
Anecdotes and empirical research in Chernobyl

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Invited reply

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Although Chernobyl is perhaps the largest environmental disaster ever, there has been minimal monitoring of the status of free-living organisms or humans in stark contrast to Hiroshima and Nagasaki, where careful monitoring has continued for over 60 years. Public health issues are traditionally evaluated using stringent meta-analysis methodology to assess whether there is support for conclusions and to identify sources of heterogeneity. Surprisingly, recent inter-governmental reports on the status of Chernobyl did not use exhaustive quantitative assessment of available evidence (Chernobyl Forum 2005; EGE 2005). The conclusion that Chernobyl is a thriving ecosystem was widely cited in the popular press without even mentioning this methodological deficiency (e.g. Rosenthal 2005). We conducted extensive long-term field studies of animals and plants in Ukraine since 1991, in an attempt to quantify effects.

Smith (2008) raised questions about our procedures for assessing the frequency of abnormalities in barn swallows, *Hirundo rustica*, at Chernobyl (Møller *et al.* 2007). We used precise, stringent and well-established protocols (Møller *et al.* 2006), following colonies throughout the study, although natural meta-population dynamics result in some colonies being abandoned and others recolonized. We reported only overall frequencies of abnormalities owing to space limitations. If we use frequency of abnormalities per site as the dependent variable in a generalized linear model with log-transformed background radiation and sampling year as predictors, we find a strong effect of radiation ($F_{1,23}=23.22$, $r^2=0.50$, $p<0.0001$, slope (s.e.)=0.294 (0.061)), with a similar effect for partial albinism alone. Thus, our previous conclusion is upheld.

Smith also suggested habitat effects on abnormalities, although the underlying mechanism remains obscure. Barn swallows commonly breed in sites with no animal farming or human habitation, and this ancestral habitat readily allows for successful reproduction and survival. We have studied the effects of farmland practice on barn swallows (Møller 2001), but have found no abnormalities similar to those reported in Chernobyl (Møller *et al.* 2007), nor are such abnormalities reported in the literature. Likewise, levels of non-breeding documented for female barn swallows in the Chernobyl region (Møller *et al.* 2005) are so extreme that nothing similar has been reported elsewhere in any passerine bird. Additional data on abnormalities in black

redstart, *Phoenicurus ochruros*, and house sparrow, *Passer domesticus*, showing positive relationships between background radiation and frequency of abnormalities (A. P. Møller *et al.*, unpublished data), suggest parsimoniously that all species are affected by the same factor, most probably by radiation.

Finally, Smith suggested, based on two-page reports, that animal populations are thriving in Chernobyl (e.g. Baker & Chesser 2000). These reports provide anecdotal evidence with no information on methods or empirical findings. Although animals and plants can be censused using standard, rigorous methodology (e.g. Bibby *et al.* 2005), surprisingly, the first large-scale censuses of any living organism were conducted by us during 2006–2007, 20 years after the disaster, showing reduced population densities of most species of birds in contaminated areas (Møller & Mousseau 2007a,b). If we classify species as farmland and otherwise, we find no evidence for farmland species having different slopes between abundance and radiation when compared with other species ($F_{1,78}=0.0003$, $p=0.99$), providing no support for Smith's suggestion.

Why has there been no concerted effort to monitor the long-term effects of Chernobyl on free-living organisms and humans? The official reports by IAEA, WHO and UNDP were narrative renditions of parts of the literature, and these reports, with Smith as co-author, concluded that Chernobyl was a thriving ecosystem with increasing populations of animals (Chernobyl Forum 2005; EGE 2005), despite no census data existing. Scientific enquiry depends on rigorous analysis of data rather than rendition of anecdotal evidence.

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The accompanying comment can be viewed on page 63 or at <http://dx.doi.org/doi:10.1098/2007.0430>.

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