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Determination of Some Heavy Metals in the Blood, Brain, Flesh and Liver of Quelea Birds (*Quelea quelea*) in Gyawana Ecosystem, Adamawa State, Nigeria

Buba, Z.M. [*1], Yusufu, S.D[2]., Akan, J.C. [3], Shinggu, D.Y. [4]
[1]Department of Zoology, Adamawa State University, Mubi, Nigeria
[2]Department of Biological Sciences, University of Maiduguri, Maiduguri, Nigeria
[3]Department of Chemistry, University of Maiduguri, Maiduguri, Nigeria
[4] Department of Chemistry Adamawa State University, Mubi, Nigeria
Contact: zainabbubamshelia@gmail.com

Abstract

Heavy metals have a serious impact on the environment and can threaten the stability of an ecosystem. This study was conducted in Gyawana ecosystem, Adamawa State, Nigeria to determine the concentration of heavy metals (As, Cd, Co, Cr, Cu, Ni, Pb and Zn) in the blood, brain, flesh and liver of Quelea birds (Quelea quelea). A total of four hundred and eighty (480) male and female birds were used. The Quelea birds were dissected separately to obtain the organs. The brain, liver and flesh of each Quelea birds sample were dried at 105^{o}C and digested with tri-acid mixture (HNO_3: HCO_4: H_2SO_4). Determination of the heavy metals was done using a Buck Scientific 200A Model, Atomic Absorption Spectrophotometer (AAS). The studied metals (As, Cd, Co, Cr, Cu, Ni, Pb and Zn) were detected at different concentrations in the blood and organs of the studied birds with the exception of Cr which was not detected. The blood samples had highest mean concentration of As, Co, Ni, Pb and Zn (0.081± 0.005mg/g, 0.831± 0.015mg/g, 0.046± 0.001mg/g, 1.064± 0.020mg/g, 11.963± 0.113mg/g) respectively. The least concentration of As, Cu and Ni was detected in the brain of birds; 0.028±0.004mg/g, 16.869± 0.065mg/g, 0.026± 0.000mg/g respectively. The highest mean concentration of Cd was detected in the flesh of birds 1.156± 0.024mg/g and the lowest mean concentration of Cd, Co and Pb was detected in the liver of birds with 0.478± 0.005mg/g, 0.379± 0.006mg/g, 0.330 Z± 0.005mg/g respectively. The flesh of birds had the least mean concentration of Zn. In conclusion, the results obtained in this study shows that the concentrations of As, Cd, Co, Cr, Cu, Ni, Pb and Zn in the blood and organs of the study birds were within the permissible limit. Regular monitoring of heavy metals in the birds species of Gyawana ecosystem should be carried out to ascertain the level of toxicants. Pesticide residue levels and other heavy metals like mercury should be studied to monitor their concentration in the birds of Gyawana ecosystem.

Keywords: Determination; Heavy Metals; Quelea Birds; Gyawana; Ecosystem

Introduction

Heavy metals occur naturally in the ecosystem with large variations in their concentration (McDowell *et al.*, 2006; Mohsen and Salisu, 2008; Salwa and Shuharmi-Othman, 2013).They are metallic elements that are toxic and have high density, specific gravity or atomic weight. Heavy metals occur naturally in the soil from the pedogenetic processes of weathering of parent materials at levels that are regarded as trace (<1000 mg/g) and rarely toxic (Kabata-Pendias and Pendias, 2001; Pierzynski *et al.*, 2006). Anthropogenic activities and acceleration of nature's slowly occurring geochemical cycling of metals by man have caused most environments to accumulate one or more of the heavy metals above the defined background values, high enough to cause risks to human health, plants, animals, ecosystems, or other media (D' Amore *et al.*, 2005).

Generally, birds acquire heavy metals through intake of food, drinking of contaminated water and geophagy. The rate of heavy metal absorption varies depending on species physiology, metal properties, and their availability in the environment. After absorption, metals circulate in the body and are excreted or get deposited in various body tissues, or are sequestered in feathers (Salwa and Shuharmi-Othman, 2013). The high toxicity of heavy metals may result in eggshell thinning, low reproduction rate, suppression of the immune system, reduced growth/ weight, and developmental malformations, which all lead to possible population decline in birds (Dauwe *et al.*, 2006). Long-term exposure to heavy metals can also cause disruptive behavior and reduction in disease resistance and affect other physiological processes (Dauwe *et al.*, 2005). This study was carried out mainly to determine the concentrations of heavy metals in the blood, brain flesh and liver of Quelea birds (*Quelea quelea) i*n Gyawana Ecosystem. As the subsequent consumption of this birds may lead to passage of these metals to humans and other species that depend on such birds as food, thereby causing bioaccumulation and biomagnification so the need for this study.

