What 'Chernobyl dogs' can tell us about survival in contaminated environments

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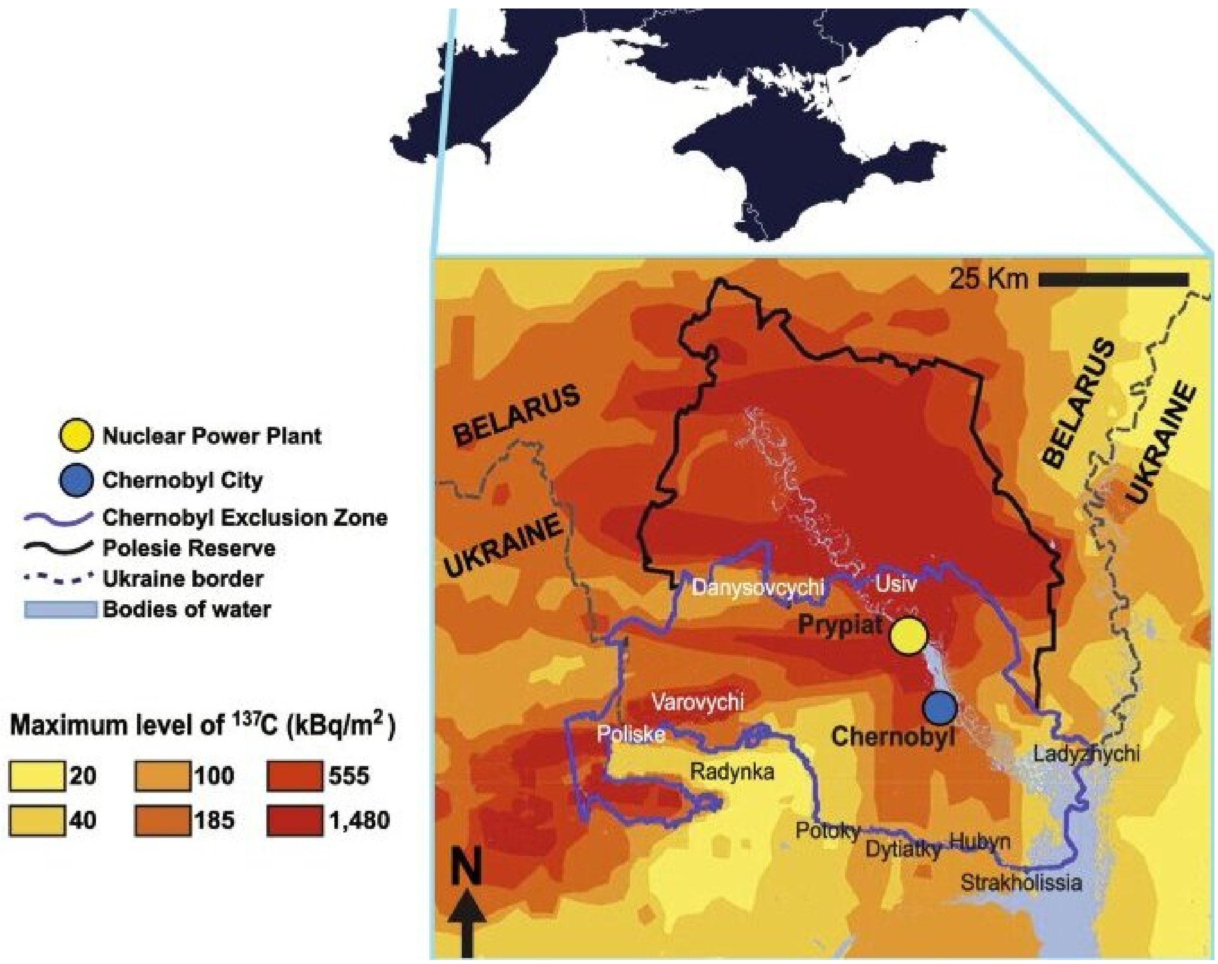

Map of sampling locations. Zoomed in portion of map highlights cesium deposition across Chernobyl Exclusion Zone (blue outline) in Northern Ukraine and a portion of Southern Belarus, adapted from Ager et al. Sampling locations are indicated, with Nuclear Power Plant (N = 60) in yellow and Chernobyl City (N = 56) in blue. Credit: *Canine Medicine and Genetics* (2023). DOI:

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In the first step toward understanding how dogs—and perhaps humans—might adapt to intense environmental pressures such as exposure to radiation, heavy metals, or toxic chemicals, researchers have found that two groups of dogs living within the Chernobyl Exclusion Zone, one at the site of the former Chernobyl reactors, and another 16.5 km away in Chernobyl City, showed significant genetic differences between them.

