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Heavy Metals in Feathers of Six Species of Birds in the District Nilgiris, India

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Birds are among the taxa in which heavy metal exposure and toxicity have been extensively examined (Burger 1993; Eens et al. 1999; Gragnaniello et al. 2001). Heavy metals even at levels insufficient to produce outright mortality or other acute effects in birds may nevertheless, have profound consequences by way of increased reproductive dysfunction, increased susceptibility to disease or other stresses and changes in normal behaviour patterns (White et al. 1986; Furness 1996).

Earlier studies have led to an increased interest in the use of birds as monitors of geographical, historical and global patterns of heavy metal pollution in the environment as they occupy a wide range of trophic levels in different food chains. Regular monitoring of heavy metal contamination in birds may not be possible if birds were to be sacrificed. However, feathers could be a better option as sampling is non-invasive. Use of feathers as bioindicators of heavy metal contamination has also been recommended by many workers (Geode and de Bruin 1986; Spahn and Sherry 1999 and Dmowski 1999).

In India there are some information available on heavy metal contamination in the tissues of some species of birds (Bakre and Sharma 1995; Muralidharan 1995; Jayakumar 1999). But there is little information available on metal contamination in feathers. Here we report on the feathers of six species of birds, namely Cormorant *Phalacrocorax carbo*, Pond Heron *Ardeola grayii,* Cattle Egret *Bubulcus ibis*, Little Egret *Egretta garzetta,* Jungle Babbler *Turdoides striatus* and Common Myna *Acridrotheres tristis.*

MATERIALS AND METHODS

The district Nilgiris falls within the Nilgiri Biosphere Reserve in South India. Although the area is relatively less polluted, there are seven major industries including electroplating, film and ammunition manufacturing units, 175 tea factories and many small scale industries in the district .

Feathers for this study were obtained from birds collected during 1998-1999 from places such as Pykara, Kamaraj Sagar, Glen Morgen, Vazhai Thottam, Kerbetta, Thavani-Adasolai, Emerald, Kundah, Upper Bhavani, Cherumbadi, Aravankadu, Barliyar

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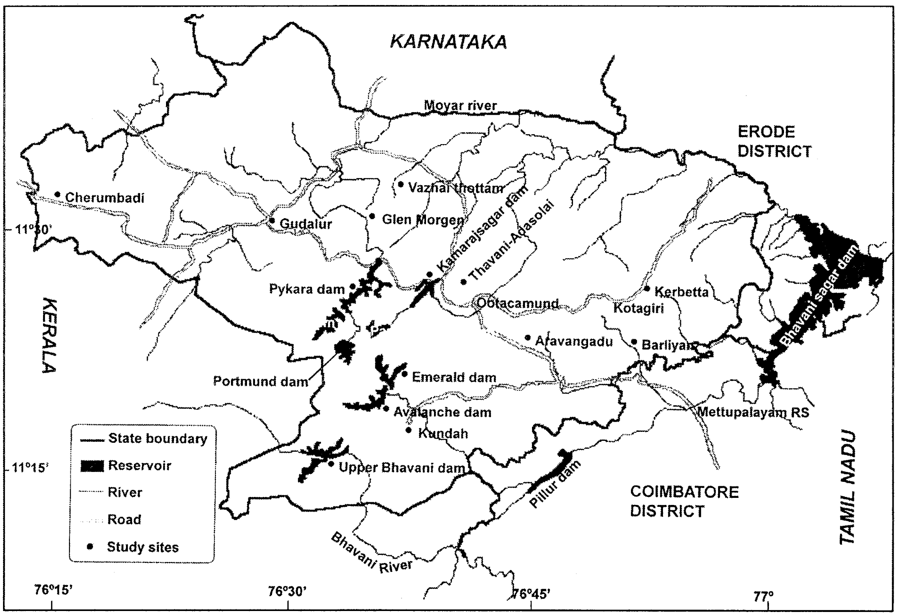

Figure 1. Map of Nilgiris district showing study sites.

and Gudalur (Fig.1) in the district Nilgiris, Tamil Nadu for a project that documented pesticide contamination. The feathers were cleaned with high quality detergent (Labolene - Glaxo India Limited) and running tap water thoroughly to remove external dirt and stains. After complete drying under room temperature they were stored in clean polythene bags till digestion was completed.

