



(The USC Chernobyl + Fukushima Research Initiative

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SUMMARY OF THE INITIATIVE AND ITS RESEARCH

The Chernobyl Research Initiative began formal research activities in Ukraine in 2000, Belarus in 2005, and Fukushima, Japan, in July, 2011. To date, the group has conducted more than 30 research expeditions to Chernobyl and 10 expeditions to Fukushima.

Key funding sources have included the Samuel Freeman Charitable Trust, the CNRS (France), the National Science Foundation, and the National Geographic Society. Subsequently, additional funding sources have included NATO, the Civilian Research Development Foundation (CRDF), the National Institutes of Health (NIH), Qiagen GmbH, the Fulbright Foundation, the University of South Carolina Office of Research and the College of Arts and Sciences, the Academy of Finland, and gifts from private citizens.

To date, more than 60 scientific publications have resulted from this initiative, most in the past seven years (see attached list for 2013 publications), with many others in progress. This research has been highlighted in many newspaper reports and television programs including the New York Times, The Economist, Harpers, the BBC, CNN and the PBS News Hour (see attached list for 2013 media coverage). In addition, Mousseau has delivered 23 keynote and public lectures in 2013 alone (list attached) including a lecture at the Japanese House of Representatives in Tokyo (July 2013).

The team has pioneered the use of advanced ecological, genetic and dosimetric technologies in order to unravel the health and environmental consequences of chronic low-dose exposure resulting from the Chernobyl and Fukushima disasters. These have included massively replicated ecological censuses of natural populations of birds, mammals and insects to investigate population and demographic effects; DNA sequencing and genotoxicity testing to assess short and long term genetic damage to individuals living in the wild; and the use of miniature dosimeters attached to wild animals and field measurements of whole body burdens of radioisotopes in birds and mammals to obtain accurate estimates of realized external and internal radiation doses to animals living under natural

conditions. Recently, the group has expanded to include epidemiological and genetic studies of human populations (especially children) living in Chernobyl-affected regions of Ukraine.

Key results published in 2013 include the discovery of tumors, cataracts and damaged sperm in birds from high radiation areas of Chernobyl, and impacts on biodiversity in Fukushima. Exciting as yet unpublished results include the discovery that some species of birds may have developed resistance to the effects of radiation and effects on neurological development in small mammals in both Chernobyl and Fukushima.

USC's Chernobyl Research Initiative was the first and currently is the only research group to utilize a multidisciplinary approach to address the health and environmental outcomes of radiation effects in free-living natural populations. This has permitted the investigation of both acute (short term) and chronic (long term and multi-generational) exposures.

The Chernobyl Research Initiative is also currently the only research team working in both Chernobyl and Fukushima. These two disasters differ in the time since the events, and the amount and diversity of radionuclides that were released, although the predominant source of radiation is cesium-137 in both locations.

INITIATIVE GOALS FOR 2014-15

The following is a summary of ongoing and planned future research activities of the Chernobyl + Fukushima Research Initiative:

- 1) Continued monitoring of Fukushima populations of birds, small mammals, and insects in order to test for changes in population sizes (abundances) and numbers of species (biodiversity) through time.
- 2) Continued monitoring of barn swallows and rodents (mice and voles) populations for cancers, survival, reproduction, and genetic damage in Fukushima and Chernobyl (in collaboration with the CNRS, France, Rikkyo University, Tokyo, the Wild Bird Society of Japan, the National Institute of Forestry, Japan, and the University of Jyväskylä, Finland).
- 3) Initiate a new project to study effects of radiation on tree growth and soil microbial activity in Fukushima (in collaboration with Chubu University, Nagoya, Japan).
- 4) Initiate a new project to investigate effects of radiation growth, fertility, and genetic damage in cows living in highly radioactive regions of Fukushima (in collaboration with the Fukushima Cattle Ranchers Association).
- 5) Initiate a new project to examine mutation rates in humans using whole genome DNA sequencing. Initially this project will focus on families living in contaminated regions of Ukraine. The project is in collaboration with the Montreal Neurological Institute and Hospital at McGill University, the Center of Radiological Research at Columbia University, and the Institute for Radiation Medicine in Kiev, Ukraine.
- 6) Continued development of new methods for measurement of dose and genetic damage in wild populations of animals.
- 7) Coordination of an international consortium of independent scientists to provide unbiased evidenced-based information concerning the health and environmental risks related to nuclear accidents. This group will compile, evaluate, and interpret the current scientific and medical literature and develop a literature

suitable for public distribution via the print and internet media, as well as public presentations in Japan and internationally.

