Chapter (non-refereed)

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CADMIUM AND MERCURY IN SEABIRDS

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ABSTRACT

At some colonies, seabirds can contain high levels of cadmium and mercury. Tissue metal levels are higher at some periods of the year than at others. Very high levels can be found in individuals which are members of breeding pairs and which could, therefore, be considered as 'apparently healthy'. Biochemical studies on seabirds with high toxic metal levels have shown that, in common with other vertebrates, they contain a metallothionein-like protein in their liver and kidney. However, despite the presence of this 'protective' protein, ultrastructural studies revealed that the kidneys of these seabirds had various types of nephrotoxic lesions which could be reproduced in the laboratory by dosing birds with cadmium and mercury. These findings open a number of questions about the significance of the toxic metal levels found in some colonies of seabirds.

INTRODUCTION

When this study began in 1976, there were relatively few data on the levels of metals in seabirds and no information on their possible significance. However, it was clear from unpublished work done earlier at Monks Wood that, on occasion, seabirds found dead on the shore could contain far higher levels of cadmium than were found in other species of birds. This observation raised the question as to what significance toxic metals had for seabirds, especially if the metals were accumulated as a result of pollution.

To investigate this question, it was necessary (i) to determine what the metal levels were in seabirds from a colony far from sources of pollution (as a natural 'control' observation); (ii) to determine whether seabirds contained metallothionein when they contained high metal levels; and (iii) to try to determine whether high levels of toxic metals were in any way deleterious to the birds. This report summarises the results of our investigations on seabirds to date.

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METHODS

Much of the work has concerned 3 species of birds, collected from 2 colonies. The colonies were St Kilda - off the west coast of Scotland in the north-east Atlantic, and the Isle of May - off the east coast of Scotland on the edge of the North Sea. The species studied were puffin (*Fratercula arctica*), fulmar (*Fulmarus glacialis*) and Manx shearwater (*Puffinus puffinus*).

Other procedures are described in papers referred to elsewhere in this report.

RESULTS

The initial data from St Kilda, largely obtained from birds that were members of breeding pairs, were surprising in that higher levels of cadmium were found in tissues of these birds than had then been reported in any other wild vertebrate (Bull *et al.* 1977). Substantial amounts of mercury were also found (Murton *et al.* 1978). These findings were confirmed in a subsequent study which also showed that the cadmium was not confined to the liver and kidney but was found in other organs, such as gonad, pancreas and intestine. In addition, the mercury was present in the form of methyl mercury (Osborn *et al.* 1979), generally regarded as more toxic than inorganic mercury - partly because it may not be as readily excreted.

A metallothionein-like protein was found in the tissues of the fulmar which, while binding much of the cadmium in the tissue, bound very little of the mercury (Osborn 1978). Although there was a body of evidence to suggest that metallothionein might protect animals from the effects of metals, it seemed worthwhile checking to see if kidney damage was associated with the high metal levels. To make such a study fully effective, it was necessary to examine not only birds contaminated with high levels of metals, but also birds that contained relatively little metal. Osborn (1979) described the intercolony differences in tissue metal concentrations that existed between puffins from St Kilda and those from the Isle of May. Although the Isle of May is in the North Sea (often regarded as more polluted than the Atlantic), puffins from this colony had much lower levels of both cadmium and mercury than did puffins from St Kilda (Figure 1). Further, a seasonal trend in metal concentrations was observed in the Isle of May puffins, with the highest metal concentrations occurring at the beginning of the breeding season (Osborn 1979). This suggested that there would be times when metal levels in St Kilda seabirds were even higher than those recorded, as the St Kilda birds were collected only in the middle of their breeding period.

This regional difference meant seabirds from both a 'high' and a 'low' metal colony could be obtained, and a comparison made of their tissue metal levels and the histological appearance of their kidneys. In addition, birds were dosed in the laboratory with cadmium and mercury, to guard against the possibility that any unusual features seen in seabird kidneys were caused by some factor other than cadmium or mercury.