Materials and Methods

Sampling Area and Sample Collection

Sampling area and sampling site was from Gyawana ecosystem, Lamurde Local Government Area, Adamawa State of Nigeria. Gyawana is located at latitude 9˚.35' N and longitude 11˚.55' E and is 135 meters above Sea level. Lamurde Local Government Area lies between longitude 9˚.36' 03.92"N and latitude 11˚.47' 36.25"E at an elevation of 137 meters above sea level and has a population of 77,522 people (Adebayo and Tukur, 1999). Adamawa State is located in the North Eastern part of Nigeria, and lies between latitudes 7˚ and 11˚ N and between longitudes 11˚ and 14˚ E. It is on an altitude of 185 meters above Sea level and covers a land area of about 39,741km^2 (Adebayo *et al*., 2012).

A total of four hundred and eighty (480) male and female birds were captured in the wild, using black nylon mist nets with dimensions of 7 x 2.5m and mesh size of 16 mm. Subtotal of forty birds were captured per month. The birds were captured at their night roosts and water drinking points. The mist nets were set between 9:00a.m and 11:00 am to catch the birds that went to drink after morning feeding and 5:00pm and 6:00pm to catch those that went to drink before going to their night roosts, adopting the method of (Kirkpatric *et al.,* 1969; Jonathan and Frederich, 1994; Lester and Van, 2014).

Eight (8) birds each were collected at Gokumbo, Italiah and Goro Mbemun Rivers; five (5) birds each were collected at Canal Rivers A and B; and six (6) birds collected at Canal River C sampling sites, making a total of forty birds monthly. Their blood samples were collected immediately when trapped, using micro-capillary tube to obtain blood from the lower limb vein after being anesthetized with 2ml of 5% chloroform. The blood was dropped on a Whatman No.1 filter paper, and air dried then kept for digestion and determination of the heavy metals. The birds 'biometrics were measured and weighed after being sacrificed by suffocation, using chloroform in air tight transparent plastic containers. The birds were then dissected to obtain liver, flesh and brain which was dried at 105^{o}C until a constant weight is obtained. The samples were grounded individually according to sex, using porcelain mortar and pestle. The ground bird's samples were transferred to a porcelain basin and put into a muffle furnace and the temperature was increased gradually until 550^{o}C was reached, following the method of Gonul *et al.,* (1994).

Determination of Heavy Metals

Samples of the brain, blood, flesh and liver of the birds were digested with tri-acid mixture (HNO_3: HCO_4: H_2SO_4) in the ratio of 10:4:1, respectively at a rate of 5ml per 5.0g of sample and placed on a hot plate at 100^{o}C temperature. Digestion was allowed to continue until the liquor became clear. All the digested liquor was filtered through Whatman 541 filter paper and diluted with 25mls of distilled water. Determination of the heavy metals was done directly on each final solution using a Buck Scientific 200A Model, Atomic Absorption Spectrophotometer (AAS). Values obtained were expressed in milligram per gram (mg/g) (APHA, 1995; AOAC, 2000; APHA, 2005).

Data Analysis

Data obtained were analyzed by one way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT) for means separation. Using a statistical software package (SPSS for Windows). The results were presented as mean ± standard error and $P > 0.05$ was regarded as not statistically different.