RESEARCH HIGHLIGHTS PUBLISHED BY THE CHERNOBYL RESEARCH INITIATIVE:

- Population sizes and numbers of species (i.e. biodiversity) of birds, mammals, insects, and spiders are significantly lower in areas of high contamination in Chernobyl.
- For many birds and small mammals, life spans are shorter and fertility is depressed, in areas of high contamination.
- In Fukushima, only birds, butterflies, and cicadas showed significant declines during the first summer following the accident. Other groups were not negatively affected.
- There is considerable variability among species in their sensitivity to radionuclides. Many species are not affected, and a few species even appear to increase in numbers in areas of high contamination in both Chernobyl and Fukushima, presumably in response to competitive release (i.e. more available food and shelter) and fewer predators.
- Many species show evidence of genetic damage stemming from acute exposures and the differences observed between Fukushima and Chernobyl suggests some species may show the consequences of mutation accumulation over multiple generations.
- Some individuals and species show no evidence of genetic damage in relation to radiation exposure and some even show evidence of evolutionary adaptation to the effects of radiation through increased antioxidant activity, which may provide protection against ionizing radiation.
- The bird species that are most likely to show declines in numbers in response to radiation are those that historically have shown increased mutation rates for other reasons possibly related to DNA repair ability or reduced defenses against oxidative stress.
- Deleterious effects of radiation exposure seen in natural populations in Chernobyl include increased rates of cataracts, tumors, growth abnormalities, deformed sperm, and albinism.
- Neurological development is impacted as evidenced by depressed brain size in both birds and rodents and consequent effects on cognitive ability and survival have been demonstrated in birds.
- Tree growth and microbial decomposition in the soil are also depressed in areas of high radiation.
- In Fukushima, the first signs of developmental abnormalities have been observed in birds in 2013, although significant genetic damage has not yet been documented.

Publications – 2013

1. Mousseau, T.A., S.M. Welch, I. Chizhevsky, O. Bondarenko, G. Milinevsky, D. Tedeschi, A. Bonisoli-Alquati, and Møller, A.P., 2013. Tree rings reveal extent of exposure to radiation in Scots pine, *Pinus sylvestris*. **Trees – Structure and Function**, DOI 10.1007/s00468-013-0891-z
2. Mousseau, T.A., and A.P. Møller. Elevated frequencies of cataracts in birds from Chernobyl. **PLoS One**, 8(7): e66939. Doi:10.1371/journal.pone.0066939.
3. Hermosell, I.G., T. Laskemoen, M. Rowe, A.P. Møller, T.A. Mousseau, T. Albrecht, J.T. Lifjeld. 2013. Patterns of sperm damage in Chernobyl passerine birds suggest a trade-off between sperm length and integrity. **Biology Letters** 9(5):20130530. Doi: 10.1098/rsbl.2013.0530
4. Møller, A.P., A. Bonisoli-Alquati, and T.A. Mousseau. 2013. High frequencies of albinism and tumors in free-living birds at Chernobyl. **Mutation Research**, 757:52-59.
5. Møller, A.P., and T.A. Mousseau. 2013. The effects of low-dose radiation: Soviet science, the nuclear industry – and independence? **Significance** 10(1): 14-19.
6. Møller, A.P., and T.A. Mousseau. 2013. Assessing effects of radiation on abundance of mammals and predator-prey interactions in Chernobyl using tracks in the snow. **Ecological Indicators**, 26: 112-116.
7. Møller, A.P., Mousseau, T.A., 2013. Investigating the effects of low-dose radiation from Chernobyl to Fukushima: History repeats itself. **Asian Perspective**, 37:551-656.
8. Møller, A.P. and T.A. Mousseau. 2013. The effects of natural variation in background radioactivity on humans, animals and other organisms. **Biological Reviews**, 88:226-254.
9. Møller, A.P., I. Nishiumi, H. Suzuki, K. Ueda, and T.A. Mousseau. 2013. Differences in effects of radiation on abundance of animals in Fukushima and Chernobyl. **Ecological Indicators**, 14: 75-81. (<http://dx.doi.org/10.1016/j.ecolind.2012.06.001>).
10. A.P. Møller, S. Merino, F. de Lope, T. Eeva, E. Flensted-Jensen, H. Gwinner, D. Heylen, K. Klarborg, J. Martínez de la Puente, A. Marzal, E. Matthysen, P. Matyjasiak, M. Molina, T.A. Mousseau, J. Tøttrup Nielsen, P. Pap, J. Rivero de Aguilar, J. J. Soler, T. Szép and N. Ziane. 2013. Quantifying effects of climate change on host-parasite interactions: A comparative study of European birds and their parasites. **PLoS ONE** 8(12): e82886. Doi:10.1371/journal.pone.0082886.
11. Møller, A.P., and T.A. Mousseau. 2013. Low-dose radiation, scientific scrutiny, and requirements for demonstrating effects. **BMC Biology** 11(92): doi:10.1186/1741-7007-11-92.
12. T. Laskemoen, T. Albrecht, A. Bonisoli-Alquati, J. Cepak, F. de Lope, I. G. Hermosell, L. E. Johannessen, O. Kleven, A. Marzal, T. A. Mousseau, A. P. Møller, R. J. Robertson, G. Rudolfson, N. Saino, Y. Vortman, J.T. Lifjeld. 2013. Variation in sperm morphometry and sperm competition among barn swallow (*Hirundo rustica*) populations. **Behavioral Ecology and Sociobiology**, 67(2): S 301-309 (DOI: 10.1007/s00265-012-1450-0).
13. Møller, A.P., and T.A. Mousseau. 2013. Uncomfortable questions in the wake of nuclear accidents at Fukushima and Chernobyl. *The Asia-Pacific Journal* 11(13):#1.
14. Mousseau, T.A., G. Milinevsky, J. Kenney-Hunt, A.P. Møller. Highly reduced mass loss rates and increased litter layer in radioactively contaminated areas. *Oecologia*, Tentatively accepted, pending final revisions.
15. Burlakova, E.B., D. M. Grodzinsky, K.N. Lohanovsky, T.A. Mousseau, A.P. Moller, M.V. Naboka, V.M. Shestopalov. Chernobyl and the new knowledge of the effects of low-dose radiation. **Radiation Biology** (In Russian), in press.
16. Galvan, I., A. Bonisoli-Alquati, S. Jenkinson, G. Ghanem, K. Wakamatsu, T.A. Mousseau, A.P. Møller. Chronic exposure to low-dose radiation at Chernobyl favors adaptation to oxidative stress in birds. In review.
17. Jenkinson, S., A. Bonisoli-Alquati, A.P. Møller, D.A.E. Beasley, T.A. Mousseau. Rate of development, not parental radiation exposure, predicts genetic damage in grasshoppers (*Chorthippus albomarginatus*). In review.

