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Distribution of Some Heavy Metals in the Tissues of Arm, Thigh, Kidney and Liver after Continuous Feeding of Rabbits with Diet Contaminated with Crude Oil

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Authors' contributions

This work was carried out in collaboration between all authors. Author JMO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author OET managed the analyses of the study. Authors JIA and TJJ managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This experiment was conducted to assess the distribution of these heavy metals in the tissues of rabbits from the continuous feeding of diets contaminated with crude oil.
Study Design: Completely randomized design (CRD).
Place and Duration of Study: University of Benin Teaching and Research Farm for a period of 9 months.
Methodology: The experiment was carried out using 40 rabbits of New Zealand breed obtained from the University of Benin Teaching and Research Farm, Nigeria. The rabbits were divided into four treatments with each treatment having ten replicates. A single diet was formulated based on the nutrient requirement of growing rabbits and partitioned into Diets A, B, C and D with 0, 15, 30

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and 45 mL of crude oil added to every 3 kg of the feed. Analysis of heavy metals in the tissues was based on standard procedures.
Results: The highest level of cobalt recorded in the arm was found among the highest dosed rabbits (45 mL) which differed significantly from the groups that received lower or no dosage. No traces of nickel and cadmium were found in any of the tissues. The dose-related increase in the distribution of lead and copper in the thigh was observed. Generally, the kidney and liver had an increasing accumulation of the heavy metals with increasing crude oil contamination in the diets except for nickel and cadmium that were not also detected.
Conclusion: It was therefore concluded that crude oil ingestion could result in increased accumulation of heavy metals in the tissues of arm, thigh, kidney and liver of growing rabbits.

Keywords: Distribution; heavy metals; tissues; crude oil.

1. INTRODUCTION

Meat contamination by toxic trace element is nowadays an evident health problem worldwide. For general population [1], there has been increasing concern about the entry of potentially harmful substances into the food chain destined for human consumption [2,3] because heavy metals can be responsible for a very acute and chronic toxic effect in vertebrates [4].

Crude oil, commonly known as petroleum is a liquid oil found within the earth; comprised hydrocarbons, organic compounds and some amounts of heavy metals. While hydrocarbons are usually the primary component of crude oil, the composition of heavy metals such as lead, copper, nickel, vanadium etc. varies depending on the type of crude oil and how it is extracted. Crude oil also consists of some organic compounds like nitrogen, oxygen and sulphur [5].

The impact of crude oil spillage and discharge on the ecosystem as a result of oil exploration and exploitation activities is an obvious environmental problem particularly with regards to the associated heavy metal content. Livestock and animals in the wild come across the crude oil resulting from oil spills which they unknowingly ingest. The human population gets exposed to hazardous chemicals, through the consumption of contaminated animal tissues.

The heavy metals, such as lead, cadmium, chromium, and mercury are also found as pollutant substance within the human body, although the heavy metals, such as zinc, Iron, cobalt and selenium are necessary element for normal development and growing humans and animals [6]. When living creatures are excessively exposed to these metals, they become harmful. Nwude et al. [7] observed that tissue accumulation in animals was related to concentrations of the heavy metals in soils and forages. It is mentioned that heavy metals are encountered for unknown reasons of disasters lasting for a long time [8].

The monitoring of such substances in air, water, plant or feed consumed by rabbit used for meat production is necessary. This experiment was conducted to assess the distribution of these heavy metals in the tissues of rabbits from the continuous feeding of diets contaminated with crude oil.

2. MATERIALS AND METHODS

2.1 Site of Experiment

The experiment was conducted in the rabbit unit of the University of Benin Teaching and Research Farm, Benin City in Southern Nigeria.

2.2 Experimental Animals and Management

The experiment was carried out using 40 rabbits of New Zealand breed obtained from the University of Benin Teaching and Research Farm. The average initial weight of the rabbits was 740g. The rabbits were homogenized by balancing for sex and weight for experimental treatment. They were randomly assigned to their individual hutches and were provided with separate feeders and drinkers. Routine management practices were carried out. Adaptation period was 2 weeks during which the rabbit was fed on the control diet. The experiment with four treatment groups lasted for 12 weeks. Each treatment had ten replicates with each rabbit serving as a replicate in a completely randomized design (CRD). The crude oil used was obtained from Brass Terminal of the Nigerian Agip Oil Company Limited.

