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HEAVY METAL ASSESSMENT AND DIVERSITY OF WILD BIRDS WITHIN MARGUBA RANGE OLD OYO NATIONAL PARK, NIGERIA

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ABSTRACT

The aim of this analysis was to see how much of a difference there was in terms of four heavy metals that are potentially toxic namely Zinc (Zn), Cadmium (Cd), Lead (Pb), and Nickel (Ni) among avian species captured in Marguba range of Old Oyo National Park, Nigeria. Mist-nets were used to capture the various bird species opportunistically in a variety of habitat types to improve capture of four feeding guilds. The birds captured individuals belong to: Frugivores (3), Granivores (40), Insectivores (46), Nectarivores (2) and IF (both an insectivore and frugivore; 1). Feather samples from each bird captured were examined using Atomic Absorption Spectrophotometer (AAS). After heating to clarity, sample was purified and appropriately diluted using distilled water. Mean concentration for Lead (Pb), Cadmium (Cd), Nickel (Ni) and Zinc (Zn) was 0.44, 0.98, 0.58 and 1.06 respectively. Zinc was with the most abundant concentration and then Cd, Ni and lastly Pb (Zn > Cd> Ni>Pb). The nectarivore group recorded the highest concentration of all the metals. All the concentration recorded were a lot higher than the maximum permissible limit except Cd. The significantly high level of heavy metals found in the avian feathers provides a useful indication that feathers can be used to detect presence of heavy metal contamination, and monitoring remediation of pollution caused by heavy metal in protected area.

Keywords: Heavy metals, Wildbirds, Marguba, Feather Samples, Old Oyo National Park.

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INTRODUCTION

Protected areas are among the most essential ways to wild animals' conservation (Abramovitz, 1991). The National Parks Service which is the highest conservation ministry in the nation has become the major citadel for protecting endangered species, alongside collaborative efforts from non-governmental conservation organization like NCF (Nigerian Conservation Foundation) (Idowu and Morenikeji, 2015). Over the years, ecologists have used wild birds as indices for heavy metal pollution, tissue or blood are obtained from birds and used to assess heavy metal content in the ecosystem. They are reported to pass out elements into growing feathers (Burger and Gochfeld, 1993) and can also get rid of metals through excrements or by depositing them in the uropygial gland and salt gland (Burger and Gochfeld, 1985). The heavy metals may affect the central nervous system of the birds, disrupt the function of their internal organs and may affect the bird's population through reproductive failures and high chick's mortality and pose a threat to organisms with high trophic levels with greater bioaccumulation potential (Gamal-

Eldein*et al.,* 2008). Among some other reasons for the choice of site for this study is the presence of a major river (River Ogun) that runs through the range from the surrounding communities and the recorded activities of poachers like burning which can result in heavy metal pollution. The quality of water supplies is essentially regulated by factors such as downstream distances from mining sites, colloid loads, pH perturbations, and dilution.

According to Glanze (1996), there are 35 metals that concern living organisms and are due to occupational or residential exposure and that 23 of these are the heavy elements or "heavy metals". Interestingly, small amounts of these elements are present in our environment and diet and are actually necessary for good health, but large amounts of any of them may cause acute or chronic toxicity (poisoning). Heavy metal toxicity can result in damaged or reduced mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidneys, liver, and other vital organs. Long-term (chronic) exposure may result in slowly progressing physical, muscular, and neurological degenerative processes that mimic Alzheimer's disease, Parkinson's disease, muscular dystrophy, and multiple sclerosis. Allergies are not uncommon and repeated long-term contact with some metals or their compounds may even cause cancer (International Occupational Safety and Health Information Centre 1999).

This study presents information on the level of heavy metal concentration in resident wild birds and the variation in heavy metal concentrations will further suggest the best bird species to use in the future as an indicator for each metal.

MATERIALS AND METHODS

Study area

OONP is located in Oyo State, South-west Nigeria with an area of 2,512km^2, shaped like 'Saxophone' (Figure 1). It is the fourth largest Park in Nigeria. Most of the Park area is covered by plains lowland, undulating from 300m to 500 m above sea level. The Park has unique and spectacular features of abundant water resources that drain most part of the park through-out the year like the Ibuya pool and the Ikere Gorge dam. It is situated in a transition vegetation zone between mixed deciduous rainforest ecosystem and open savannah woodlands in the north (Adeola, 1995).