Public Lectures – 2013

- Keynote Speaker, Wild Bird Society of Japan Annual Meeting, Chiba, Japan, November 9, 2013
- Keynote Speaker, House of Representatives, Tokyo, Japan, July 29, 2013
- National Council for Science and the Environment, Washington, DC, January 2013, Plenary presentation, “Japan 2011:Cascading Disasters” (televised on C-SPAN).
- Keynote Speaker, USC TRIO Programs closing reception, June 27, 2013.
- The South Carolina Association of Naturalists, January 2013, Keynote lecture, “The Impacts of the Fukushima and Chernobyl Disasters on Wildlife”
- Citizen’s Group, Kokura, Japan, November 18, 2013
- University of Tokyo, Japan, November 16, 2013
- Koriyama Citizens Group, Japan, July 30, 2013
- Hamamatsu Citizens Group, Japan, July 23, 2013
- Osaka Citizens Group, Japan, July 25, 2013
- Otsu Citizens Group, Japan, July 26, 2013
- The New York Academy of Medicine, March 2013, “The Medical and Ecological Consequences of Fukushima”
- The 3rd Citizen-Scientist International Symposium on Radiation Protection, Tokyo National Olympics Memorial Youth Center, Oct 13th, 2013, “Non-Human Animal Models for Effects of Radiation Exposure in Nature”
- Society for Molecular Biology and Evolution meetings, Chicago, July 8, 2013, “Chernobyl, Fukushima and Other Hot Places”
- National Council for Science and the Environment, Washington, DC, January 2013, Symposium presentation, “Ecosystem Impacts from Nuclear Energy: Lessons from Chernobyl and Fukushima”
- National Institute of Biomedical Innovation, Osaka, Japan, Nov 13, 2013
- Tohoku University, Dept of Pathology, November 17, 2013
- Osaka University, Osaka, Japan, July 24, 2013
- Chubu University, Nagoya, Japan, July 27, 2013
- University of Lancaster, February 2013, “Uncertainties in field studies on chronic low level effects due to radiation”
- Imperial College, February 2013, “Chernobyl, Fukushima, and Other Hot Places: Biological Consequences”
- George Washington University, Asian Studies Program, March 2013, “Ecological Consequences of the Fukushima Disaster”
- George Washington University, January 2013, Nuclear Studies Program, “Chernobyl, Fukushima, and Other Hot Places: Biological Consequences”

