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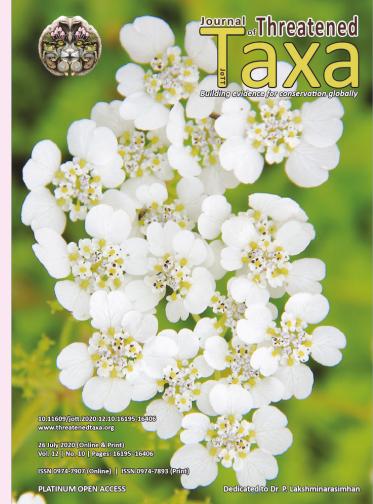
NOTE

TRACING HEAVY METALS IN URBAN ECOSYSTEMS THROUGH THE STUDY OF BAT GUANO - A PRELIMINARY STUDY FROM KERALA, INDIA

Jithin Johnson & Moncey Vincent

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Tracing heavy metals in urban ecosystems through the study of bat guano - a preliminary study from Kerala, India

Jithin Johnson¹  & Moncey Vincent² 

^{1,2} Department of Zoology, Sacred Heart College (Autonomous), Pandit Karuppan Road, Thevara, Kerala 682013, India.

¹jithinjohnson94@gmail.com (corresponding author), ²moncey.vincent@gmail.com

Heavy metal pollution has greatly increased the mobilisation of metals in the air, water, and soil. Metals such as arsenic, cadmium, chromium, copper, mercury, manganese, nickel, lead, and tin are toxic at elevated levels and some even at low concentrations. As these elements do not decay with time, their emission to the environment is a serious problem. Bio-indicator organisms like small mammals, particularly bats allow detection of biological responses and provide a tool in assessing the state of ecosystem health (Clark 1981). Insectivorous bats are considered to be the best bio-indicators as they are exposed to contaminants more directly through invertebrates that may consume soil (Ma & Talmage 2001). Being the only flying mammal, bats are sensitive to a wide range of environmental stresses to which they respond in predictable ways (Zukal et al. 2015) and thus, are important keystone species in the ecosystem, having enormous potential as biodiversity, ecological, and environmental indicators (Jones et al. 2009). Their widespread distribution and proximity to humans make them susceptible to contamination through anthropogenic activities. The potential of bats as bio-indicators of pollution is two-fold: Firstly, exposure to contaminants, including heavy

metals, contributes to the decrease in bat populations. Secondly, levels of the contaminants in bat guano serve as an indicator of the prevalent pollution levels in the surrounding environment. This study aims to evaluate the pollution levels in two different environments using bats as indicator organisms and it is hypothesized that urban areas would reveal comparatively greater amounts of contaminants than rural areas.

Sampling was carried out in different sites from Ernakulam (Mangalavanam Bird Sanctuary and Tripunithura) and Thrissur (Irinjalakuda) districts of Kerala. Fresh (whenever possible) and few-days-old guano deposits of bats like *Pteropus medius* Temminck, 1825, *Megaderma spasma* (Linnaeus, 1758) and *Taphozous melanopogon* Temminck, 1841 were collected by placing nets fitted onto PVC frame of size 0.8 × 0.8 m on the floor of the bat's roosting site and left undisturbed for 4–6 days to allow for sufficient guano deposition. For sample digestion, a mixture of concentrated nitric acid and perchloric acid (5:1 ratio) was added to 0.5g of dry guano in a Borosil glass beaker; the beaker kept in a heating mantle at 90°C for 1–2 h or until digestion was complete. After cooling, the sample was diluted to 20ml using distilled water, the contents filtered and transferred

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to clean Borosil glass vials and then stored at room temperature prior to analysis. Analysis of the metals was done using the Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES) facility at the Kerala University of Fisheries and Ocean Studies, Panangad. Mercury (Hg) analysis was performed using direct Hg analyser at the Sophisticated Test and Instrumentation Centre, Cochin University of Science and Technology (CUSAT). Elemental compositions of dry homogenised samples were determined by X-ray fluorescence (XRF) analyser at the CSIR-Central Electrochemical Research Institute, Karaikudi. Statistical analyses was done using the software package PAST v 3.18 and graphs were made using MS Excel.

It has been known that the composition of elements in bat guano normally equals that in the undigested portion of the ingested food, and as such may provide some clues to the location of contaminants in the environment (Martin 1992). Factors such as the bats' diet, roosting location, foraging habitat, and metabolism may significantly influence accumulation. It seems likely, therefore, that heavy metal exposure pathways differ between frugivorous and insectivorous bat species.

Contamination in fruit bats is likely to be through atmospheric pollution, contact with contaminated foliage whilst searching for and eating food, which may be later ingested directly while grooming. Insectivorous bat species become contaminated mainly through bio-accumulation through the food-chain, i.e., from water/soil/sediments/plants or other sources to insects and finally to the bats themselves. The additional routes of exposure to heavy metals may include contact with skin and inhalation (Allinson et al. 2006). Usually, upon oral ingestion, about 5–10% of the metal gets absorbed and about 99.5% of total ingested metal is excreted through faeces/guano thus leaving only 0.5% to be deposited in

various body tissues (Klaassen 1976). Table 1 represents the general composition of elements detected by the XRF analyser in the bat guano used for the study.

