

RESEARCH ARTICLE

# Maternal Exposure to Cadmium and Manganese Impairs Reproduction and Progeny Fitness in the Sea Urchin *Paracentrotus lividus*

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## Abstract

Metal contamination represents one of the major sources of pollution in marine environments. In this study we investigated the short-term effects of ecologically relevant cadmium and manganese concentrations ( $10^{-6}$  and  $3.6 \times 10^{-5}$  M, respectively) on females of the sea urchin *Paracentrotus lividus* and their progeny, reared in the absence or presence of the metal. Cadmium is a well-known heavy metal, whereas manganese represents a potential emerging contaminant, resulting from an increased production of manganese-containing compounds. The effects of these agents were examined on both *P. lividus* adults and their offspring following reproductive state, morphology of embryos, nitric oxide (NO) production and differential gene expression. Here, we demonstrated that both metals differentially impaired the fertilization processes of the treated female sea urchins, causing modifications in the reproductive state and also affecting NO production in the ovaries. A detailed analysis of the progeny showed a high percentage of abnormal embryos, associated to an increase in the endogenous NO levels and variations in the transcriptional expression of several genes involved in stress response, skeletogenesis, detoxification, multi drug efflux processes and NO production. Moreover, we found significant differences in the progeny from females exposed to metals and reared in metal-containing sea water compared to embryos reared in non-contaminated sea water. Overall, these results greatly expanded previous studies on the toxic effects of metals on *P. lividus* and provided new insights into the molecular events induced in the progeny of sea urchins exposed to metals.