2.3 Experimental Diets

The experimental diet was formulated based on the nutrient requirement for growers' rabbits [9]. Diet A had no crude oil serving as control while diets B, C and D had 15, 30 and 45 ml of crude oil added to 3 kg of feed and used within 1 week. The animals were fed both mornings (between 8.00 am and 9.00 am) and evening (3.00 pm and 4.00 pm). Feed and water intake and weight changes were monitored.

Careful observations such as posture, the activity of the animal, fur texture, excretion etc. were made during the period of the experiment. Five rabbits from each treatment were slaughtered for analysis. Portions of tissue from arm, thigh, kidney and liver in each of the four doses were taken.

2.4 Sample Preparation and Heavy Metal Analysis

About 10.0 g of each tissue sample was placed in conical flasks, 5 ml of phosphoric was added and then heated on a heating mantle for about 1 h until heated to dryness. 100 ml of distilled water was added and thoroughly shaken. It was filtered into a 100 ml standard flask and the filtrate was made up to mark with distilled water. Aliquots of these were analysed for Co, Ni, Cd, Pb, Cr and Cu using atomic absorption spectrophotometer, model Shimadzu AA-6800 as described by Nwude et al. [7].

2.5 Statistical Analysis

All data collected from the chemical analysis were subjected to analysis of variance in a completely randomized design, using the procedure of SAS [10]. Mean separation was done using the Duncan multiple range tests where significant differences existed.

3. RESULTS

The results of the analysis of the tissues of the rabbits are presented. Tables 1 and 2 show the means of the distribution of heavy metals in some tissues of the rabbits after the continuous feeding of diet contaminated with different doses (0, 15 30 and 45 mL crude oil/ 3 kg feed) of crude oil. The figures (Figs. 1-8) describe the comparative accumulations of these metals in the various tissues monitored. The highest level of cobalt recorded in the arm was found among the highest dosed rabbits (45 ml) which was significantly (P<0.05) different from the groups that received lower or no dosage. Significant differences (P<0.05) was also observed in the thigh but were not dose-related. For nickel and cadmium, no traces of the metals were found in the various treatments. Their concentrations were 0.000 ppm in all the groups showing the absence of nickel and cadmium in the arm and thigh irrespective of the amount of crude oil ingested during the study.

The dose-related increase in the distribution of lead and copper in the thigh was observed. The concentration of lead in the thigh muscle showed a significant (P<0.05) increase from 0.034 ppm in control groups to 0.134 ppm among rabbits fed diet contaminated with 45 ml of crude oil. Copper followed a similar trend.

Table 1. Concentration of some heavy metals in the tissues of arm and thigh of rabbits fed diets contaminated with crude oil

Heavy metal	Tissue	Diets (Crude oil level) ml				SEM
		A (0)	B (15)	C (30)	D (45)	
Cobalt (Co)	Arm	0.044^{c}	0.095^{b}	0.088^{b}	0.133^{c}	0.023
	Thigh	0.078^{a}	0.027^{b}	0.089^{b}	0.060^{b}	0.011
Nickel (Ni)	Arm	0.000	0.000	0.000	0.000	0.000
	Thigh	0.000	0.000	0.000	0.000	0.000
Cadmium (Cd)	Arm	0.000	0.000	0.000	0.000	0.000
	Thigh	0.000	0.000	0.000	0.000	0.000
Lead (Pb)	Arm	0.049	0.044	0.065	0.076	0.024
	Thigh	0.034^{b}	0.030^{b}	0.051^{b}	0.134^{a}	0.061
Chromium (Cr)	Arm	0.221^{b}	0.258^{b}	0.143^{c}	0.325^{a}	0.094
	Thigh	0.215	0.273	0.283	0.224	0.099
Copper (Cu)	Arm	0.069	0.062	0.082	0.082	0.021
	Thigh	0.046^{c}	0.089^{b}	$0.061b^{c}$	0.142^{a}	0.032

[abc] Means within the same rows with different superscript are significantly (P < 0.05) different