About 1 to 1.5 g of the feather sample was digested in Microwave Digestion System (Milestone, Model 1200) using 10 ml HNO_3 (69%W/V, Merck) for 10 min, 1 ml perchloric acid (70% W/V, Merck) for 5 min and 7 ml of H_2O_2 (30% W/V, Merck) for 10 min at 250 W power settings. The digested solutions were filtered and stored in well-cleaned polythene vials in refrigerator and analysed for metals such as copper, lead, zinc, cadmium and chromium using a double beam Atomic Absorption Spectrophotometer (Perkin Elmer, Model 3300). While the detection limit for copper and chromium was 0.002 ppm, the same for cadmium, lead and zinc was 0.0006, 0.01 and 0.009 ppm respectively. Atomic absorption spectrometry standards for all the metals manufactured by SRL, India were used for calibration and recovery studies. High purity acids and all quartz double distilled water were used for the analyses. Recovery rates for copper, lead, zinc, cadmium and chromium were 86, 85, 90, 88 and 95 per cent respectively.

RESULTS AND DISCUSSION

Altogether feathers of 39 adult birds comprising six species (Table 1) were considered for this study.

Table 1. Birds included in the study.

S.No	Name	No.of birds
1	Cormorant *Phalocrocorax carbo*	4
2	Pond Heron *Ardeola grayii*	6
3	Cattle Egret *Bubulcus ibis*	3
4	Little Egret *Egretta garzetta*	7
5	Jungle Babbler *Turdoides striatus*	10
6	Common myna *Acridotheres tristis*	9
	Total	39

The data obtained were consolidated to look at the variation in metal concentration among different species of birds and distribution pattern among different feathers such as primary, secondary and tail. To look at the variation in contamination among species and feathers, a two-way ANOVA was done using SPSS students version 9.0.

Metal levels in feathers differed among the feathers and species (Table 2). On an average, Pond Heron had the lowest concentration of zinc (100.97 ppm) in primary feathers and Little Egret the maximum (196.32 ppm) in tail feathers which is less than the levels of zinc (5 to 250 ppm) recorded in feathers of *Columba livia* in Finland (Solonen et al. 1999). However, the study did not report any threshold effects. It has been proved that zinc has more affinity towards keratin and gets built into the feathers during growth. Moreover, zinc was also found to be an essential element for the feather growth (Sunde 1972). The copper values ranged from below detection limit in Common Myna to 235.43 ppm in the tail feathers of Pond Heron and was also higher than the values (4 to 117.4 ppm) reported by Dmowski (1999) in Polish Magpies. However, no information is available on the effects. Although copper's affinity to keratin in feather could be quoted as the plausible reason for the high values, external contamination and topographical variations cannot be ruled out.

Lead concentration ranged from below detectable level (BDL) to a maximum of 18.6 ppm in the primary feathers of Pond Heron. These values are lower than the levels (6.6 to 240 ppm) reported in *Columba livia* (Solonen et al. 1999) and comparable with the levels in chicks of Little Blue Heron (1.2 to 16.9 ppm) reported by Sphann and Sherry (1999).

Average cadmium concentrations ranged between BDL in the primary and tail feathers of Cattle Egret and to a maximum of 11.01 ppm in the tail feathers of Pond Heron. Although the levels are lower than the levels (1.70 ppm) reported by Solonen et al. (1999) in *Columba livia*, and by Eens et al. (1999) in Great Tits (2.56 ppm) and Blue Tits (2.96 ppm), a few values as high as 12.45 ppm and 20.35 ppm have also been recorded. However, the above mentioned studies did not comment on the threshold levels.