Annual rainfall in the Park ranges between 900 mm and 1,500 mm and main annual temperature is between 12°Cand 37°C. The rainy season begins in April through September with the highest rainfall record between July and August. Temperature is highest in the dry season with the mean daily maximal, which is greatest during February and March with values of about 33.6°C with the lowest values of about 20°C during the height of harmattan in December and January. Study sites are located different spots at Marguba range in Ibuya, Sepeteri (Figure 1). Sampling sites were chosen based on both human activities and easy accessibility.

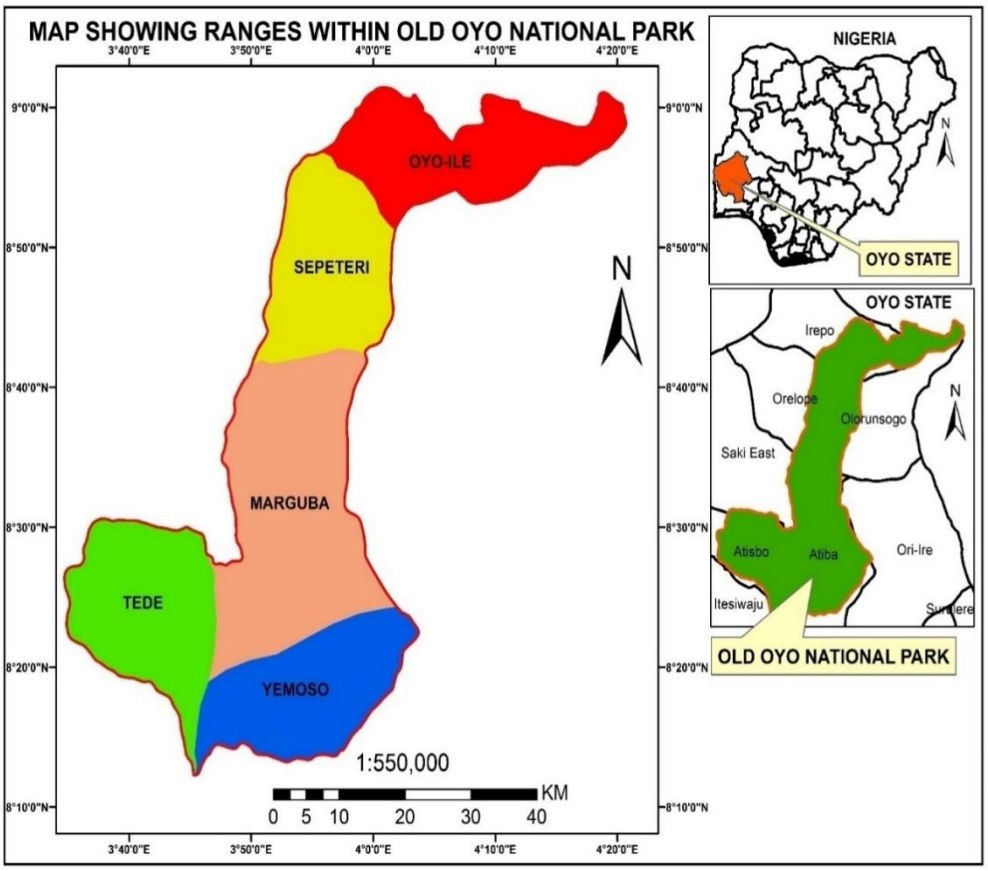

Figure 1: Map of Old Oyo National Park showing the ranges
Source**:** Adetuga*et al*., 2018

Sample collection

Ninety-two (92) tail feather samples of different wild bird individuals were obtained from Marguba range in the National Park, Oyo State in the south western part of Nigeria in July 2018 and 86 of them were selected for further analysis. The birds captured were categorized into 4 main groups based on the feeding guilds as follows: Insectivores (46), Granivores (40), Frugivores (3), Nectarivores (2) and IF (insectivore and frugivore) (1) as per availability of birds during the sampling period. The bird species were captured during the day from various spots in the park using mist nets. Morphometric data were taken of weight, wing length, moth status and age. The two outermost tail feathers were collected from each bird captured after taking record of body conditions (Costa *et al.,* 2013). Birds were held with ringer's grip while the tail feathers were gently pulled out. The feather samples were kept in labeled envelopes, and stored in a light-inhibiting container until they were transported to the environmental laboratory Department of Agronomy, University of Ibadan for analysis (Ahmadpour*et al.,* 2016). All birds sampled were released on site.