Table 2 shows the results of the analysis of kidney and liver. There were inconsistent changes in the amount of cobalt present in the liver. Trace of nickel and cadmium was also not detected in the tissues obtained from the kidney and liver. High significant (P < 0.01) levels of lead in the kidney were recorded as the animals increasingly ingested the crude oil, 0 ml (0.066 ppm), 15 ml (0.223 ppm), 30 ml (0.281 ppm) and 45 ml (0.329 ppm). The liver of the group with the highest dose had about ten times (0.900 ppm) higher concentration than the control group (0.091 ppm). Copper concentration in the kidney also increased significantly from 0.250 ppm (control) to 0.329 ppm (D) while in the liver it was from 0.284 ppm (control) to 0.878 ppm (D).

Figs. 1-4 compare the concentration of the heavy metals in the arm, thigh, kidney and liver. Fig. 2 showed that while lead was significantly (P < 0.05) accumulated in the liver, chromium was evenly distributed in the various tissues under study. Figs. 5-8 present the results of the heavy metal profiles in the tissues. The most noticeable results were the high concentration of chromium in the arm and thigh while lead and copper were of significant concern in the kidney and liver.

Table 2. Concentration of some heavy metals in the kidney and liver of rabbits fed diets contaminated with crude oil

Heavy metal	Tissue	Diets (Crude oil level) ml				SEM
		A (0)	B (15)	C (30)	D (45)	
Cobalt (Co)	Kidney	0.067	0.059	0.077	0.075	0.012
	Liver	0.073^c	0.141^a	0.110^b	0.056^c	0.032
Nickel (Ni)	Kidney	0.000	0.000	0.000	0.000	0.000
	Liver	0.000	0.000	0.000	0.000	0.000
Cadmium (Cd)	Kidney	0.000	0.000	0.000	0.000	0.000
	Liver	0.000	0.000	0.000	0.000	0.000
Lead (Pb)	Kidney	0.066^c	0.223^b	0.281^b	0.329^a	0.017
	Liver	0.091^d	0.101^c	0.670^b	0.900^a	0.013
Chromium (Cr)	Kidney	0.092^d	0.309^a	0.169^b	0.216^c	0.011
	Liver	0.124^c	0.278^b	0.317^a	0.305^a	0.043
Copper (Cu)	Kidney	0.250^b	0.233^b	0.281^{ab}	0.329^a	0.098
	Liver	0.284^d	0.312^c	0.454^b	0.878^a	0.101

^{abcd} *Means within the same rows with different superscript are significantly (P < 0.05) different*

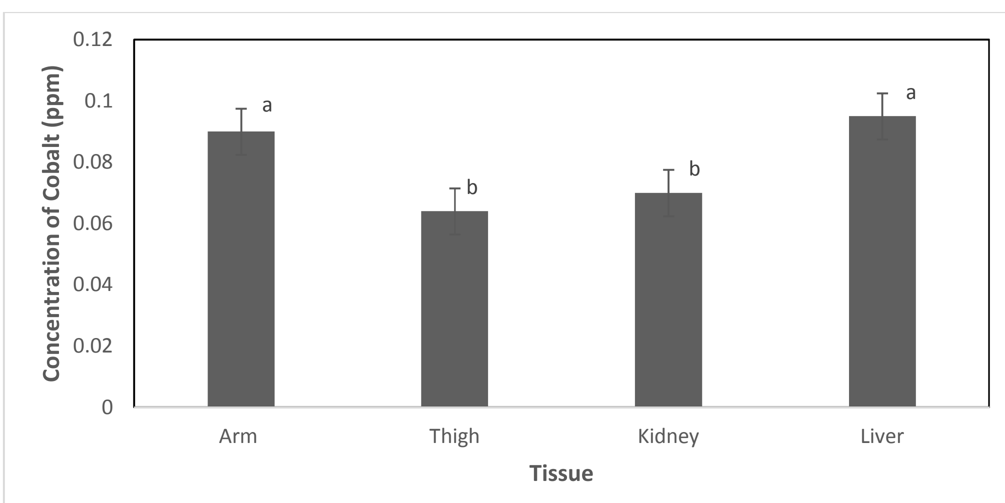

Fig. 1. Bioaccumulation of cobalt in some tissues of rabbit fed diet contaminated with crude oil

