INSTITUT
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ET DE SÛRETÉ NUCLÉAIRE

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Information Notice

IRSN analysis of the Japanese study on the biological impact of the Fukushima nuclear accident, published by the scientific journal *Nature* on 9 August 2012

IRSN's laboratories are involved in several scientific collaborations with Japanese universities and scientific organizations focusing on the environmental impact of the Fukushima accident. The Institute's science watch team also focuses on the main scientific publications on this subject. Within this context, it has produced an analysis of the recently published article on mutations observed in a butterfly species.

On 9. August 2012, the scientific journal Nature published on its website an article entitled "*The biological impacts of the Fukushima nuclear accident on the pale grass blue butterfly*"[1]. The publication reveals cases of physiological and genetic damage in several generations of a butterfly population in the vicinity of the Fukushima Daiichi nuclear power plant. In the weeks following its publication, the article was given considerable coverage in the French and international press.

Few scientific publications to date have reported on the results of studies relating to the ecological impact of the Fukushima accident. To the best of IRSN's knowledge, only two reports, by Anders Møller's CNRS team on observations of ecological effects within a 100 km radius of the Fukushima Daiichi site, predate the Japanese study. The interpretation given to the results of A. Møller's team, however, has been disputed in some scientific circles and needs to be confirmed. This is largely because:

i) dose rates to organisms have not been estimated in a reliable manner or properly characterized;

ii) and no details are given as to the statistical method applied for processing the data used.

In this new study led by Professor Otaki's team, the authors chiefly base the relevance of their work on the main results of A. Møller's team following the Chernobyl disaster. These include a change in specific diversity, as well as reduced abundance particularly affecting a number of bird and insect species. This is connected with the level of ambient gamma radiation, essentially in the exclusion zone around the Chernobyl nuclear power plant. The authors also shed more light on the subject by reproducing some of their field observations in laboratory experiments.
One of the aims of this Japanese study was to examine the causal relationship between the level of radiation exposure and the physiological condition (morphology, developmental characteristics from egg to adult) of the population of *Zizeeria maha*, a species of blue butterfly that is very widespread in Japan. This species is a "bioindicator", which means that its state of health and/or abundance can provide precious early warning of various changes in environmental conditions including, in particular, the presence of different types of stressor. This characteristic has led the species to be used, for example, to explore the possible impact of transgenic maize pollen on insect populations.

Based on various studies carried out *in situ* and in the laboratory, the authors conclude that the population of *Z. maha* in the vicinity of Fukushima has experienced physiological and genetic

[1] Hiyama et al. "The biological impacts of the Fukushima nuclear accident on the pale grass blue butterfly" SCIENTIFIC REPORTS | 2 : 570 | DOI: 10.1038/srep00570 1

damage. Abnormalities found in the first generation following the accident were not necessarily observed in parents exposed at the larval stage. In the authors' opinion, the existence of these varied and unexpected abnormal phenotypes cannot be explained simply by the phenotypic plasticity[2] that normal populations may exhibit in response to changes in their environment. Furthermore, the hypothesis that genes with an important role in morphological development might inherit the observed mutations is borne out by the increase in the abnormality rate from one *in situ* generation to the next, despite the fact that absorbed dose probably decreases over generations owing to the decay of short-lived radioisotopes. Epigenetic[3] processes cannot be completely ruled out either.

IRSN's analysis of this publication shows that the Japanese study is both original and serious. Its main strength lies in the interrelatedness of the *in situ* and laboratory studies and in the adoption of experimental methods, normally used in evolutionary ecology, to identify which observable changes in traits (and their accumulation over generations) are due to mutations, and which are due to direct physiological and radiotoxic effects, in other words, changes in traits observed within the exposed generation.

Its weak point, however, is that the estimation of *in situ* radiological exposure is based entirely on the measured external dose rate and ignores the contribution of internal contamination through the ingestion of contaminated plants. This has led to doses to these organisms being underestimated – perhaps significantly so. For this reason – and given the clear evidence of impact – this work should be backed up by a dosimetric study that takes into account both external and internal exposure, in order to assess the exposure of the population studied with greater accuracy. Scientific evidence should also be provided to demonstrate that other stressors, such as metals and other pollutants (multiple pollution context) that might be found in the area, have no significant impact.

[2] Phenotypic plasticity is the ability of an organism to exhibit different phenotypes (i.e. observable traits such as colour and shape) from a given genotype (i.e. all of an individual's genes) as a function of the biotic and/or abiotic environment.

[3] Epigenetics: the study of heritable changes in gene function that cannot be attributed to a change in nuclear DNA sequence.