Newspaper and Magazine Coverage of the Chernobyl Research Initiative – 2013

- The Economist: Radiation and Birds: Not So Blindingly Obvious, Sept 7, 2013
- BBC News: Chernobyl's legacy recorded in trees (Mark Kinver), August 8, 2013
- The Weather Channel: Seven Unexpected Places Wildlife Call Home - Pripyat, Ukraine, Sept 18, 2013.
- NRK (Norway): Tsjernobyl-ulykka kan lesast av i arringar (Unni Eikeseth), Aug 8, 2013.
- Le Figaro: Tchernobyl a ralenti la croissance des arbres (Cyrille Vanlergerghe), Aug 16, 2013
- UPI: Legacy of 1986 Chernobyl disaster seen in impact on region's forests, August 9, 2013
- Nature World News: Trio of new studies suggest lingering environmental effects from Chernobyl Incident (James A. Foley), August 9, 2013.
- USC News: Viewing Fukushima in the cold light of Chernobyl (Steven Powell), August 8, 2013. (widely reprinted across the web)
- Anne Fontaine Foundation Blog: The growth of trees in Ukraine slowed by Chernobyl radiations (Ségolène Brunisholz), Aug 21, 2013
- Kottke.org: The trees of Chernobyl, Aug 9, 2013
- Nature: Fukushima offers real-time ecolab (Ewen Callaway), July 16, 2013
- ABCNews: Deformed Vegetables, fruit, reportedly pop up around Japan nuclear plant (Kevin Dolak), July 18, 2013
- SFORA Newsy: Tak po scieciu wygladaja drzewa z Czarnobyla, Aug 10, 2013.
- Asian Scientist: Viewing Fukushima in the cold light of Chernobyl, Aug 26, 2013
- Homeland Security News Wire: Long-term radiation effects: Chernobyl's lessons for Fukushima, Aug 26, 2013
- Open Your Eyes: Tchernobyl, Fukushima, consequences biologiques - Dr. T. Mousseau, Aug 15, 2013
- Vivre apres Fukushima: Tchernobyl est-il vraiment devenu un eden pour la vie sauvage? Aug 25, 2013
- BistroBarBlog: Consequences biologique des catastrophes de Tchernobyl et Fukushima, Aug 22, 2013
- Science Newsline Biology (Japan): チェルノブイリの現在から判るフクシマの未来, Aug 26, 2013
- Earthsky.org: Understanding the radioactive legacy of Chernobyl and Fukushima (Shireen Gonzaga), Sept 3, 2013
- BreakthruRadio.com: Wildlife of Chernobyl - Taboo week (Tanya Silverman), Sept 3, 2013
- WashingtonsBlog: What is the ACTUAL Risk for Pacific Coast Residents from Fukushima Radiation?, Dec 1, 2013

Selected TV and Radio Coverage of the Chernobyl Research Initiative - 2013

- ARD TV (Germany): Zu viel Regen Fur Fukushima (Philipp Abresch), Oct 21, 2013 (video here)
- Tokyo Broadcasting System: Nightly News (producer Takao Kanagawa), Sept 11, 2013
- Animal Planet: River Monsters with Jeremy Wade: Excerpt from “Atomic Assassin”, April 14, 2013.
- HUFFPOST Live (WorldBrief with Carol Moderessy) : Record radiation readings near Fukushima, Sept 4, 2013.
- HUFFPOST Live (Hosted by Josh Zepps): Fukushima 2 Years Later, March 13, 2013 (5:36 in)
- Living Well Show: What ARE the long term effects of nuclear accidents (Donna Descoteaux), June 2013. (Part 1) (Part 2)
- C-SPAN: NCSE - 2013 Disaster Conference, Ronald Reagan Building, Plenary Session Japan’s 2011 Earthquake, January 15, 2013
- New York Academy of Medicine: Symposium: The Medical and Ecological Consequences of the Fukushima Nuclear Accident (Mousseau - Day 1, Session 2), March 11, 2013
- BistroBarBlog: Consequences biologique des catastrophe de Tchernobyl et Fukushima, Aug 22, 2013 (French translation of NYAM presentation, March 11, 2013).
- WIS TV News: Fukushima Two Years Later (Hannah Horne), March 12, 2013
- The Katherine Albrecht Show, January 19, 2013.
- Tokyo Broadcasting System: Nightly News, December 2012.
- GeoBeats: Chernobyl Nuclear Fallout Still Affecting Trees, August 12, 2013