Sample Treatment and Analysis

The feather samples were washed using tap water, rinsed 3 times alternating between water and acetone to remove external contamination, and dried out in an oven at 60 °C for 24hrs (Ahmadpour*et al.,* 2016). Finally, they were cut into small pieces, weighed, and transferred into quartz crucibles. About 1.0 mL of HNO3 and 0.25 mL of perchloric acid were added to the crucibles, which were covered with watch glasses. The digestion was carried out by using a hot plate with a magnetic stirrer, initially at low temperature and then at higher temperature. The digested samples were analyzed in triplicate for heavy metal concentrations using an atomic absorption spectrophotometer. When a

difference was found, posteriori pairwise comparisons were made using the Mann–Whitney U test.

Feather samples were processed for atomic absorption spectrophotometry following Fransion (1981), for determination of four metal concentrations in the feather samples which are Lead (Pb), Cadmium (Cd), Nickel (Ni) and Zinc (Zn). They are reported to have direct effects on the central nervous system, and can cause acute renal failure and they are readily soluble and environmentally mobile (Ombugadu*et al.,* 2014).

RESULT

The results showed that there are heavy metal deposits in the environment even in a protected area like the Old Oyo National Park The heavy metals of interest in this work which are Zinc (Zn), Cadmium (Cd), Lead (Pb) and Nickel (Ni) were detected in various samples of avian feathers (Table 1). These metals were considered in this research because of their high degree of toxicity, they also rank high among the priority metals that are of public health significance which are widely reported to be potentially toxic on living tissues (Duruibe *et al*., 2007). Out of the four heavy metals of choice evaluated, zinc recorded the highest level of contamination in the feeding categories of wild birds within the study area (Table 1). All the metals analyzed for had the highest concentration in adult species except for Cadmium while the male sex indicated higher values for most metals except for Lead. All the concentration recorded were a lot higher than the maximum permissible limit except Cadmium.

Highest metal deposit of Cadmium observed in the IF group represented by a single individual whereas deposits are lower for the granivore and insectivore groups.

Table 1: The Mean Concentration of Heavy Metal in Wild birds within Old Oyo National Park (OONP).

Heavy Metal	Lead	Cadmium	Nickel	Zinc
Mean	0.447	0.98	0.58	1.60
FAO/WHO Maximum Permissible Limit (Mg/Kg)	4.0	0.10	0.67	20

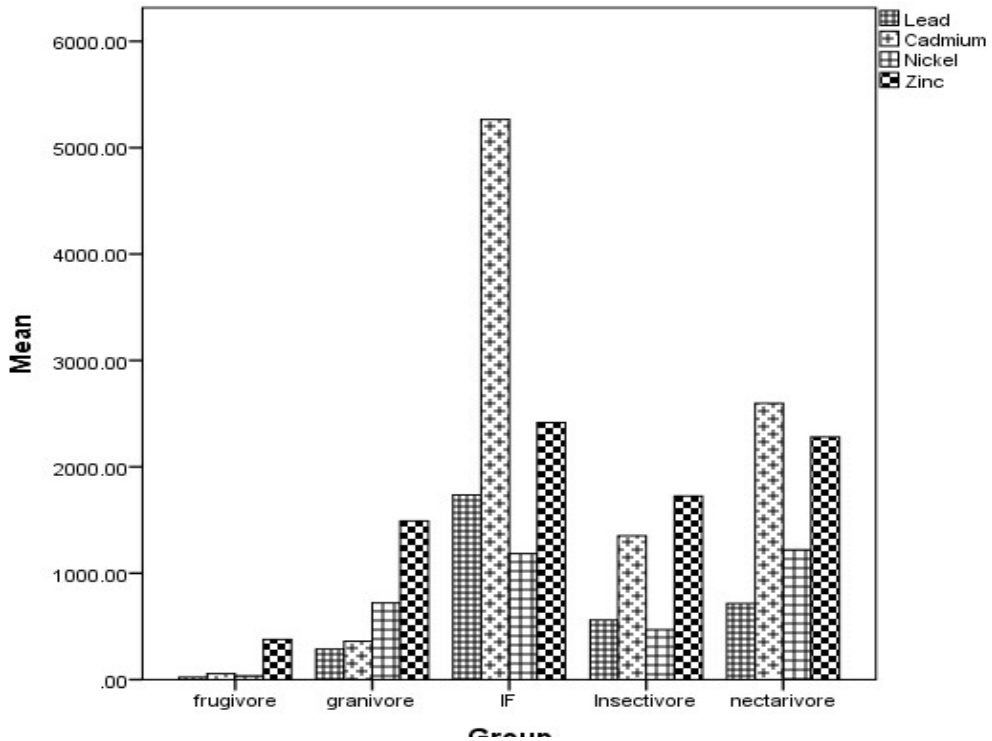

Fig 2: Mean Concentration of Heavy Metals across feeding guilds in Wild birds within OONP ×0.001 mg/kg