Chromium levels were found to be the minimum (0.11ppm) in the secondary feathers of Jungle Babbler and maximum (3.66) in tail feathers in Pond Heron. Studies done

Table 2. Mean concentration of heavy metals in feathers of a few species of birds (ppm)

S.#	Name of the bird	Copper			Lead			Zinc			Cadmium			Chromium		
		P	S	T	P	S	T	P	S	T	P	S	T	P	S	T
1	Little Egret	9.65 (±1.82)	8.20 (±5.09)	31.96 (±59.4)	2.70 (±4.95)	2.13 (±4.07)	3.16 (±8.56)	106.09 (±13.7)	153.61 (±124.9)	196.32 (±58.78)	0.39 (±0.25)	0.10 (±0.14)	0.57 (±0.66)	0.50 (±0.64)	1.35 (±2.36)	0.56 (±0.77)
2	Cattle Egret	14.09 (±1.36)	12.44 (±1.41)	219.93 (±25.8)	10.22 (±9.60)	3.92 (±5.72)	3.77 (±4.34)	108.81 (±9.73)	153.18 (±35.76)	182.42 (±14.20)	ND	1.90 (1±1.1)	ND	0.58 (±0.10)	0.33 (±0.57)	1.01 (±1.01)
3	Pond Heron	11.12 (±4.22)	15.65 (±4.75)	235.43 (±73.9)	5.87 (±7.2)	9.19 (±8.83)	3.22 (±6.43)	100.97 (±33.7)	156.29 (±47.41)	188.90 (±65.40)	0.70 (1±0.4)	0.90 (±0.34)	11.01 (±4.93)	0.44 (±0.50)	0.55 (±0.32)	3.66 (±4.48)
4	Jungle Babbler*	6.14 (±4.15)	2.39 (±2.83)	*	1.63 (±4)	ND	*	137.85 (±30.5)	156.52 (±30.50)	*	3.79 (±3.69)	3.60 (±0.97)	*	4.90 (1±7.5)	0.11 (±0.19)	*
5	Common Myna*	1.86 (±2.63)	5.69 (±3.44)	*	2.20 (±3.1)	ND	*	137.98 (±8.57)	179.68 (±35.16)	*	1.89 (±1.59)	3.08 (±1.45)	*	0.58 (±0.75)	0.27 (±0.39)	*
6	Cormorant**	11.27 (±0.89)	*	*	18.60 (±14.5)	*	*	107.84 (±12.3)	*	*	0.25 (±0.12)	*	*	0.47 (±0.35	*	*

P - Primary feather; S - Secondary feather; T - Tail feather; * - Samples not included; ND - No Data
Standard Deviation in parentheses

by Dmowski (1999) reported 0.21 to 4.85 ppm of chromium in feathers of Polish Magpies, which are comparable with the levels recorded in the current study. The physiological mechanisms such as secretions of uropygial glands, supra-orbital nasal glands and the affinity of metals to bind to the keratin are also notable reasons for lead, cadmium and chromium concentrations in feathers (Howarth et al. 1981, 1982).

The Pond Heron had significantly ($P<0.001$) higher metal load than the other species included in the study except zinc which was the highest in Jungle Babbler. Metals enter into the body of a bird through food and get incorporated during feather development. Activities such as preening (Geode and DeBruin 1986; Pilastro et al. 1993) and contaminants in external environment (Dmowski 1999) may also contribute. The accumulation of metals in feathers is influenced by a variety of factors such as shaft-vane variation (Rose and Parker 1982), concentration of amino acids, habitat and dietary habits (Dmowski 1999) age and gender (Burger and Gochfeld 2000), and also food-web (Solonen et al. 1999). However, in the current study these parameters were not included.