The results indicate that these are two distinct populations that rarely interbreed. While earlier studies focused on the effects of the Chernobyl Nuclear Power Plant disaster on various species of wildlife, this is the first investigation into the genetic structure of stray dogs living near the Chernobyl nuclear power plant.

The 1986 Chernobyl nuclear power plant disaster displaced more than 300,000 people living nearby and led to the establishment of an Exclusion Zone, a "no man's land" of an approximately 30 km radius surrounding the damaged reactor complex.

While a massive steam explosion releasing enormous amounts of ionizing radiation into the air, water, and soil was the direct cause of the catastrophe, radiation exposure is not the only environmental hazard resulting from the disaster. Chemicals, toxic metals, pesticides, and organic compounds left behind by years-long cleanup efforts and from abandoned and decaying structures, including the nearby abandoned city of Pripyat and the Duga-1 military base, all contribute to an ecological and environmental disaster.

"Somehow, two small populations of dogs managed to survive in that highly toxic environment," noted Norman J. Kleiman, Ph.D., assistant professor of Environmental Health Sciences at Columbia Mailman School of Public Health, and a co-author. "In addition to classifying the population dynamics within these dogs at both locations, we took the first steps towards understanding how chronic exposure to multiple environmental hazards may have impacted these populations."

"The overarching question here is: does an environmental disaster of this magnitude have a genetic impact on life in the region?" says Matthew Breen, Oscar J. Fletcher Distinguished Professor of Comparative Oncology Genetics at NC State, and a corresponding author. "And we have two populations of dogs living at and near the site of a major environmental disaster that may provide key information to help us answer that question."

Earlier research by the co-authors, led by collaborators at NIH, used a much smaller set of genetic variants, but a larger number of dogs, to show that the two populations were separate and that each had complicated family structures.

In this parallel study, the team analyzed the dog DNA samples with four times the number of genetic variants, which provided a closer look at the genomes. In addition to confirming that the two populations are indeed genetically distinct, the team were also able to identify 391 outlier regions in the genomes of the dogs that differed between dogs living at the two locations.

"Think of these regions as markers, or signposts, on a highway," Breen says. "They identify areas within the genome where we should look more closely at nearby genes. Moreover, some of these markers are pointing to genes associated with genetic repair; specifically, with genetic repair after exposures similar to those experienced by the dogs in Chernobyl."

He went on to say "at this stage we cannot say for sure that any genetic alterations are in response to the multigenerational and complex exposures; we have a lot more work to do to determine if that is the case"

"The question we must answer now are why are there striking genetic differences between the two dog populations?" says Megan Dillion, Ph.D. candidate at NC State and a lead author of the published study. "Are the differences just due to genetic drift, or are they due to the unique environmental stressors at each location?"

"The dog is a sentinel species," Breen says. "By and teasing out whether or not the genetic changes we detected in these dogs are the canine genome's response to the exposures the populations have faced, we may be able to understand how the dogs survived in such a hostile environment and what that might mean for any population—animal or human—that experiences similar exposures."

"Though 37 years have passed since the accident, the ~30-year-long half-lives of lingering radioisotopes means the danger posed by radiation exposure is still very much real," notes Kleiman, who is also director of the Columbia University Radiation Safety Officer Training course.

"When radiation exposure is combined with a complex toxic chemical mixture of uncertain composition, there are very real human health concerns raised for the thousands of people who continue to work within the Exclusion Zone on continuing cleanup efforts as well as at two newly constructed nuclear fuel reprocessing plants."

"Understanding the genetic and health impacts of these chronic exposures in the dogs will strengthen our broader understanding of how these types of environmental hazards can impact humans and how best to mitigate health risks."

The research appears in *Canine Medicine and Genetics.*

More information: Megan N. Dillon et al, Population dynamics and genome-wide selection scan for dogs in Chernobyl, *Canine Medicine and Genetics* (2023). DOI: 10.1186/s40575-023-00124-1

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