Table 2: Correlation among the body conditions, feeding guilds and heavy metal concentration

Group				Wing Length (mm)	Tarsus	Weight (g)	Lead	Cadmium	Nickel	Zinc
Spearman's rho	Granivore	Wing Length(mm)	Correlation Coefficient	1.000	.167	.803**	-.551**	.023	-.358	-.320
			Sig. (2-tailed)		.368	.000	.002	.906	.062	.097
			N	33	31	33	28	28	28	28
		Tarsus	Correlation Coefficient	.167	1.000	.390*	-.019	-.296	-.231	-.406*
			Sig. (2-tailed)	.368		.030	.928	.143	.256	.040
			N	31	31	31	26	26	26	26
		Weight (g)	Correlation Coefficient	.803**	.390*	1.000	-.471*	.015	-.382*	-.367
			Sig. (2-tailed)	.000	.030		.011	.940	.045	.055
			N	33	31	33	28	28	28	28
		Lead	Correlation Coefficient	-.551**	-.019	-.471*	1.000	-.038	.365	.490**
			Sig. (2-tailed)	.002	.928	.011		.850	.056	.008
			N	28	26	28	28	28	28	28
		Cadmium	Correlation Coefficient	.023	-.296	.015	-.038	1.000	-.235	.122
			Sig. (2-tailed)	.906	.143	.940	.850		.228	.535
			N	28	26	28	28	28	28	28
		Nickel	Correlation Coefficient	-.358	-.231	-.382*	.365	-.235	1.000	.694**
			Sig. (2-tailed)	.062	.256	.045	.056	.228		.000
			N	28	26	28	28	28	28	28
		Zinc	Correlation Coefficient	-.320	-.406*	-.367	.490**	.122	.694**	1.000
			Sig. (2-tailed)	.097	.040	.055	.008	.535	.000	
			N	28	26	28	28	28	28	28
	Insectivore	Wing Length(mm)	Correlation Coefficient	1.000	.320	.179	-.114	-.112	-.106	-.230
			Sig. (2-tailed)		.079	.319	.523	.530	.550	.190
			N	34	31	33	34	34	34	34
		Tarsus	Correlation Coefficient	.320	1.000	.397*	-.224	.000	-.297	-.217
			Sig. (2-tailed)	.079		.030	.217	1.000	.099	.233
			N	31	32	30	32	32	32	32
		Weight (g)	Correlation Coefficient	.179	.397*	1.000	-.058	-.077	-.124	.031
			Sig. (2-tailed)	.319	.030		.748	.669	.492	.862
			N	33	30	33	33	33	33	33
		Lead	Correlation Coefficient	-.114	-.224	-.058	1.000	.251	.596**	.478**
			Sig. (2-tailed)	.523	.217	.748		.145	.000	.004
			N	34	32	33	35	35	35	35
		Cadmium	Correlation Coefficient	-.112	.000	-.077	.251	1.000	.328	.311
			Sig. (2-tailed)	.530	1.000	.669	.145		.055	.069
			N	34	32	33	35	35	35	35
		Nickel	Correlation Coefficient	-.106	-.297	-.124	.596**	.328	1.000	.567**
			Sig. (2-tailed)	.550	.099	.492	.000	.055		.000
			N	34	32	33	35	35	35	35
		Zinc	Correlation Coefficient	-.230	-.217	.031	.478**	.311	.567**	1.000
			Sig. (2-tailed)	.190	.233	.862	.004	.069	.000	
			N	34	32	33	35	35	35	35

DISCUSSION

Lead

The mean concentration for Lead (Pb) was 0.44. The nectarivore group had all the metals in high concentration. Lead (Pb), with environmental exposure linked to emissions and waste from industries, vehicles, paint, burning, plastics papers, etc. is known to cause impairment of neurological development, suppression of haematological system and kidney failure in human (UNEP, 2016). It was present in all the feeding guilds and lowest in frugivore group. The nectarivore group has the highest concentration of Pb. It is the heavy metal of least concern for this study and its mean concentration is also below the maximum permissible level for avian population (Table 1). An earlier study observed that Pb levels of 4 mg/kg in bird feathers are associated with negative effects such as delayed parental and sibling's recognition, impaired thermoregulation, locomotion, depth perception, abnormal feeding behaviour and lowered nestling survival (Burger and Gochfield, 2000). Pb and Cd have no documented positive role in most living organisms, they are rather associated with breeding failure, decreased body weight and reproduction impairment in some egret and heron species (Burger, 1993).