Results and Discussion

Table 1 shows the mean concentrations of As, Cd, Co, Cu, Ni, Pb and Zn in the different organs of Quelea birds. With exception of Cr, all the studied metals were detected in the blood samples and organs of Quelea birds. The highest mean concentration of As (0.081± 0.005mg/g) was found in the blood of Quelea birds, followed by the flesh (0.030±0.000mg/g) and liver (0.030±0.000mg/g). The least mean concentration was found in the brain with a value of 0.028±0.000mg/g, but the differences were not significant ($p > 0.05$). For Cd the results shows that flesh had the highest mean concentration (1.156±0.024mg/g), followed by the brain (0.878±0.172mg/g) and blood (0.869±0.015mg/g) and the least mean concentration was found in the liver (0.478±0.004mg/g). The differences were significant ($p < 0.05$). The highest Co concentration was detected in the blood with a mean value of 0.831±0.015mg/g, followed by flesh with mean value of 0.600±0.011mg/g and 0.473±0.009mg/g in brain. The lowest concentration of Co was detected in the liver with a value of 0.379±0.006mg/g.

Quelea birds' liver had the highest mean concentration of Cu (18.318±0.054 mg/g), followed by the blood (18.249±0.054mg/g) and flesh (17.118±0.035mg/g). The least mean concentration (16.869±0.065mg/g) was found in the brain. There were no significant differences ($p > 0.05$) in the concentrations of Cu between the blood, liver, flesh and brain of Quelea birds. Nickel concentration was highest in the blood of birds (0.046±0.000mg/g), followed by liver (0.039±0.000mg/g) and flesh (0.039±0.000mg/g), while the least mean concentration of Ni was found in the brain (0.026±0.000mg/g) and the differences

were significant ($p < 0.05$). The blood of the birds contained the highest mean concentration of Pb (1.064±0.020mg/g), followed by the flesh (0.578±0.011mg/g), brain (0.462±0.007mg/g) and the liver (0.330±0.005mg/g). These differences were significant ($p < 0.05$). Also Table 1 shows that blood had the highest mean concentration of Zn (11.963±0.113mg/g) followed by the brain (11.619± 0.114mg/g) and liver (11.099 ± 0.114mg/g), while the flesh showed the least value of 10.110± 0.095mg/g and these differences were significant ($p < 0.05$).

In this study different mean concentrations of heavy metals (As, Cd, Co, Cr, Cu, Ni, Pb and Zn) were observed in the blood, brain, liver and flesh of birds (*Quelea quelea*) in Gyawana Ecosystem, Lamurde Local Area of Adamawa State, Nigeria. The blood concentration of As in Quelea birds sampled was significantly higher than in the other organs. The higher concentration of As in blood might be an indication of tissue accumulation of this metal since metals stored in tissues can be mobilized and transferred back to the blood due to the constant blood flow (Rattner *et al.*, 2008). Although it is expected that the organs with large blood supplies such as liver and kidney would build up higher concentrations of the heavy metals over time. Asenic especially in its inorganic forms, can bring about the death of an individual, produce sublethal effects and affect avian reproduction (Eisler, 1994; Marcos *et al*., 2008).The results of this study are not consistent with the results of Kirkpatrick *et al.* (2010) and Michael and Charles, (2014) as all arsenic levels in the organs of Quelea birds in this study were lower than their findings, on the distribution and extent of heavy metal accumulation in Song Sparrows (*Melospiza melodia*) in Upper Santa Cruz river watershed, Southern Arizona, U.S.A. There is also a similarity in the results of this study with the results of Aleya and Sabritna (2013), who reported lower mean concentrations of arsenic in the liver of pigeons (*Columba livia),* (0.01–0.04mg/g (d.w). This disparity might be due to ecological factors and differences in the species of birds studied and their feeding habit.

For Cd, the result shows that flesh of the birds had the highest mean concentration followed by brain and the least mean concentration was found in the liver. The trend for Cd in this study does not conform with the findings of Ping *et al*. (2014), who reported that the concentrations of cadmium in tissues of chickens were in the descending order of liver > kidney > feather > muscle > blood. This may be due to the differences of species and organs or parts of the birds used and their environment. The result of Co shows that, blood had the highest mean concentration followed by flesh, brain and liver. Cr was not detected in all the organs of the birds analyzed. This was not in agreement with the findings of Nellie *et al*., (2008) who reported that chromium levels in blood of Passerine birds in Meadowlands were relatively high with a value of 0.452±0.0712mg/g. The differences could likely be due to ecological factors and even the birds of study.

