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Accumulation of organochlorine pesticides in fat tissue of wild Nile crocodiles (*Crocodylus niloticus*) from iSimangaliso Wetland Park, South Africa

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HIGHLIGHTS

- First report on OCP concentrations in fat tissues from Nile crocodiles.
- Analyses reveal highly elevated DDT contaminant burdens.
- We describe a novel surgical technique for the analysis of fat from crocodilians.
- We highlight ecotoxicological concerns and the need to better understand risks.

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ABSTRACT

Nile crocodiles (*Crocodylus niloticus*) are important apex predators in many tropical and subtropical aquatic habitats throughout much of sub-Saharan Africa. In South Africa, large crocodile populations inhabit lakes and wetlands that are impacted by organochlorine pesticides (OCPs). Despite the continued use of these compounds and their potential adverse effects on key wildlife populations in southern Africa, limited ecotoxicoloigcal data exist. In this study, we examined the accumulation of OCPs in fat tissues of live, wild Nile crocodiles from iSimangaliso Wetland Park, a region of significant biological importance. All samples ($n = 15$) contained multiple contaminants in highly elevated concentrations, with total residue burdens varying between 3600 and 8000 ng g^{-1} ww. DDT and its metabolites were the dominant compounds detected in most samples, with $\sum$DDT concentrations ranging between 520 and 3100 ng g^{-1} ww. Elevated levels of other OCPs were also detected, including lindane (67–410 ng g^{-1} ww), aldrin (150–620 ng g^{-1} ww) and heptachlor (170–860 ng g^{-1} ww). Our findings show that crocodiles are exposed to OCPs throughout their range within iSimangaliso Wetland Park and contain some of the highest concentrations ever recorded in crocodilian tissue. Results indicate the need for a greater understanding of the impacts of OCP exposure and toxicological responses in crocodiles from iSimangaliso, and in Nile crocodile populations in general. The novel surgical technique described in this study provides an effective method for assessing relationships between contaminant body burdens and their potential reproductive and developmental consequences in crocodilians.

1. Introduction

Organochlorine pesticides (OCPs) have been used extensively in South Africa (SA) since the early 1950s in agriculture and for disease-vector control, and DDT continues to be applied in the malaria endemic regions of the country. While the toxic and endocrine-disrupting nature of these compounds is now well established, their continued use in SA is of particular concern as application often occurs in close proximity to key areas of conservation. We recently reported the detection of high concentrations of several OCP residues in sediments from iSimangaliso Wetland Park (Buah-Kwofie and Humphries, 2017), located on the east coast of SA (Fig. 1). The park forms part of the Maputaland-Pondoland-Albany biodiversity hotspot, is a designated World Heritage Site,