Guano analysis indicated the presence of heavy metals such as mercury (Hg) and various other metals in varying concentrations. The concentration of metals like lead, cadmium and zinc, however, were below detection limits. Figure 1 represents the concentration of Hg obtained from the direct Hg analyser and Table 2 represent the concentrations of the metals (Chromium, Copper, Manganese and Nickel) obtained using the ICP-AES analyser.

In our study, the concentration of mercury varied between the bats from the urban areas of Ernakulam and the rural areas of Irinjalakuda (Thrissur), with higher contamination levels in the Ernakulam District. The composition of guano also varied between the insectivorous and frugivorous bats and this was indicated by the presence of the elements Aluminium (Al) and Titanium (Ti) in insectivorous bat guano. It was also noted that the levels of Copper (Cu), Chromium (Cr), Manganese (Mn), and Nickel (Ni) were significantly

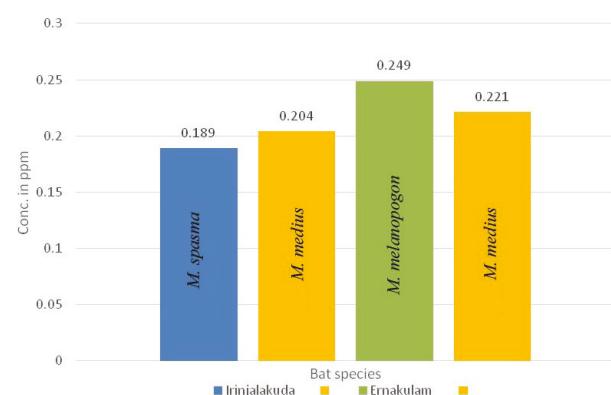


Figure 1. Average mercury levels (n=4) in bat guano (in ppm)

Table 1. Elemental composition of guano from different bats.

Element	Avg. mass (%) (n=4)			
	<i>T. melanopogon</i>	<i>M. spasma</i>	<i>P. medius</i> (1)	<i>P. medius</i> (2)
Aluminium (Al)	4.6105	5.5846	BDL	BDL
Calcium (Ca)	10.7272	17.0122	21.221	21.1739
Copper (Cu)	BDL	0.4237	1.3149	0.1164
Iron (Fe)	42.8869	15.2537	4.1669	6.8953
Potassium (K)	BDL	3.1887	35.3471	36.4112
Molybdenum (Mo)	0.0001	0.0002	0.0003	0.0002
Oxygen (O)	34.7198	39.3272	27.7743	27.3338
Silicon (Si)	6.7776	16.8635	8.335	7.2244
Titanium (Ti)	0.278	1.1079	BDL	BDL
Zinc (Zn)	BDL	1.2382	1.8369	0.5562
BDL → Below detection limit ≈ 0				
(1) → Irinjalakuda, Thrissur; (2) → Ernakulam				

Table 2. Comparison of metal concentrations (mg/kg wet weight) in the guano of insectivorous bats from Ernakulam and Thrissur (mean \pm standard deviation [n=12]).

Metals	Cr	Cu	Mn	Ni
Ernakulam	79.69 \pm 35.56	3973.68 \pm 418.38	820.12 \pm 464.26	60.03 \pm 22.23
Thrissur	24.93 \pm 10.56	2869.22 \pm 503.13	76.92 \pm 38.62	24.61 \pm 16.68
p-value	0.016	0.057	0.016	0.033
p-values were calculated at 95% confidence using Mann-Whitney U test				

different between the insectivores from Ernakulam and those from Irinjalakuda. This may be probably due to the elevated pollution levels in Ernakulam. Further studies are needed to determine if these values are representative of the bat colonies from Kerala, to pinpoint the sources of contamination, and to determine if these levels of contamination adversely affect bats.

Variability in the levels of metals found in bat bodies is influenced by their background environmental levels, which in turn reflects the amounts accumulated. Metals may interfere with the normal functioning of the immune system, cause physiological and histological distress and thus, increase the prevalence of parasites or wildlife infectious diseases (Hernout et al. 2016). Environmental pollution and contamination, in turn, can cause population declines in bats. Assessments of these contaminants thus, help us to understand the levels that would harm humans.

As far as we are aware, there are no other time-trend data for heavy metals in bats in Kerala, and so it is impossible to assess whether the trend in the studied bats is typical for other bat species. Ecotoxicological data are essential for risk assessment and decision-making in bat conservation. Data from this study provides information on baseline levels of interest to monitor status and trends in the heavy metal residue in the bats of the study areas, and therefore, they represent a tool to evaluate potential wildlife, ecological, and human health exposure. Such an evaluation of the contaminant load through guano analysis sheds light on the potential

use of guano as a simple, relatively inexpensive and non-invasive bio-indicator tool to assess the prevalent pollution levels and thus, the environmental quality. The relationship between levels of heavy metals in bat guano, prey analysis, and the various components of the environment in which the insects develop, should also prove to be a fruitful area for future research.

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