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COMPARATIVE ASSESSMENT OF HEAVY METAL CONTENTS IN ORGANS AND FLESH OF MARKETED CANE RAT (*Thryonomys swinderianus* Temminck, 1827) ALONG FIVE HIGHWAYS IN SOUTH-WESTERN NIGERIA

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ABSTRACT

Comparative heavy metal pollution in organs and flesh of marketed cane rat along five highways in southwestern Nigeria was studied. Twenty-three wildlife markets were visited and there, samples were taken randomly on quarterly basis. Visceral organs of raw kidney, liver, lung, flesh and roasted flesh of Thryonomys swinderianus (cane rat) as the most sourced wild animal were taken and screened using Wet Digestion Method for heavy metals including lead, cadmium, chromium, astatine, copper, manganese and cobalt. Results showed that lung had the least contamination, followed by kidney, then liver; raw flesh and lastly roasted meat as the highest. Chromium and Astatine were significantly different in distribution (0.017 and 0.049 respectively) at P> 0.05.Follow-up procedures showed that at P>0.05, for Astatine, the descending order was concentration was Roads,5 4, 2, 3 and1 . For chromium the distribution order was Roads 5, 4, 3, 2 and 1 also in descending order. Average values in all the samples pooled together showed lead falling within the permissible range of 0.5mg/kg for offals and 0.1 mg/kg for meat, Copper exceeded the values of 0.01 mg/kg flat along all market Roads for both categories, chromium was within the safe limit of 1.00mg/kg for both meat and offals; cadmium was within the safe range of 0.5 mg/kg for both offals and meat throughout the study areas. Cobalt exceeded the value of 0.08mg/kg for offals and 0.03 mg/kg for meat along Road 3 only. Manganese and astatine fell within safe range of 0.5 mg/kg for both samples classes limit. Expansion of environmental conservation strategies was recommended. It was concluded that the marketed wildlife in the study area are partially safe for consumption.

Key Words: analysis, contamination, Heavy Metal, highways, markets, Wildlife.

INTRODUCTION

Roads in Nigeria constitute major means of transportation, the failure of the railway system has contributed immensely to the proliferation of haulage trucks on Nigerian highways and these trucks have been the cause of many road crashes especially along the Lagos-Benin expressway; road construction leads to expansion of farmsteads into villages and later into markets where people settle down for different commercial activities at junctions where foot paths develop into motorable roads (Nnadi, 2011).

Marketed wild animals are substantial components of traditional diets and ethno-medicine among many subsistence communities in the tropics; rodents are a generally accepted food in western and southern Africa especially in rural communities where larger animals are limited in supply but the pouched or cane rat (*Thryonomys swinderianus*) and other rodents are readily accessible at roadsides and local markets (FAO, 2010). The meat of wild animals is widely cherished by the populace in both rural and urban communities of West Africa because of the taste and medicinal purposes, among these animals, the family of rodents contributes the highest percentage of meat protein; the big rodents include the grasscutter/cane rat (*Thryonomys swinderianus*), porcupine (*Hystrix cristata*), giant rat *Cricetomys* *emini* and ground squirrel *Xerus erythropus* (Imran *et al*., 2013).

Social acceptance studies among different ethnic groups of West Africa as reported by Imran *et al*. (2013) have shown in all instances that the meat of grasscutter is acceptable to all social classes of people both in the urban and rural areas. The acceptability cuts across either religion or cultural beliefs. According to them, the meat is particularly favoured among other wild animals because of its good taste, low fat and high dressing percentage. The demand for the grasscutter meat is so high that it is vigorously hunted, in West Africa. This observation was supported by Opara (2010) that grasscutter continues to lead the wildlife trade

While most game meats are produced from healthy animals, some are produced from sick animals, this situation has raised public health concerns because the meat may harbor infectious agents that are not destroyed by smoking, salting nor brining preparations and as a result, could cause human diseases (Klein, 2005).