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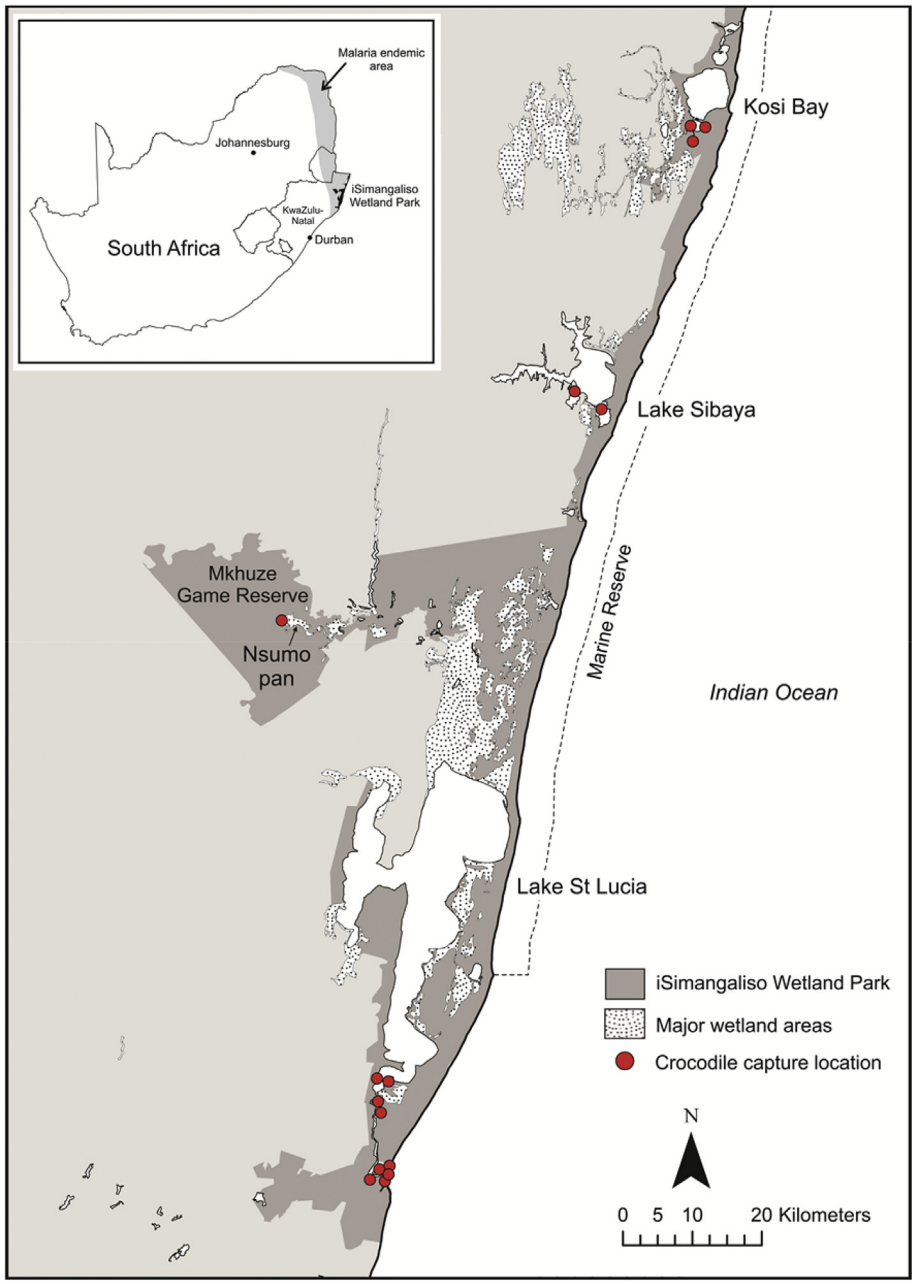

Fig. 1. Location of iSimangaliso Wetland Park showing crocodile sampling sites.

and is globally recognised as an important protected area for biological conservation (Porter, 2013). Despite the rich biodiversity of the region and widespread environmental occurrence of OCP residues, few studies on contaminant concentrations have been conducted in wildlife here.

OCPs tend to bioaccumulate in the food web because of their environmental persistence and affinity to fatty tissues (Arnot and Gobas, 2006). Owing to their high trophic status and long life span, crocodiles are particularly susceptible to the accumulation of contaminants released into the environment and OCP residues have been detected in crocodilians from multiple localities (e.g., Phelps et al., 1989; Campbell, 2002; Rauschenberger et al., 2004; Yoshikane et al., 2006; Wu et al., 2014). Contaminant studies have focused largely on residues in eggs and include American alligators (*Alligator mississippiensis*) (Heinz et al., 1991; Cobb et al., 1997; Sepúlveda et al., 2004), American crocodiles (*Crocodylus acutus*) (Hall et al., 1979; Wu et al., 2000), Morelet's crocodiles (*Crocodylus moreletii*) (Wu et al., 2000, 2006; Pepper et al., 2004), Nile crocodiles (*Crocodylus niloticus*) (Wessels et al., 1980; Phelps et al., 1986; Skaare et al., 1991; Bouwman et al., 2014) and broad-snouted caimans (*Caiman latirostris*) (Stoker et al., 2011). OCPs have also been detected in the caudal scutes of Morelet's crocodiles (Sherwin et al., 2016) and American crocodiles from Central America (Rainwater et al., 2007, 2011). Evidence suggests that OCP residues can be maternally transferred to developing eggs, potentially leading to reduced clutch size, reduced hatchling success and altered plasma steroid hormone concentrations (Guillette et al., 2000; Rauschenberger et al., 2004; Stoker et al., 2011). While such studies highlight the potential developmental and reproductive effects of OCP exposure in crocodilians, assessments based on egg