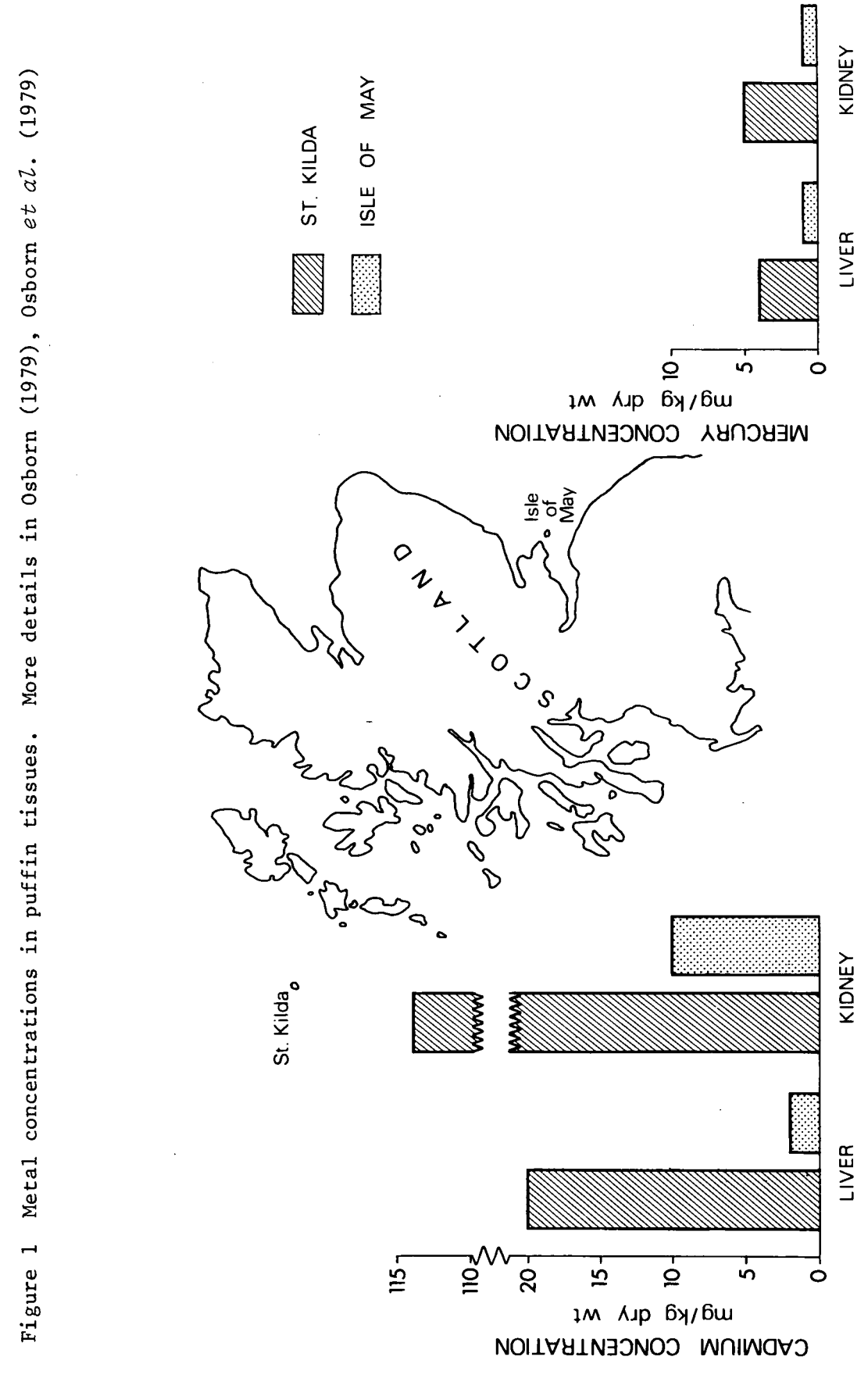

Figure 1 Metal concentrations in puffin tissues. More details in Osborn (1979), Osborn *et al.* (1979)

Accounts of the observations on the seabird and metal dosed bird kidneys have now been published (Nicholson & Osborn 1983) and the results are summarised in Table 1. In brief, St Kilda birds exhibited numerous nephrotoxic lesions, while no abnormalities were observed in birds from the 'low' metal site on the Isle of May. Metal induced lesions in laboratory birds were strikingly similar to those of the St Kilda birds and occurred at similar tissue levels of metals in both groups of animals.

DISCUSSION

To some extent, these results leave our original question about the significance of high metal levels in seabirds unanswered. We now know that high metal levels are found at various seabird sites around the globe (Anderlini *et al.* 1972; Bull *et al.* 1977; Osborn *et al.* 1979; Furness & Hutton 1979; Stoneburner & Harrison 1981) and it is becoming an accepted view - that still requires more investigation - that the metal arises from natural rather than anthropogenic sources.

This study has shown that metallothionein-like proteins cannot prevent tissue damage occurring, although they may reduce its extent allowing tissue repair mechanisms time to come into operation. Indeed, evidence for tissue regeneration was obtained in both seabirds and metal dosed birds (Nicholson & Osborn 1983). These results raise questions about the role of metallothionein in metal toxicity.

Further research is needed to determine the significance of the high metal levels for seabirds, and a number of factors not mentioned here must be taken into account, including (i) the influence of age and sex on metal accumulation; and (ii) the role of nutritional status on metal binding in the tissues (Bremner & Davies 1975) - a potentially important variable in animals like seabirds which may feed little while incubating eggs for days at a time. Also, this report has taken no account of the levels of essential metals such as zinc, copper and iron, although some of these have been subjects of study (eg Osborn *et al.* 1979; Osborn 1979). To understand the effects of toxic metals on seabirds there can be little doubt that a sound knowledge of essential metal metabolism in birds must be obtained.

In short, there is much to be done before we can say whether high metal levels have effects on seabirds which are ecologically significant, ie before we can answer the question: do metals influence either the breeding success or survival prospects of individuals and/or different populations of seabirds?

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TABLE 1 Pathological features observed in St Kilda seabirds

Severity and types of pathological features observed	Puffin	Manx shearwater	Fulmar
Renal corpuscles			
Necrosis of Bowman's capsule cells	-	+	+
Podocyte vacuolation and nuclear crenation	+	++	++
Mesangial matrix, changes and abnormal electron lucency	-	+	+
Proximal tubules			
Dilation of extracellular spaces	+++	+	+
†Mitochondrial swelling (intramatrical)	+	++	++
Nuclear pyknosis	-	++	++
Degree of cell necrosis	+	++	++
Obstruction of distal tubules, etc, by necrotic debris	+	++	++

†Varied considerably from cell to cell.

Severity of changes and degree of damage: - no detectable abnormalities; + few and/or slight changes; ++ common and/or moderately severe changes; +++ very frequent and/or severe changes.