biology letters
Evolutionary biology
Biol. Lett.
doi:10.1098/rsbl.2007.0528

Invited reply

Anecdotes and empirical research in Chernobyl

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 (in press) 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 likely 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 2007*a*,*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.

A. P. Møller[1,2,3,4,*], T. A. Mousseau[1,2,3,4], F. de Lope[1,2,3,4], N. Saino[1,2,3,4]
[1]*Laboratoire de Parasitologie Evolutive, CNRS UMR 7103, Université Pierre et Marie Curie, Case 237, 75252 Paris Cedex 05, France*
[2]*Department of Biological Sciences, University of South Carolina, Columbia, SC 29208, USA*
[3]*Departamento de Biología Animal, Universidad de Extremadura, Avenida de Elvas s/n, 06071 Badajoz, Spain*
[4]*Dipartimento di Biologia, Università degli Studi di Milano, via Celoria 26, 20133 Milano, Italy*
**amoller@snv.jussieu.fr*

Baker, R. J. & Chesser, R. K. 2000 The Chornobyl nuclear disaster and subsequent creation of a wildlife preserve. *Environ. Toxicol. Chem.* **19**, 1231–1232. (doi:10.1897/1551-5028(2000)019<1231:TCNDAS>2.3.CO;2)

Bibby, C. J., Hill, D. A., Burgess, N. D. & Mustoe, S. 2005 *Bird census techniques*. London, UK: Academic Press.

Chernobyl Forum 2005 *Chernobyl: the true scale of the accident*. New York, NY: IAEA, WHO, UNDP.

EGE 2005 *Environmental consequences of the Chernobyl accident and their remediation: twenty years of experience*. New York, NY: IAEA, WHO, UNDP.

Møller, A. P. 2001 The effect of dairy farming on barn swallow *Hirundo rustica* abundance, distribution and reproduction. *J. Appl. Ecol.* **38**, 378–389. (doi:10.1046/j.1365-2664.2001.00593.x)

Møller, A. P. & Mousseau, T. A. 2007*a* Determinants of interspecific variation in population declines of

Received 22 October 2007
Accepted 2 November 2007

RSBL 20070528—10/11/2007—09:57—SHYLAJA—287023—XML – pp. 1–3

birds from exposure to radiation at Chernobyl. *J. Appl. Ecol.* **44**, 909–919. (doi:10.1111/j.1365-2664.2007.01353.x)

Møller, A. P. & Mousseau, T. A. 2007*b* Species richness and abundance of birds in relation to radiation at Chernobyl. *Biol. Lett.* **3**, 483–486. (doi:10.1098/rsbl.2007.0226)

Møller, A. P., Mousseau, T. A., Milinevsky, G., Peklo, A., Pysanets, E. & Szép, T. 2005 Condition, reproduction and survival of barn swallows from Chernobyl. *J. Anim. Ecol.* **74**, 1102–1111. (doi:10.1111/j.1365-2656.2005.01009.x)

Møller, A. P. *et al.* 2006 An analysis of continent-wide patterns of sexual selection in a passerine bird. *Evolution* **60**, 856–868.

Møller, A. P., Mousseau, T. A., de Lope, F. & Saino, N. 2007 Elevated frequency of abnormalities in barn swallows from Chernobyl. *Biol. Lett.* **3**, 414–417. (doi:10.1098/rsbl.2007.0136)

Rosenthal, E. 2005 Chernobyl's dangers called far exaggerated. In *Int. Herald Tribune 6 September*.

Q4 Smith, J. T. In press. Is Chernobyl radiation really causing negative individual and population-level effects on barn swallows. *Biol. Lett.*

RSBL 20070528—10/11/2007—09:57—SHYLAJA—287023—XML – pp. 1–3