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Metal Contamination in Select Species of Birds in Nilgiris District, Tamil Nadu, India

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Abstract Variation in metal contamination in six species of birds, namely the Cormorant (*Phalacrocorax carbo*), Cattle Egret (*Bubulcus ibis*), Little Egret (*Egretta garzetta*), Pond Heron (*Ardeola grayii*), Common Myna (*Acridotheres tristis*) and Jungle Babbler (*Turdoides striatus*) in Nilgiris district, Tamil Nadu, India. The accumulation of heavy metals differed among the species studied. On an average, Little Egret accumulated high concentrations of copper (53.31 ± 23.19 ppm) followed by Cattle Egret (16.27 ± 9.83 ppm) in liver. Of all the species, Jungle Babbler recorded the maximum concentrations (20.59 ± 9.07 ppm) in muscle. The Pond Heron recorded the maximum concentration (35.38 ± 11.14 ppm) in brain. On an average the maximum level was in the kidney of Common Myna (7.76 ± 1.80 ppm).

Keywords Birds · Indicators · Metal contamination · India

Over the years among wildlife, birds have served as bioindicators for a number of environmental contaminants (Eens et al. 1999; Gragnaniello et al. 2001) particularly heavy metals (Mochizuki et al. 2002) since they are visible, widely distributed in the ecosystem, sensitive to toxins and high on the food chain. Chronic exposure of birds to potentially toxic metals at levels insufficient to produce outright mortality or other acute effects, may nevertheless, lead to profound consequences on the birds such as increased reproductive dysfunction, increased susceptibility to disease or other stresses (Furness 1996) and changes in behaviour patterns. Thus, monitoring of environmental contaminants such as heavy metals in select species from a delimited area could be useful to assess not only the health of the species but also the fluctuations in contaminant levels in the environment where they live (Erwin and Custer 2000).

In India studies on heavy metal contamination in birds are limited. However, there is some information available on sixteen species of aquatic birds in Koeladeo National Park, Bharatpur (Muralidharan 1995), one species of urban bird in Jaipur (Bakre and Sharma 1995) and four species of birds in Nilgiris (Jayakumar 1999). Further, there is also some information available on the levels of metals in the feathers of six species of birds (Manickam 2002; Muralidharan et al. 2004).

This study examined the variation in metal contamination in six species of birds, in Nilgiris district, Tamil Nadu, India.

Materials and Methods

The Nilgiris district Tamil Nadu, India, also called as Blue Mountain or Queen of hills extends over an area of 0.25 million hectares which includes jungle covered slopes of uplands, lower adjoining tracts and the plateau. Although the Nilgiris 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.

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A total of 55 birds comprising six species, namely the Cormorant (*Phalacrocorax carbo*) (n = 10), Cattle Egret (n = 5) (*Bubulcus ibis*), Little Egret (*Egretta garzetta*) (n = 10), Pond Heron (n = 10) (*Ardeola grayii*), Common Myna (*Acridotheres tristis*) (n = 10) and Jungle Babbler (*Turdoides striatus*) (n = 10) were collected from various places such as Pykara, Kamaraj Sagar, Glen Morgan, Vazhai Thottam, Kerbetta, Thavani-Adasolai, Emerald, Kundah, Upper Bhavani, Cherumbadi, Aravankadu, Barliyar and Gudalur (Fig. 1) in the district, during the year 1998–1999 for a project that documented the pesticide contamination in the avifauna of Nilgiris district. Samples were brought to the laboratory over ice and preserved at −20°C till post-mortem was performed.