The liver had the highest mean concentration of Cu, followed by blood, flesh and the brain of the Quelea birds. This is in line with other previous studies which showed similar body part specific distributions such as high concentrations of Cu in the liver, and low concentrations in the brain (Kim *et al*., 1998; Nam *et al*., 2005). A significantly higher level of Cu in the muscle than in the liver and intestine had also been observed by Torres *et al.*, (2010), which is different from the findings of this study. Copper is an essential part of several enzymes and it is necessary for the synthesis of haemoglobin. Blood of birds had the highest mean concentration of Ni, followed by liver and flesh with the same mean concentration and the least mean concentration was found in the brain. The overall mean concentration of Ni in this study was low, which does not conform to Lulzim *et al*. (2015), who reported 0.674±0.451mg/g (d.w) in House Sparrow (*Passer domesticus*) in Mitrovica. The latter study was carried out in a polluted area with dumps of domestic wastes, sewage, industrial and agricultural wastes, but using a different species of birds from the one in this study. Ni is a harmful carcinogenic substance that enters the body through contaminated food, inhalation and skin contact (Das *et al*., 2008). Studies conducted by the International Agency for Research on Cancer (IARC) and US, Department of Health and Human Services found that all Ni compounds are human and animals carcinogens (ATSDR, 2007). Researchers at the Dominican University of California have also linked Ni exposure to breast cancer (Edward, 2015).

Table 1: Mean Concentrations of Heavy Metals in Blood, Brain, Flesh and Liver of Quelea birds

Organs	Concentrations (mg/g) of Heavy Metals							
	As	Cd	Co	Cr	Cu	Ni	Pb	Zn
Blood	0.081±0.005[a]	0.869±0.015[ab]	0.831±0.015[a]	ND	18.249±0.054[a]	0.046±0.000[a]	1.064±0.020[a]	11.963±0.113[a]
Brain	0.028±0.000[a]	0.878±0.017[ab]	0.473±0.009[b]	ND	16.869±0.065[a]	0.026±0.000[c]	0.462±0.008[b]	11.619±0.114[a]
Flesh	0.030±0.000[a]	1.156±0.024[a]	0.600±0.011[ab]	ND	17.118±0.035[a]	0.039±0.000[b]	0.578±0.011[b]	10.110±0.095[a]
Liver	0.030±0.000[a]	0.478±0.005[b]	0.379±0.006[b]	ND	18.318±0.054[a]	0.039±0.000[b]	0.330±0.005[b]	11.099±0.114[a]
	ns	*	*		ns	*	*	ns

NB. Means with the same superscripts in each column are not significantly different at $p > 0.05$ using ANOVA and DMRT for mean separation.

Key:
ns = Not significant
* = significant
ND = Not Detected

The results of this study show that the blood of Quelea birds had the highest mean concentration of Pb, than the flesh, brain and liver. This conforms to the results of Nellie *et al*., (2008), who reported that the concentrations of Pb in the blood was higher than the other organs in all species of birds studied in Meadowlands of New Jersey. Neille (2008) also found that the value for blood lead of Marsh Wrens studied in Meadowlands of New Jersey was higher than 0.4mg/g. The adverse physiological effects are said to occur in birds with blood lead levels from 0.4 mg/g (Burger and Gibbons, 1998; Nellie *et al*., 2008), but the mean concentrations of lead in this study are generally low when compared with the US Environmental Protection Agency (USEPA, 1997) guide lines reported by Anonymous (2013). Also, blood had the highest mean concentration of Zn followed by brain, liver and flesh having the least mean concentration. The mean concentration of zinc observed in the liver of Quelea birds in this study was higher than that reported by Marcos *et al*. (2008), who found a range of 0.0087mg/g to 0.114mg/g in raptor birds. This discrepancy might be due to the higher concentration of human waste in this study and the tissues used. Blood levels generally reflect the most recent exposure, while feather levels reflect the conditions and diet during the period of feather growth (Dauwe *et al.,* 2005; Okati, 2013). Marcos *et al.,* (2008), however reported that excess zinc increases stress in birds.

In conclusion, the results obtained in this study shows that the concentrations of arsenic, cadmium, cobalt, copper, nickel, lead and zinc in the blood and organs of the study birds were within the permissible limit. From the outcome of this study, the following recommendations could be made: *R*egular monitoring of heavy metals in the birds species of Gyawana ecosystem should be carried out to ascertain the level of toxicants. Pesticide residue levels and other heavy metals like mercury should be studied to monitor their concentration in the birds of Gyawana ecosystem.

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