In man's efforts to increase food production, raise standard of living and boost agricultural and industrial activities, atmospheric pollution from release of oxides of carbon, sulphur and Nitrogen, results; other ways involve the release of pollutants such as, hydrocarbons and chlorofluorocarbons into the ecosystem, resulting in air, water, land and thermal pollution. (Ramalingan, 2012). Heavy metal pollution is common in areas where vehicular traffic is persistent, these metals include Zinc, Lead, Mercury, Cadmium and copper; smog and particulates (Jerrie, 2005). Afolarin (2006) reported that vegetables grown in areas that are subjected to pollution from vehicles and industrial emissions are prone to absorption of contaminants such as heavy metals and move along tropic levels either in simple ways (food chain) or complex (food web) manners. This paper assesses heavy metal accumulation in kidneys, lungs, livers and flesh of marketed cane rat along the above highways as indicators of health status of the animal because it is integral part of human diet.

MATERIALS AND METHODS

Study Area

The study area is the catchments of five highways within South Western Nigeria: Ibadan-Ife-Ado Ekiti road named Road 1 (264km), Ibadan-Ife-Akure road tagged Road 2 (204 km), Ibadan-Oyo-Ogbomoso road or Road 3 (120 km), Lagos-Benin road (from Sagamu Interchange to Ore Junction in Ondo State (153 km) labeled Road 4 and Lagos – Ibadan (from Sagamu Interchange to old Ibadan Toll Gate) or Road 5 that covers (62km) (Figure 1).