The birds were dissected and about 1–1.5 g of tissues, namely brain, liver, kidney and muscle was weighed with the aid of a top loading balance (Mettler AE 240) and stored in clean vials at −20°C till the date of digestion. The samples were digested in Microwave Digestion System (Milestone, MLS 1200) using 10 mL HNO_3 (69% GR) for 10 min, 1 mL $HClO_4$ (70% GR) for 5 min and 5 mL H_2O_2 (30%GR) for 10 min at 250 W magneteron power settings. All reagents used in digestion were of analytical grade (Merck). The digested solutions were filtered using Whatman No. 1 filter paper and stored in well-cleaned polythene vials in refrigerator and subsequently analysed using a double beam Atomic Absorption Spectrophotometer (Perkin Elmer, Model 3300). Atomic absorption spectrometry standards for metals, namely copper (99.9% pure), lead (99.5% pure), zinc (99.9% pure) and cadmium (99.5% pure) manufactured by Sisco Research Laboratories Pvt. Ltd., India were used for calibration. In order to validate calibration during measurements, after every ten samples, blank and calibration standards were read three times and % relative standard deviations were computed. While the detection limit for copper was 0.002 ppm, the same for cadmium, lead and zinc was 0.001, 0.03 and 0.02 ppm respectively. The quantification limits of metals were three times the detection limit. Recovery rates for copper, lead, zinc, and cadmium are performed through standard addition method. Ten recovery tests were performed for recovery and keeping the reference value as 1, the recovery rates for copper: 86% (0.86 ± 0.019), lead: 85% (0.85 ± 0.11), zinc: 90% (0.90 ± 0.23) and cadmium: 88% (0.88 ± 0.01). The results were not corrected for per cent recovery and expressed in μg/g of wet weight. Statistical tests, namely Kolmogrov-Smirnov test and Kruskal–Wallis were performed using statistical software SPSS version 10, to understand the level of variation in metal concentrations among the species.

Results and Discussion

The data is viewed in two angles so as to understand the variation in metal contamination and tissue wise accumulation of metals among the six species of birds included in the study. The accumulation of metals differed among the species studied. On an average, Little Egret accumulated high concentrations of copper (53.31 ± 23.19 μg/g) followed by Cattle Egret (16.27 ± 9.83 μg/g) in liver (Table 1). The accumulation of copper in Cattle Egret and Little Egret were fifteen and four folds respectively higher than the levels recorded in the liver of Cormorant

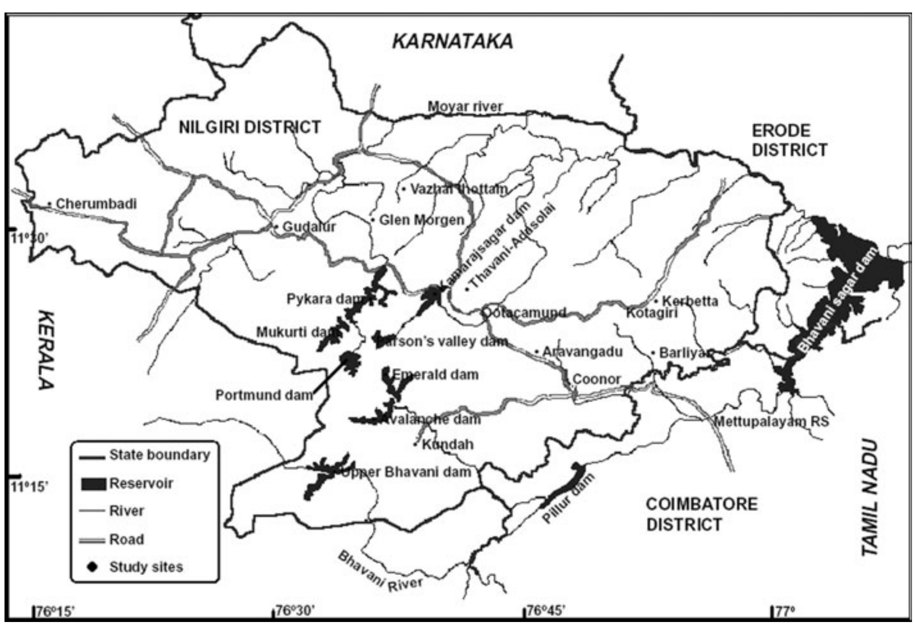

Fig. 1 Map of Nilgiris showing study sites

Table 1 Metal contamination among various species of birds collected from Nilgiris district (μg/g Mean ± SE), Tamil Nadu, India