In the present study when all the feathers, namely primary, secondary and tail were pooled irrespective of species, the concentrations of all the metals except lead were significantly higher ($P<0.001$) in the tail feathers (Fig.2) than primary and secondary. Earlier workers (Eens et al. 1999; Dmowski 1999; Dauwe et al. 2000) also had used only tail feathers to evaluate the heavy metal contamination in birds, namely Great Tit, Blue Tit and Polish Magpie. Hence, it is presumed that tail feathers could reflect the contamination of any given area better. But it is important to note that these values could only serve as a signal to carry out further intensive investigations.

An attempt was also made to find out the differences, if any, on the metal accumulation pattern in the feathers based on the feeding habits of the birds included in the study. It may be noted that only primary feathers were considered as secondary and tail feathers were not available for all the species. In the case of copper, Cormorant, Pond Heron and Little Egret which feed mostly on fishes accumulated more than the Jungle Babbler, a predominant insectivorous bird. The Cormorant, an exclusive fish-eating bird showed higher concentrations of lead than Jungle Babbler while cadmium and chromium accumulated more in the latter than the former.

The relation between metal levels in feathers and the reproductive success and growth rate was also compared with the available information. The concentration of lead in the primary feathers of Cormorant (18.6 ppm) included in the current study assumes significance because increased nestling mortality was observed in Little Blue Heron in South Louisiana wetlands (Spahn and Sherry 1999) at a level of 1.2 to 16.9 ppm. Cadmium in the range of 0.6 to 25.4 ppm in the feathers was reported to be associated with reduced growth rates and poor fledgling success in Little Blue Heron (Sphan and Sherry 1999). Hence, the levels recorded in the present study (11.01 ppm in Pond Heron) are to be viewed with concern as it may cause serious effects in long run. However, the possibility of external contamination as well as their use as excretory organs to excrete metals have also to be admitted. Moreover, there could

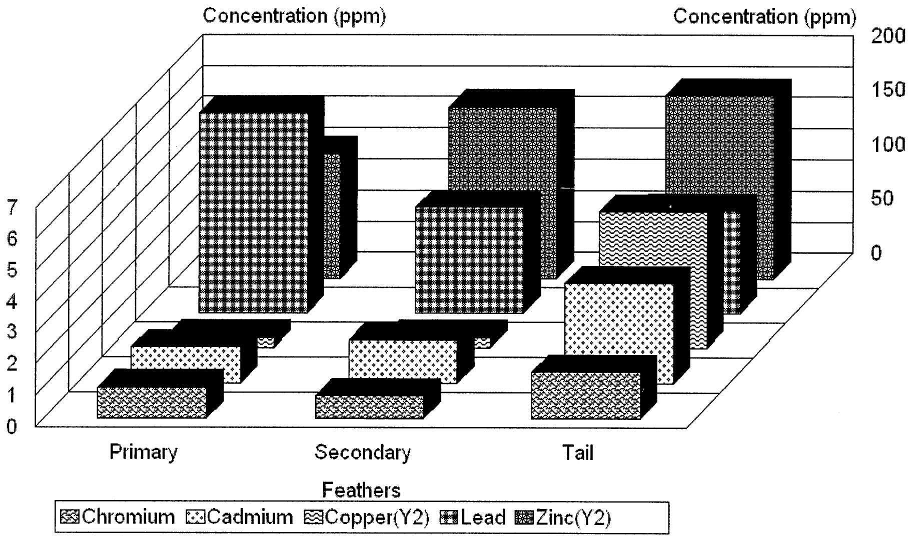

Figure 2. Comparision of metal levels among different feathers of birds of Nilgiris District.

be several orders of magnitude differences in terms of effects, among species. Hence, it is difficult to categorically predict the effect on any particular species.

Our data suggest that tail feathers could be considered as appropriate indicators of heavy metal contamination. However, the magnitude of contamination could be influenced by several exogenous and endogenous factors.

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