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Nurse sharks, space rockets and cargo ships: Metals and oxidative stress in a benthic, resident and large-sized mesopredator, *Ginglymostoma cirratum*☆

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ABSTRACT

It is widely recognized that apex predators, such as large sharks with highly migratory behavior, are particularly vulnerable to pollution, mainly due to biomagnification processes. However, in highly impacted areas, mesopredator sharks with resident behavior can be as vulnerable as apex sharks. In this context, this study evaluated cadmium (Cd), mercury (Hg), lead (Pb), and rubidium (Rb) concentrations, as well as the potentially protective effects of selenium (Se) and the behavior of two non-enzymatic biomarkers, metallothionein (MT) and reduced glutathione (GSH), employing the Atlantic nurse shark *Ginglymostoma cirratum* as a study model and compared the results with other resident benthic sharks, as well as highly mobile apex sharks. Muscle tissue samples from 28 nurse sharks opportunistically sampled from the Brazilian Amazon Coast were analyzed. Lower metal concentrations were observed for Pb, Rb and Se in the rainy season, while statistically significant correlations between metals were observed only between Hg and Cd and Pb and Se. Molar ratio calculations indicate potential protective Se effects against Pb, but not against Cd and Hg. No associations between MT and the determined metals were observed, indicating a lack of detoxification processes via the MT detoxification route. The same was noted for GSH, indicating no induction of this primary cellular antioxidant defense. Our results indicate that benthic/mesopredator sharks with resident behavior are, in fact, as impacted as highly mobile apex predators, with the traditional detoxification pathways seemingly inefficient for the investigated species. Moreover, considering the studied population and other literature data, pollution should be listed as a threat to the species in future risk assessments.

1. Introduction

Among the criteria used to assess species extinction risks both at the global and regional levels, population size reduction, labeled as criteria A by the International Union for Conservation of Nature red list committee, is the most commonly applied (IUCN, 2012). Among all threats to biodiversity, human exploitation has proven the main driving force for the extinctions observed in the last centuries (Pievani, 2014), as the removal of parental biomass from a population significantly compromises species recruitment (Ricker, 1954). Population reduction can also result from other direct or indirect anthropic pressures. More specifically, along with introduced taxa, hybridization, pathogens, competitors, or parasites, pollutants are also considered driving factors for population declines (IUCN, 2012) and conservation plans should consider the potential impacts of pollution on population health and resilience (Deem et al., 2001).

Allied to this, geographic distribution reduction, whether caused by habitat loss or overexploitation on a local scale, also significantly compromises biodiversity conservation. In the marine environment, pollution has been highlighted as a significant yet emerging contributing

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