S. No.	Bird name	Organ	Cu*	Pb*	Zn**	Cd*
1	Cormorant (n = 10)	Brain	0.72 ± 0.33	1.47 ± 0.49	11.39 ± 2.18	0.26 ± 0.11
		Kidney	1.50 ± 0.62	1.16 ± 0.82	8.55 ± 2.93	0.33 ± 0.14
		Liver	3.54 ± 0.88	0.63 ± 0.44	11.16 ± 4.96	0.40 ± 0.13
		Muscle	3.30 ± 1.67	1.82 ± 1.65	7.09 ± 1.54	0.40 ± 0.15
2	Pond heron (n = 10)	Brain	8.47 ± 2.28	3.25 ± 1.44	35.38 ± 11.14	0.62 ± 0.22
		Kidney	9.77 ± 1.67	9.40 ± 3.45	14.03 ± 5.92	0.80 ± 0.15
		Liver	9.32 ± 3.75	15.44 ± 13.05	4.74 ± 1.58	0.07 ± 0.04
		Muscle	4.53 ± 1.25	20.77 ± 12.84	21.31 ± 8.02	0.23 ± 0.07
3	Little egret (n = 10)	Brain	11.87 ± 3.20	4.61 ± 2.75	18.15 ± 4.92	0.15 ± 0.06
		Kidney	5.67 ± 2.36	2.76 ± 2.32	27.65 ± 5.41	0.20 ± 0.16
		Liver	53.31 ± 23.19	0.97 ± 0.48	8.50 ± 3.30	0.11 ± 0.06
		Muscle	5.30 ± 1.23	1.52 ± 0.55	8.18 ± 3.65	0.14 ± 0.07
4	Cattle egret (n = 5)	Brain	7.32 ± 3.28	1.02 ± 1.02	20.04 ± 11.48	BDL
		Kidney	4.46 ± 2.10	0.09 ± 0.09	32.93 ± 13.69	0.07 ± 0.05
		Liver	16.27 ± 9.83	3.98 ± 3.69	2.10 ± 1.99	0.03 ± 0.03
		Muscle	5.54 ± 1.62	0.90 ± 0.73	6.15 ± 2.87	0.06 ± 0.03
5	Common myna (n = 9)	Brain	4.34 ± 0.69	7.71 ± 2.15	5.78 ± 1.50	4.15 ± 1.20
		Kidney	5.99 ± 1.05	8.75 ± 3.08	10.82 ± 1.50	7.76 ± 1.80
		Liver	4.12 ± 0.57	0.37 ± 0.26	15.14 ± 3.11	1.50 ± 0.35
		Muscle	6.36 ± 1.96	3.09 ± 1.73	11.49 ± 4.11	0.66 ± 0.17
6	Jungle babbler (n = 10)	Brain	0.64 ± 0.22	10.77 ± 4.10	2.52 ± 0.72	0.07 ± 0.07
		Kidney	2.41 ± 0.51	9.91 ± 4.69	7.23 ± 2.21	1.00 ± 0.30
		Liver	2.78 ± 0.65	4.43 ± 1.48	8.82 ± 3.08	1.38 ± 0.45
		Muscle	1.95 ± 0.24	20.59 ± 9.07	4.27 ± 0.97	BDL

Significance level: * $p < 0.05$; ** $p > 0.05$

(3.54 ± 0.88 μg/g). Significant variation could be perceived in copper concentration among different species ($p < 0.05$).

The levels of copper recorded in the present investigation are comparatively lower than the levels recorded in the sixteen species of birds (0.8–93.38 μg/g) collected from Koeladeo National Park, Bharatpur, India. It may be noted that such levels were reported to be too low to induce any mortality in birds (Muralidharan 1995). Further, studies recording more than 100 μg/g of copper in liver tissues of Mute Swan which did not exhibit any sign of copper toxicity are also available.

Although concentrations of lead recorded in most of the species studied were comparably low, significant variation in contamination levels ($p < 0.05$) among species could be perceived. Of all the species, Jungle Babbler recorded the maximum concentrations (20.59 ± 9.07 μg/g) in muscle which was 22 times higher than those in Cattle Egret which had the minimum (0.90 ± 0.73 μg/g) (Table 1).