Cadmium

The mean concentration for Cadmium (Cd) was 0.98. Cd is listed in the "most dangerous trace element category" and is present in both the environment and food with long persistence and high toxicity (Gushit*et al.,* 2016). It is not a nutritionally essential element for animals (Furness, 1996). Its average concentration in all the feeding guilds indicates how high the level of Cd contamination across the feeding guilds was when compared to the threshold limits of 0.1mg/kg for a potential threat in avian population (Burgar and Gochfeld, 2000). In addition to being toxic when above certain levels, cadmium may induce deficiencies of essential elements through competition at active sites in biologically important molecules (Walker *et al.,* 1996). It is also known to cause cardiovascular disorder by substituting for calcium in the bone at the smallest dose (Conor, 1982). Cadmium had the second highest concentrations in all the categories. The mean concentration was above the Maximum permissible limit for avian population and this may be likely due to the activities in and around the protected area. This provides an indication on the extent of involvement of the avian populations with emissions and releases from man-made activities such as erosion of surface deposits of minerals containing Cd, ores purifications from smelters/mines and commercial products such as batteries, paints, coatings on metals devices and plasticizers (Qadir *et al.,* 2008) around the study areas covered by the bird species.

Nickel

The mean concentration for Nickel (Ni) was 0.58. Nickel is not an important trace element in organisms, but at high levels as we have in this study, they can cause adverse health effects. Sources of heavy metals vary considerably. It can be emitted into the environment by both natural and man-made sources (Mansouri and Hoshyari, 2012). Once released into the environment, nickel readily forms complexes with many ligands, making it more mobile than most heavy metals (Mansouri *et al.,* 2012). Nickel is related to the pigmentation of feathers in birds and excreted via the feathers by moulting (Honda *et al.,* 1986)

Nickel is reported to affect the respiratory system of birds, causing asthma, as well as birth defects, vomiting, and damage to DNA (Gushit*et al.,* 2016). The mean concentration of Nickel in this study and the other heavy metals are higher than most studies. The maximum permissible limits (MPL) of 0.67 mg/kg for Ni set by FOA/WHO (2001) in food (cereals) as indicated in Table 1, compared to the mean concentration of Ni in this study suggests that there is a reasonable contact of bird species and sources of Ni in the protected area though the concentration is within permissible limit in birds.

Zinc

The mean concentration for Zinc (Zn) was 1.06. Zinc had the overall highest concentration followed by Cadmium, which can be harmful to the birds, even at low concentration when ingested over a long period of time. Nickel and

Lead had the lowest concentrations (Zn > Cd> Ni> Pb). Despite the low value of Ni, the nectarivore group recorded the highest concentration of metals.

Heavy Metals in Feeding Guilds

The evaluated metals are recorded in the order: Zn > Cd> Ni> Pb, with the nectarivore group having the highest number of heavy metal concentration for all the heavy metals evaluated among the feeding guilds. Next are the insectivore group for Pb, Cd and Zn; and the granivore group only for Ni. Then frugivore group with the least concentration for all the metals. The nectarivore group accumulating Cd was in agreement of the study by Gushit*et al.,* 2016 which implies that the nectarivore species feed on plant nectars in polluted area of the park where these metals are in high concentration

Correlation Relationship between the Heavy Metals

For Granivore group, Lead associated positively to Zinc while Nickel associated negatively with Zinc. Zinc had a positive association with Lead and Nickel. For Insectivore group, Lead associated positively with Nickel and Zinc. Nickel also had a positive association with Zinc and Lead. Zinc in turn associated positively with Lead and Nickel (Table 2).

CONCLUSION AND RECOMMENDATION

This study validates the use of avian feather as bioindicator for heavy metal pollution in Old Oyo National Park. The presence of heavy metals detected is mainly of anthropogenic origin which is due to emissions and releases from man-made activities such as erosion of either surface deposits of minerals containing Cd, ores purifications from smelters/mines or commercial products such batteries, paints, coatings on metals devices and plasticizers (Qadir *et al.,* 2008) around the study areas covered by the bird species. This will make the avian species vulnerable apart from affecting other environmental elements, which necessitates the need to manage properly and control pollutant in the environment. Sex, age and feeding guilds have significant effects on heavy metal concentration in the bird species and due to bioaccumulate, increase in age implied increase in metal level except for Cadmium.

With this, the work recommends the need to investigate the sources of this metal with a view to proposing remediation measures that will eventually enhance the quality of the protected area. Also, Continued monitoring of avian exposure to heavy metals is suggested in order to provide a better picture of long-term bioaccumulation trends and their effects on the region's wildlife. Future studies may also consider using our study as a baseline for comparison especially with a longer period of study.

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