standards must be
adhered to. In addition, apparent biological effects attributed solely
to radioactive contamination must have a logical, mechanistic
explanation derived to some extent from existing knowledge to
support those conclusions.

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Conflict of Interest:

None declared