The varying magnitude of metal contamination among the species could be due to their interspecific food chain differences. Franson (1996) categorized liver tissue lead levels of 2–6 μg/g to be subclinical exposure, >3–6 μg/g to be toxic and >5 to >20 μg/g to be fatal in Galliformes, Falconiformes and Columbiformes respectively. Tsuji et al. (2002) recorded a range of lead levels ≥20 μg/g indicative of lead toxicosis in wild mallard ducks. In the current study the level reported in Jungle Babbler falls in the toxic category. Although the lead levels in liver tissue of the present study appear to be of a sub-clinical exposure as categorized by Franson (1996), controversy exists concerning the definition of toxicity levels of lead for avian species. A blood concentration of 10 μg/g was proposed as a conservative threshold level indicating exposure to non-background quantities. It has been suggested that birds may survive with high blood lead levels without apparent symptoms of poisoning due to production of nuclear inclusion bodies (Tirelli et al. 1996). It is also possible that lead can be bound by metallothionein like proteins produced by red blood cells and sequestered in a non-bioavailable form, thus protecting an organism against lead toxicity. However, the present study did not include blood.

Appreciable concentrations of zinc was recorded in all the species with no significant variation in the level of contamination ($p > 0.05$). The Pond Heron recorded the maximum concentration (35.38 ± 11.14 μg/g) in brain followed by Cattle Egret (32.93 ± 13.69 µg/g) in kidney (Table 1). The normal liver zinc levels in Common Raven (*Corvus corax*), Wild Turkey (*Meleagris gallopavo*), Osprey (*Pandion haliaetus)* and Mallard Ducks (*Anas platyrhynchos*) were 14–45, 75, 38 and 45 µg/g ww, respectively. Several cases of zinc toxicosis have been seen in Hispaniolan Amazon parrots (*Amazona vertralis*) with liver zinc levels ranging from 110 to 359 µg/g ww (SCWDS Cilinical Necropsy records 104-90 and 107-90) (Lewis et al. 2001). In the current study, the levels are not indicative of poisoning and can be treated as levels below the levels prescribed as normal.

Cadmium contamination was less than 1 µg/g in the other species with significant variation ($p > 0.05$) except in Common Myna and Jungle Babbler. On an average the maximum level was in the kidney of Common Myna (7.76 ± 1.80 µg/g) while the minimum (BDL) in the muscle of Jungle Babbler.

Muralidharan (1995) in his study on metal contamination in sixteen species of aquatic birds had recorded a maximum of 2.12 µg/g of cadmium in the kidney of Pond Heron. From the literature (Battaglia et al. 2005; Toman et al. 2005), it has been inferred that kidney damage occurred in many species of bird when the cadmium levels approached 20 µg/g. Thus, it is very clear that although the levels appear to be higher than the earlier levels reported in the Indian context, the levels are not indicative of toxicity.

Interestingly, except the Common Myna for copper and zinc the remaining species recorded BDL as the minimum concentration for all the metals. In birds such as Jungle Babbler, Pond Heron, Little Egret and Common Myna liver and kidney accumulated lead and cadmium significantly ($p < 0.05$) than other organs such as brain and muscle.

Of all the species, Cattle Egret suffered the maximum metal load followed by Pond Heron while in the organs, the accumulation was maximum in liver followed by kidney (Table 1). It is well understood that liver and kidney are the major organs which respond to the insult of metal contamination owing to their physiological role (Lewis et al. 2001).

Interspecific differences were clear especially for Common Myna with other species such as Cormorant, Little Egret, Cattle Egret and Jungle Babbler, which varied significantly for cadmium ($p < 0.05$) and it could probably due to its commensal association with humans. Jungle Babbler recorded significant concentrations of copper higher than Common Myna although both harvest from terrestrial food chains.

On the whole, Cattle Egret accumulated metals to a greater level than other waders, namely Pond Heron and Little Egret when compared with other species. These waders can be proposed as bioindicators since these species are tertiary consumers and are therefore representative of contaminant levels in the appropriate part of the aquatic wetland food web (Custer 2000). Further, the level of lead recorded in the Pond Heron although indicative of toxicity, controversy exists over definition of toxicity levels. Although the recorded levels could create an adverse impact on the whole population, there are no earlier records to substantiate the same in the Indian context. Hence, in order to evaluate any instance of metal poisoning, normal levels of them for the species must be known and the abnormal levels, which tend to produce either harm or no apparent harmful effects, must be recognized which is a conspicuous need in Indian context.

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