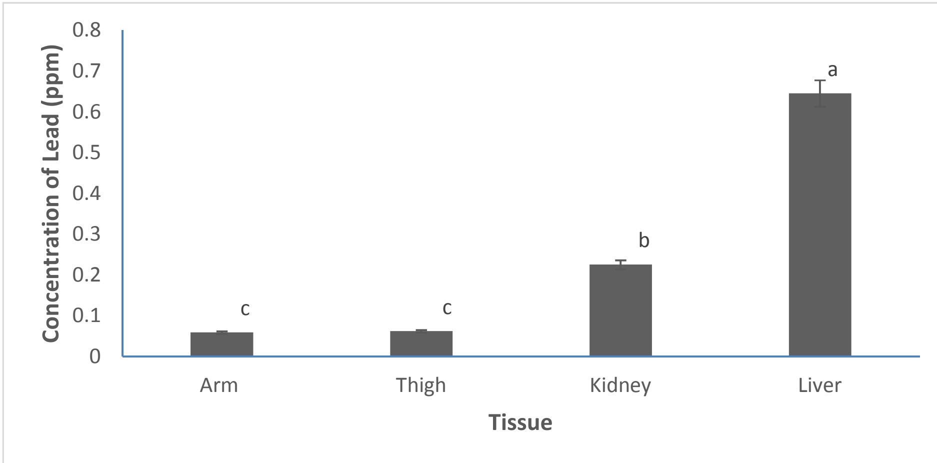

Fig. 2. Bioaccumulation of lead in some tissues of rabbit fed diet contaminated with crude oil

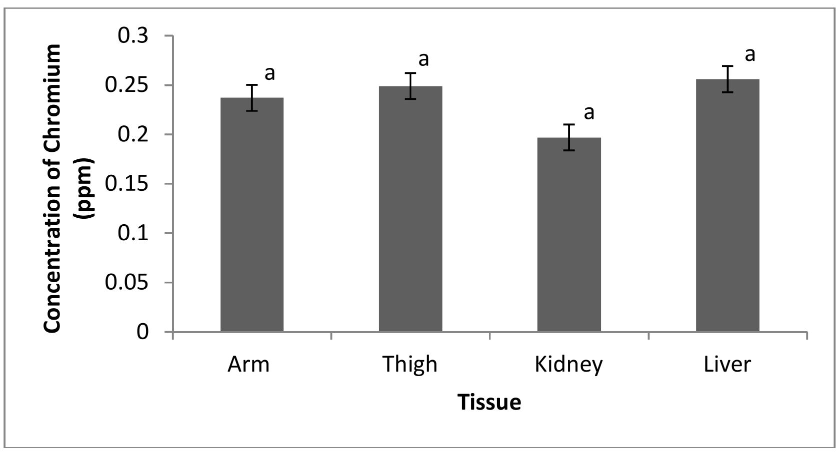

Fig. 3. Bioaccumulation of chromium in some tissues of rabbit fed diet contaminated with crude oil

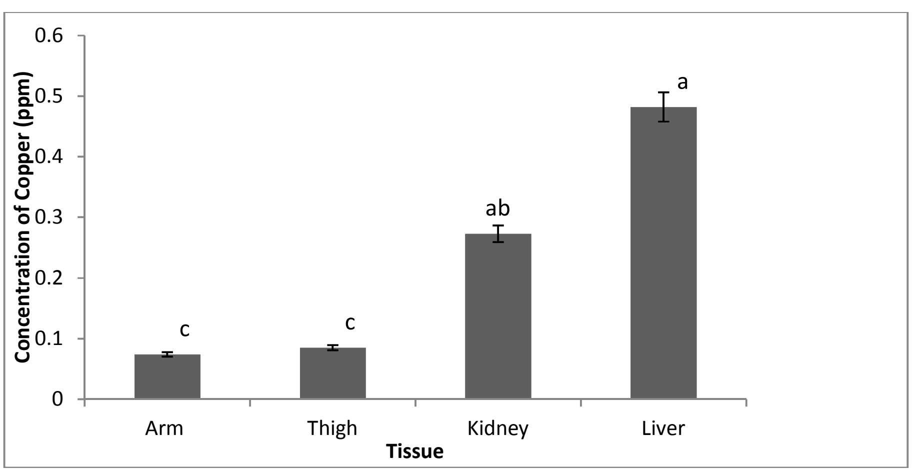

Fig. 4. Bioaccumulation of copper in some tissues of rabbit fed diet contaminated with crude oil

