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Fine scale distribution constrains cadmium accumulation rates in two geographical groups of Franciscana dolphin from Argentina

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ABSTRACT

Franciscana dolphin is an endemic cetacean in the southwestern Atlantic Ocean and is classified as Vulnerable A3d by the International Union for Conservation of Nature. Cadmium accumulation was assessed in two geographic groups from Argentina; one inhabits the La Plata River estuary, a high anthropogenic impacted environment, and the other is distributed in marine coastal, with negligible pollution. Despite the environment, marine dolphins showed an increase of renal Cd concentrations since trophic independence; while in estuarine dolphins was from 6 years. This is associated with dietary Argentine anchovy which was absent in the diet of estuarine dolphins, being a trophic vector of cadmium in shelf waters of Argentina. Cluster analysis also showed high levels of cd in association with the presence of anchovy in the stomach. The difference in the fine scale distribution of species influences dietary exposure to Cd and, along with other data, indicates two stocks in Argentina.

1. Introduction

Cadmium (Cd) is a toxic element even at very low concentrations (Goyer and Clarkson, 2001) and has no known physiological function. It is considered a hazardous environmental pollutant widely distributed in nature, with a broad spectrum of toxic effects in mammals including nephrotoxicity, hypertension and osteomalacia (García Rico et al., 2002). Bioaccumulation in the food chain is considered the major risk for the top predators (Das et al., 2003).

The longevity of cetaceans and their upper trophic level, diet contribute to the accumulation of metals in their tissues. Marine mammals are exposed to trace metals such as Cd mainly in their food, which can have qualitative and quantitative effects on metal accumulation (Monaci et al., 1998; Das et al., 2003; Dorneles et al., 2007; Gerpe et al., 2002; Seixas et al., 2007).

Franciscana dolphin (*Pontoporia blainvillei* Gervais and D'Orbigny, 1844) is a small and endemic dolphin in the Southwestern Atlantic Ocean. Its geographic distribution ranges from Itaúnas (18° 25′S, 30° 42′W, Brazil; Siciliano, 1994) to Golfo Nuevo (42° 35′S, 64° 48′W, Argentina; Bastida et al., 2007). The International Union for Conservation of Nature (IUCN) has classified this dolphin as Vulnerable A3d throughout its range (Reeves et al., 2012). This classification is based on a population decline of more than 30% over three generations, with 2000–3000 dolphins incidentally captured in fishing nets each year.

Based on mitochondrial DNA, morphometric and population parameters, Secchi et al. (2003) proposed four Management Areas for Franciscana along the coast of South America. These areas correspond to two coastal zones (Areas I and II) in Brazilian waters, one zone (Area III) along the coast of southern Brazil and Uruguay, and one zone (Area IV) in Argentine waters (Fig. 1). More than 450 dolphins are incidentally entangled in fishing nets and killed annually captured in the Area IV, mainly in the northern waters of Argentina (Bastida et al., 2007; Cappozzo et al., 2007). Moreover, available information on home range (Bordino et al., 2008) and population genetics (Mendez et al., 2008, 2010) suggest discrete stockes within Area IV with limited interbreeding with animals Areas I–III to the north. Within this zone and along the coast of Buenos Aires Province, two main ecosystems occur with notable differences in environmental quality: the La Plata River estuary and the marine coast south of the esturary (Fig. 1). The main urban and industrial centers of Argentina and Uruguay are located along the La Plata River. The largest cities are Buenos Aires and La Plata (Argentina) and Montevideo (Uruguay), which have more than

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Fig. 1. Marine and estuarine sampling zones and Management Areas of whole geographic distribution of *Pontoporia blainvillei*.

15 million residents. Most urban and industrial waste and effluents are discharged into the river without treatment (Carsen et al., 2003). In contrast, the marine coastal area is unaffected by the contaminated estuarine waters. Some of the major tourist cities of Argentina are located in this area, but they produce little environmental impact on the coastal marine ecosystem. The goal of this study was to assess the influence of the home range on Cd accumulation in two geographic groups of Franciscana from Argentina.