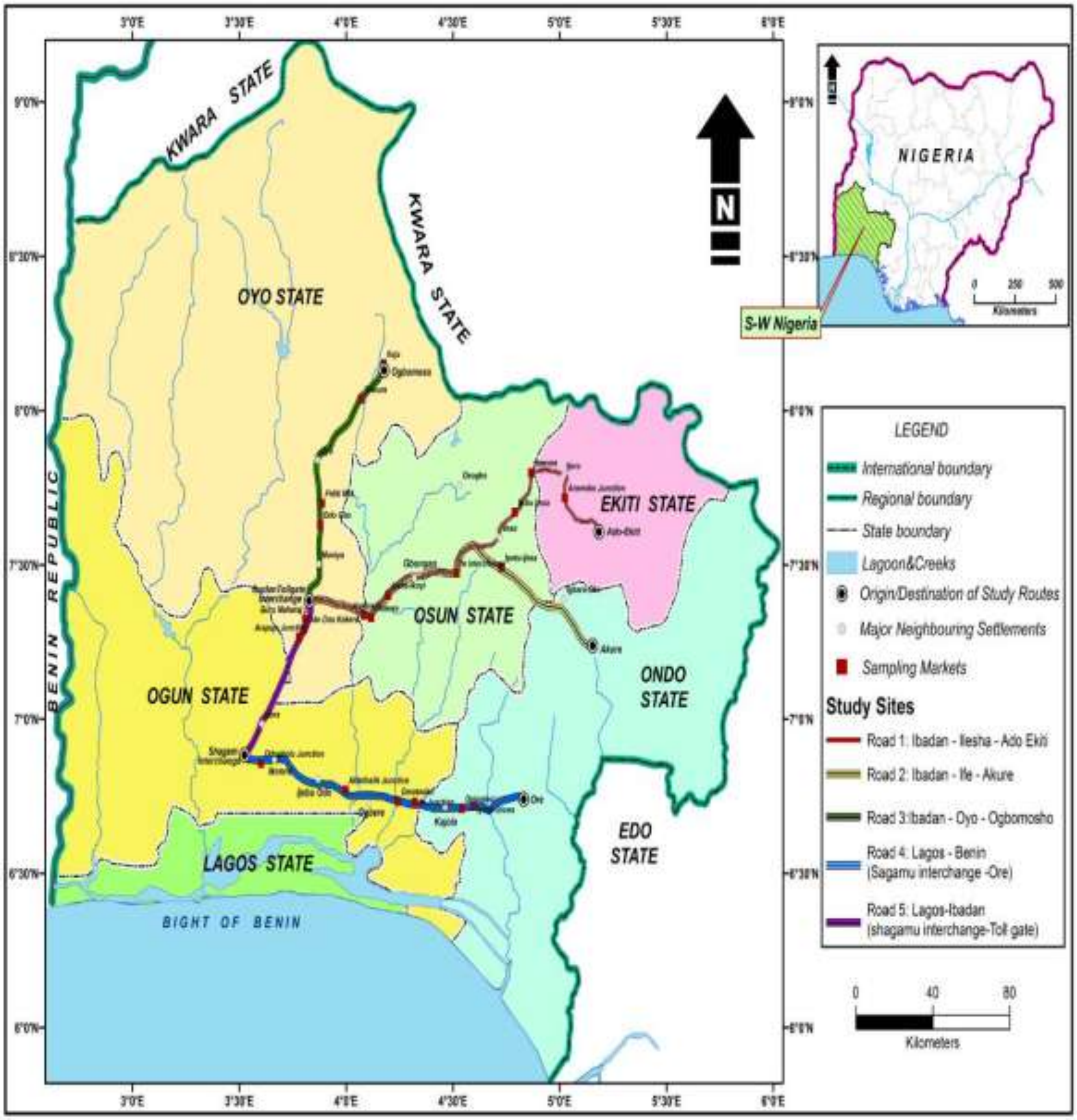

Figure 1: The Study area showing the roads and major neighbouring settlements
Source: Balogun, (2008).

Wildlife markets within 100 metres off the road on both sides of the expressways were used for the study. The markets were selected using systematic random sampling (odd numbers) method. Materials used were structured questionnaires and Global Positioning System (GPS) equipment: Trimble Juno SD indicated the markets' geographical locations. The markets were 23 in number: Ijebu-jesa, Itawure Junction, Aramoko Junction and Aba-Ebira (4 markets); along Road 1. Asejire 1, Asejire 2 (Olokere), Iyana Ikoyi/Wasinmi, Ife Interchange, and Ipetu-Ijesa (5 markets) for Road 2; Fiditi, Odo-Oba, Tewure and Iluju (3 markets) for Road 3; Odogbolu Junction, J4 Junction, Onipetesi, Iyana Oluwa, Akinfosile and Omotosho (6 markets) for Road 4 with Toll-Gate, Guru Maharaji, Odo-Ona Kekere and Arapaja Junction (4 markets) for Road5 .

All the markets were visited for two years on monthly basis; samples of raw lung, liver, kidney, liver with raw and roasted flesh were taken randomly from marketed wildlife displayed for sale. The organs and flesh were from cane rat (*Thryonomys swinderianus*) as the most sourced wild animal and were tested for heavy metal contents. Heavy metal analysis was carried out in

Laboratory Technology Unit, Institute of Agricultural Research and Training (IAR&T), Moore Plantation, Ibadan using Wet Digestion method (Preer and Rosen,1999): The prepared samples were placed in tubes and kept, placed in digestion equipment and slowly digested until complete digestion (appearance of colourless solution) occurred. The digest was washed into 100ml volume flask and made up with distilled water to 100ml level. The washed sample was then read from Atomic Absorption Spectrophotometer (AAS) Model Buck 200 using their respective lamp and wavelength. Calculation of the heavy metal values was done using the formula

Heavy metal value = Meter reading × Slope × Dilution factor.

Slope for the each of the seven heavy metals assessed was 1 ppm (Parts per million). Dilution Factor was calculated as volume of the flask used (or extractant volume of 100ml) divided by weight of the sample used (2g).The metals assessed were Lead (Pb),Cadmium (Cd), Cromium (Cr), Astantine (As), Copper (Cu), Manganese (Mn) and Cobbalt (Co).

RESULTS

Generally, among organs, considering the average contamination level of all metals put together, that of lung (0.67mg/kg) was the lowest, next was that of kidney (0.77mg/kg); this was followed closely by that of liver (0.79 mg/kg) probably because the two organs work hand in hand; next was raw meat and the highest contamination of heavy metals put together was in roasted meat (0.79 and 1.29 mg/kg respectively) (Table 1). The metals might have also been due to the water, land and air pollution. It might also be brought about by vehicular traffic.

