

Metal concentrations in liver, kidney, bone and blood of three species of birds from a metal-polluted wetland

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Abstract

The concentrations of cadmium, copper, nickel and lead in the liver, kidney, bone and blood of the herbivorous Redknobbed Coot *Fulica cristata*, the piscivorous Reed Cormorant *Phalacrocorax africanus* and the omnivorous Sacred Ibis *Threskiornis aethiopicus* were determined. Specimens were collected from the Natalspruit wetland. This wetland area is polluted by these metals. The tissues were analysed for their metal contents and were processed according to standard analytical procedures. Cadmium levels were lowest in the four tissues analysed of all three species. Highest cadmium occurred in the kidneys of the ibis (3.4 µg/g), the bone of the coot (5.1 µg/g) and the blood of the cormorant (4.7 µg/g). Copper (27 to 33 µg/g) was highest in the liver whilst nickel (11 to 36 µg/g) and lead (32 to 59 µg/g) occurred in the highest concentrations in the bone of all three bird species. Reed Cormorants generally exhibited the highest bone lead concentrations (59.0 µg/g). A high degree of variability in tissue metal concentrations was found among all three species. Except for liver, significant differences ($p < 0.05$) were recorded for the four metals in all the other tissues of the three species. The research showed that these three bird species were able to accumulate these metals at abnormal concentrations with no apparent chronic or negative effect on their survival. In this context these birds therefore comply with one of the main criteria required for their potential as indicator organisms of metal pollution in the aquatic environment.

Introduction

The eastern half of Johannesburg, commonly known as the East Rand, is the most highly developed industrial region on the Witwatersrand and probably in South Africa. It is drained by tributaries of the Elsburgspruit, Natalspruit and Blesbokspruit river systems, among others, and these systems also include extensive natural wetlands. More than 1 800 industries, ranging from large chemical industries to small one-man engineering firms, occur in this area (Viljoen et al., 1985). The bulk of the water flowing in most of these streams consists of effluents and seepage waters originating from old mines, slimes dams, ash heaps, industries, sewage purification works, suburban areas and agricultural practices. Such effluents comprise the major sources of a variety of pollutants, including dissolved metals (Viljoen et al., 1985; Jones et al., 1989; Schoonbee and Van der Merwe, 1989). These metal-containing effluents possess the potential to constitute serious hazards to the aquatic flora and fauna, including birds, when these wastes are released into river and wetland ecosystems (White and Kaiser, 1976; Kempf and Sittler, 1977; Bull et al., 1983). Of particular interest are the low breeding success and deformed chicks of various aquatic birds from the Kesterson National Wildlife Refuge (USA), which is seriously polluted by selenium- and boron-containing irrigation drainage waters (Ohlendorf et al., 1986; Hothem and Ohlendorf, 1989).

The wetlands occurring on the Witwatersrand, including those on the East Rand, provide habitats for a wide variety of aquatic and semi-aquatic birds (Tarboton et al., 1987; Ryan and Isom, 1990; Tarboton, 1993). Mismanagement and pollution of wetlands may mean a loss of habitat for a number of bird species. Furthermore, some wetlands may contain endangered biota, including certain bird species recorded in the *South African Red*

Data Book on Birds (Brooke, 1984). A number of provincial parks and bird sanctuaries are located within the boundaries of the Witwatersrand (Ryan and Isom, 1990). There are also several aquatic environments, of which the Vlakplaats Water Pollution Control Works (WPCW) is one, which do not receive any formal protection from conservation bodies.

The Vlakplaats WPCW area is relatively rich in bird life with a total of 139 species recorded here (Whitehouse and Whitehouse, 1978; Van Eeden, personal observations). The most commonly occurring aquatic birds associated with this area include the Redknobbed Coot *Fulica cristata*, Reed Cormorant *Phalacrocorax africanus* and Sacred Ibis *Threskiornis aethiopicus*. These three species occupy clearly delineated trophic levels. Reed Cormorants are mainly piscivorous (Brown et al., 1982), Sacred Ibises are omnivorous (Clark, 1979; Clark and Clark, 1979; Brown et al., 1982; Ginn et al., 1989) and Redknobbed Coots are herbivorous (Fairall, 1981; Brown et al., 1982). This particular site borders on the extensive Natalspruit wetlands and is known to contain metals in the abiotic and biotic compartments (Van Eeden, 1990; Van Eeden and Schoonbee, 1991, 1992, 1993; Adendorff, 1992; Fleischer, 1993; Steenkamp et al., 1993).

The association between aquatic birds and the industrial and mining activities of human beings prompted investigations to be carried out on the potential of some bird species, e.g. gulls (Munoz et al., 1976), as biomonitors of metal pollution in aquatic environments. Any bird that is exposed to a metal-contaminated environment can be used to quantify relative levels of metal pollution. This can be achieved by the measurement of the metal in a number of tissues that may sequester metals from the food of the bird. However, a potential bird species to be used as an indicator organism needs to comply with various requirements in order to be a reliable and continuous biomonitor (Hahn et al., 1985; Weyers et al., 1985; Ellenberg et al., 1985). The most important requirement is that birds from any trophic level should be able to accumulate a variety of metals without being killed by the excessively large concentrations encountered. It must be borne in mind that most metal-containing effluents exert a chronic impact on the aquatic avifauna, an impact which the birds should also be able to tolerate.

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