2. Materials and methods

2.1. Sample collection

Muscle, liver and kidney samples were collected from 27 Franciscana dolphins incidentally caught in gillnets from artisanal fisheries. The entangled period was less than 10 h until sampling. Male and female dolphins were obtained from two coastal areas, estuarine ($n = 13$, ♀: 5 and ♂: 8) and marine ($n = 14$, ♀: 7 and ♂: 7) zones from Buenos Aires Province, northern Argentina (Fig. 1). Total length, weight and sex were determined for each dolphin. Gross analysis during necropsy revealed no significant indication of an unhealthy condition, and samples were frozen in liquid nitrogen and stored at −20 °C until analysis.

2.2. Age determination and fine scale adjustments to decimal year

Age was determined using Growth Layers Groups (GLGs) in dentine and cementum dental layers, and each GLG was considered to be one year (Pinedo and Hohn, 2000). Harrison et al. (1981) and Kasuya and Brownell (1979) found that peak calving for Franciscana in Uruguay occurs in November. In Argentine waters, based on chronological information of newly born, calving occurs from early October to early February with a peak in November (Denuncio, unpublished information). On the basis of this information, we used mid-November as the mean birth date for calves in this study.

2.3. Cd analysis

Cd concentration was determined by Atomic Absorption Spectrometry (Perkin–Elmer Analyst 300, Massachusetts, USA). Samples were digested with perchloric and nitric acid (1:3) according to the method of the FAO/SIDA (1983). Certified Reference Material LUTS-1 (Lobster hepatopancreas from the National Research Council of Canada) was used to validate results. Blanck was performed and it was treated under the same conditions of samples and Certified Reference Material. The detection limit was 0.05 μg g^{-1}, and the concentrations were expressed in μg g^{-1} in wet weight.

2.4. Annual Accumulation Rate (AAR)

To estimate the accumulation of hepatic and renal Cd as animals matured, the AAR was calculated using the following formula:

$$AAR = (CC_2 - CC_1)/GLG_2 - GLG_1$$

where CC_2 corresponds to Cd concentration at GLG_2, and CC_1 corresponds to Cd level at GLG_1. The AAR provides information about how Cd is accumulated every year (annually), meaning how the increase is within each year respect those of previous.

2.5. Statistical analyses

Homoscedasticity of data was checked with Levene test ($p < 0.01$). After that, statistical differences between Cd concentrations of geographic groups and between kidney and liver (within each area) were checked by the non-parametric test Mann Whitney, while the differences between levels in muscle were performed by the parametricStudent-t. All analyses were conducted with Statistica® 6.0 (Statsoft, Inc.).

3. Results

The kidneys had the highest concentration of Cd followed by the liver and skeletal muscle for both geographical groups (Fig. 2). However, marine dolphins showed significantly higher concentrations than those in the estuarine group, kidney ($U = 28.00000$; $p = 0.002235$) and liver (liver, $U = 32.50000$; $p = 0.004529$), but not for muscle ($t = 0.580428$; $p = 0.566821$).

An increase in Cd concentration with age was observed in the liver and kidneys of marine dolphins, although the curves showed different trends. Renal levels increased up to an age of 2 years and the distribution fit a Gompertz curve ($r = 0.71$; $p < 0.01$; Fig. 3). Increased hepatic concentrations showed a best fit to an exponential

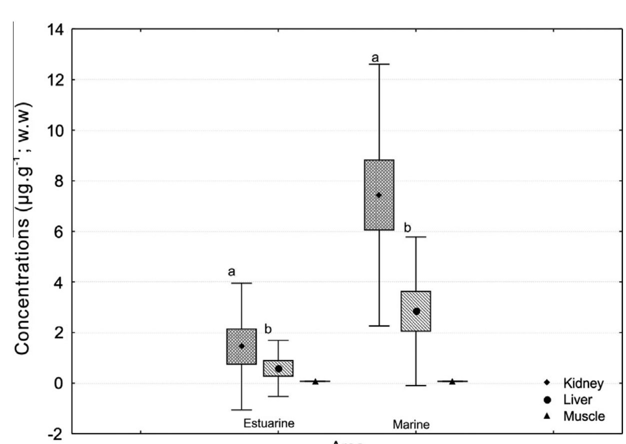

Fig. 2. Distribution pattern of cadmium concentration (μg g^{-1}, wet weight; mean ± standard deviation) in kidney, liver and muscle of *Pontoporia blainvillei*. Statistical differences between geographical groups were indicated, (a): $p = 0.05$, Mann–Whitney U Test and (b): $p < 0.05$, Mann–Whitney U Test.