Table 1: Comparison of Organs being Contaminated by heavy metals (mg/kg)

Organs	Pb	Cd	Cr	As	Cu	Mn	Co	Sum	Mean
Kidney	0.79	0.61	0.06	0.45	1.77	1.63	0.06	5.37	0.77
Liver	0.72	0.51	1.18	0.04	1.43	0.93	1.40	6.21	0.89
Lung	0.81	0.90	0.42	0.00	1.71	0.82	0.00	4.66	0.67
Flesh	0.67	0.85	0.50	0.27	1.47	1.66	0.13	5.55	0.79
Roasted flesh	1.55	1.66	0.87	0.44	2.29	1.82	0.37	9.00	1.29

Along roads, the highest value of lead was found in kidney being sold at Market Road 5 with value of 0.22mg/kg while the lowest value was obtained in kidney sourced at market Road 2 with value of 0.02mg/kg. For cadmium, the highest value was found in Market Road 4 lung (0.24mg/kg) and the lowest value was in Market Road 4 Liver (0.03 mg/kg). Considering chromium, the highest value was found in Market Road 5 roasted flesh (0.32mg/kg) while the lowest value was Market Road 3 kidney, liver and lung (0.00mg/kg). On the basis of Astatine, Market Road 5 raw Kidney had the highest value (0.44mg/kg) and the lowest value was in Market Road 1 to 4 raw lung(0.00 mg/kg). For copper, the highest value was found in Market Road 4 (0.55mg/kg) and the lowest value was Market Road 4 raw liver (0.00mg/kg). Manganese had the highest distribution in Market Road 5 raw kidney (0.39mg/kg) but the lowest value was in Market Road 1raw liver and raw lung (0.11mg/kg). The highest value of cobalt was found in Market Road 1 raw liver (0.49 mg/kg) while its lowest value was in Market Roads 1 to 4 raw lung as 0.00mg/kg, results on the pattern of variation of individual heavy metals among the market roads showed that Roasted flesh had the highest values of all heavy metals along all market roads. The metal with the highest value in roasted flesh was Copper with an average of 0.46mg/kg. The leading Road Market in this respect was along Road was Road 1 with value of 0.58mg/kg (Table 2). The pattern of distribution of other metals in the market Roads are shown in Table 3 to Table 9.

Table 2: Lead Distribution along Market Road Samples (mg/kg)

Metals	MR1	MR2	MR3	MR4	MR5	Sum	Mean
	Pb	Pb	Pb	Pb	Pb		
Raw Kidney	0.17	0.02	0.19	0.19	0.22	0.79	0.16
Raw Liver	0.17	0.19	0.10	0.22	0.04	0.72	0.14
Raw Lung	0.10	0.14	0.20	0.19	0.18	0.81	0.16
Raw Flesh	0.06	0.20	0.12	0.14	0.15	0.67	0.13
Roasted Flesh	0.22	0.33	0.33	0.27	0.29	1.55	0.29

Key: MR=Market Road

Table 3: Cadmium Distribution along Market Road Samples (mg/kg)

Metals	MR1	MR2	MR3	MR4	MR5	Sum	Mean
	Cd	Cd	Cd	Cd	Cd		
Raw Kidney	0.22	0.15	0.04	0.18	0.02	0.61	0.12
Raw Liver	0.22	0.22	0.02	0.03	0.02	0.51	0 10
Raw Lung	0.12	0.21	0.11	0.24	0.22	0.90	0.18
Raw Flesh	0.08	0.31	0.11	0.33	0.02	0.85	0.17
Roasted Flesh	0.37	0.34	0.23	0.38	0.34	1.66	0.33

Key: MR=Market Road

Table 4: Chromium Distribution along Market Road Samples (mg/kg)

Metals	MR1	MR2	MR3	MR4	MR5	Sum	Mean
	Cr	Cr	Cr	Cr	Cr		
Raw Kidney	0.00	0.00	0.03	0.03	0.00	0.06	0.01
Raw Liver	0.00	0.00	0.03	0.11	0.04	0.18	0.04
Raw Lung	0.00	0.01	0.13	0.13	0.15	0.42	0.08
Raw Flesh	0.00	0.00	0.13	0.14	0.23	0.50	0.10
Roasted Flesh	0.02	0.01	0.22	0.32	0.30	0.87	0.17

Key: MR=Market Road

Table 5: Astatine Distribution along Market Road Samples (mg/kg)

Metals	MR1	MR2	MR3	MR4	MR5	Sum	Mean
	As	As	As	As	As		
Raw Kidney	0.00	0.01	0.00	0.00	0.44	0.45	0.09
Raw Liver	0.00	0.00	0.00	0.04	0.00	0.04	0.01
Raw Lung	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Raw Flesh	0.00	0.00	0.00	0.11	0.16	0.27	0.05
Roasted Flesh	0.01	0.07	0.03	0.14	0.19	0.44	0.09

Key: MR=Market Road

Table 6: Copper Distribution along Market Road Samples (mg/kg)

Metals	MR1	MR2	MR3	MR4	MR5	Sum	Mean
	Cu	Cu	Cu	Cu	Cu		
Raw Kidney	0.49	0.27	0.01	0.55	0.45	1.77	0.34
Raw Liver	0.49	0.39	0.22	0.00	0.33	1.43	0.29
Raw Lung	0.22	0.60	0.23	0.33	0.33	1.71	0.34
Raw Flesh	0.42	0.40	0.00	0.32	0.33	1.47	0.29
Roasted Flesh	0.58	0.41	0.50	0.41	0.39	2.29	0.46

Key: MR=Market Road

Table 7: Manganese Distribution along Market Road Samples (mg/kg)

Metals	MR1	MR2	MR3	MR4	MR5	Sum	Mean
	Mn	Mn	Mn	Mn	Mn		
Raw Kidney	0.28	0.20	0.41	0.35	0.39	1.63	0.33
Raw Liver	0.11	0.24	0.13	0.22	0.23	0.93	0.19
Raw Lung	0.11	0.20	0.14	0.18	0.19	0.82	0.16
Raw Flesh	0.45	0.39	0.39	0.03	0.40	1.66	0.33
Roasted Flesh	0.45	0.39	0.39	0.12	0.47	1.82	0.36

Key: MR=Market Road

Table 8: Cobalt Distribution along the Market Road Samples (mg/kg)

Metals	MR1	MR2	MR3	MR4	MR5	Sum	Mean
	Co	Co	Co	Co	Co		
Raw Kidney	0.00	0.01	0.03	0.01	0.01	0.06	0.01
Raw Liver	0.49	0.39	0.22	0.00	0.30	1.40	0.28
Raw Lung	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Raw Flesh	0.00	0.00	0.13	0.00	0.00	0.13	0.03
Roasted Flesh	0.02	0.04	0.31	0.00	0.00	0.37	0.07

Key: MR=Market Road

Among the variables tested, Chromium (Cr) and Astatine (As) were found significant ($P \leq 0.05$) while others were not significant at 95% probability (Table 9).

Table 9: One-Way Analysis of Variance for Heavy metals in the Assessed Organs in the Study Area

Element	Variation	Sums of Squares	Df	Mean Square	F-value	Sig. test (F- value)
1. Pb	Variable	0.130	4	0.003	0.479	0.751(NS)
	Error	0.134	20	0.007		
	Total	0.264	24			
2.Cd	Variable	0.084	4	0.021	1.579	0.218(NS)
	Error	0.265	20	0.013		
	Total	0.349	24			
3. Cr	Variable	0.104	4	0.026	3.884	0.017(Sig).
	Error	0.134	20	0.007		
	Total	0.239	24			
4. As	Variable	0.086	4	0.022	2.876	0.049 (Sig.)
	Error	0.150	20	0.007		
	Total	0.236	24			
5.Cu	Variable	0.190	4	0.047	2.004	0.133(NS)
	Error	0.473	20	0.024		
	Total	0.663	24			
6. Mn	Variable	0.067	4	0.017	1.036	0.413(NS)
	Error	0.325	20	0.016		
	Total	0.393	24			
7.Co	Variable	0.033	4	0.008	2.382	0.086(NS)
	Error	0.069	20	0.003		
	Total	0.102	24			

The follow-up procedure using Duncan Multiple Range Test (DMRT) for chromium revealed significant difference in distribution among the five market roads. The highest distribution was detected along Market Road 5 followed by Road 4, 3, 2 and 1 with values of 0.1442+/-0.556^{a}, 0.1460 +/-0.047^{a}, 0.1060+/-0.035^{c}, 0.0040+/-0.002^{c} and 0.0036+/-0.002^{c} respectively (Table 7). The follow-up procedure using Duncan Multiple Range Test (DMRT) for Astatine revealed significant difference across the five Roads at p≥ 0.05(Table 10). The highest concentration was found along Road 5 followed by Roads 4, 2, 3 and 1 in with values of 0.1588, 0.9584, 0.0164, 0.0064 and0.002 respectively.

Table 10: DMRT for Chromium to Separate the Mean Differences

Market Roads	Mean ± SE
1	0.0036±0.002^{c}
2	0.0040±0.002^{c}
3	0.1080±0.035^{b}
4	0.1460±0.047^{a}
5	0.1442±0.056^{a}

Table 11: DMRT for Astatine to separate the mean differences DMRT for chromium to separate mean differences

Roads	Mean ± SE
1	0.002±0.001^{c}
2	0.0164±0.001^{c}
3	0.0064±0.002^{b}
4	0.0584±0.002^{b}
5	0.1588±0.0062^{a}

**Means carrying the same letter subscripts are not significant from each other (P≤ 0.05)*

Generally among organs, considering the average contamination level of all metals put together, that of lung was the lowest, next was that of kidney; this was followed closely by that of liver probably because the two organs work hand in hand; next was raw meat and the highest contamination of heavy metals put together was roasted meat (Table 10)

DISCUSSION

The samples (raw organs of lung, liver, kidney raw with roasted flesh) of cane rat (*Thryonomys* *swinderianus*) revealed different levels of heavy metal contamination. The lung was least contaminated probably because the animals move away from traffic to far places where the air is less polluted. Kidney and liver had close contamination values probably because the two organs work hand in hand. Furthermore, the liver is known to detoxify contaminants and kidney is ultra filtration organ, so this accounted for the high accumulation of heavy metals in them This assertion agrees partially with Soewu *et al*., (2014) that heavy metal accumulation is higher in liver and kidney than lung of cane rat in all the metals lead, copper, zinc, cadmium and chromium but for iron.

There was most heavy metal pollution in the roasted flesh sampled probably due to the use of hydrocarbon used in support of firewood for roasting especially when firewood got wet. Chromium and Astatine were significantly different in distribution but showed very high concentrations among the Road 5 at P $\geq$0.05 probably due to the heavy traffic attached to these roads as inter-regional links within the country. This result however agrees with previous study of Tanee and Albert (2013) that plants and soils become polluted by heavy metals from traffic. Average values in all the samples pooled together showed lead falling within the permissible range of 0.5mg/kg for offals and 0.1 mg/kg for meat, Copper exceeded the values of 0.01 mg/kg flat along all market Roads for both categories, Chromium was within the safe limit of 1.00mg/kg for both meat and offals; Cadmium was within the safe range of 0.5 mg/kg for both offals and meat throughout the study area, all in comparison with FAO, (2010) recommendation. Cobalt exceeded the value of 0.08mg/kg for offals and 0.03 mg/kg for meat (Agency for Toxic Substances and Disease Registry ASTDR, 2014) along Road 3 only. Manganese and Astatine fell within safe range of 0.5 mg/kg for both samples classes according to European Food Safety Authority EFSA, (2014) limit. These findings concluded that most of the wildlife terrestrial animals in the study areas were partially contaminated and at variance with the different roads each is found. The heavy metal analysis aspect suggests that wildlife in the study area is partially safe for consumption.

Recommendations

1. Hydrocarbon pollution from vehicles and other automobiles should be controlled through enactment of laws by governments with stiff penalties meted to offenders. Caution should therefore be exhibited in consuming wildlife parts and organs.
2. Environmental conservation should be as subjects in primary and secondary schools Basic Science and senior secondary classes' Biology, Geography and Agricultural science curricula.

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