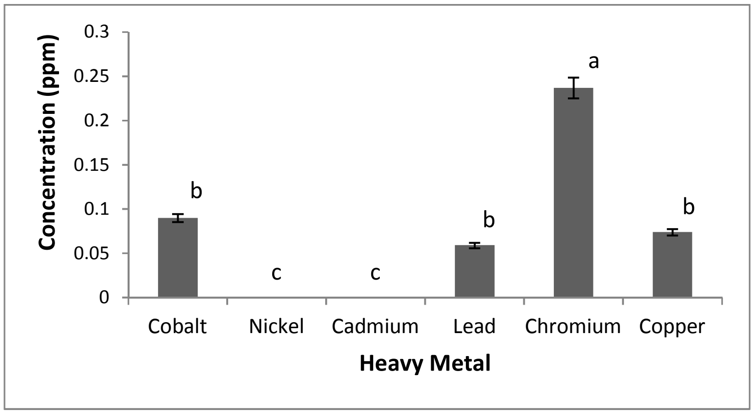

Fig. 5. Comparative analysis of some heavy metals in the arm of rabbit fed diet contaminated with crude oil

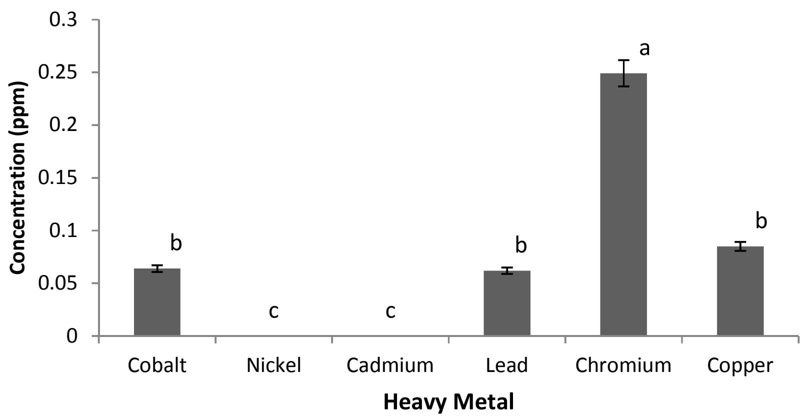

Fig. 6. Comparative analysis of some heavy metals in the thigh of rabbit fed diet contaminated with crude oil

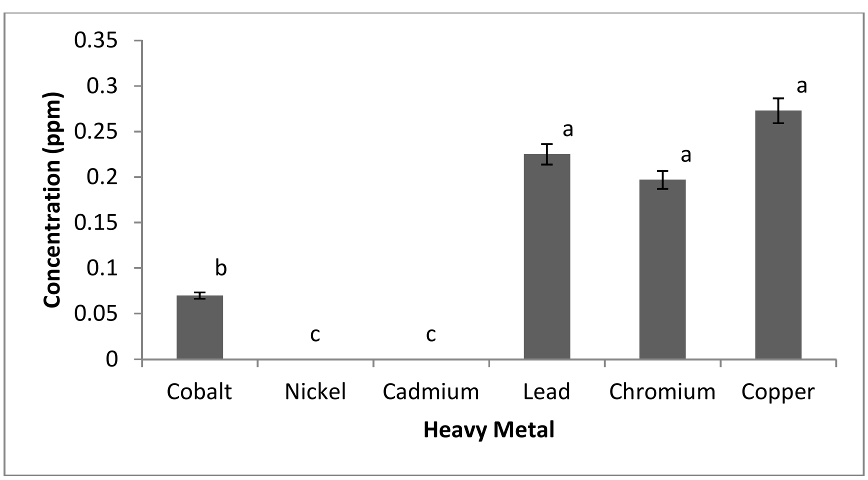

Fig. 7. Comparative analysis of some heavy metals in the kidney of rabbit fed diet contaminated with crude oil

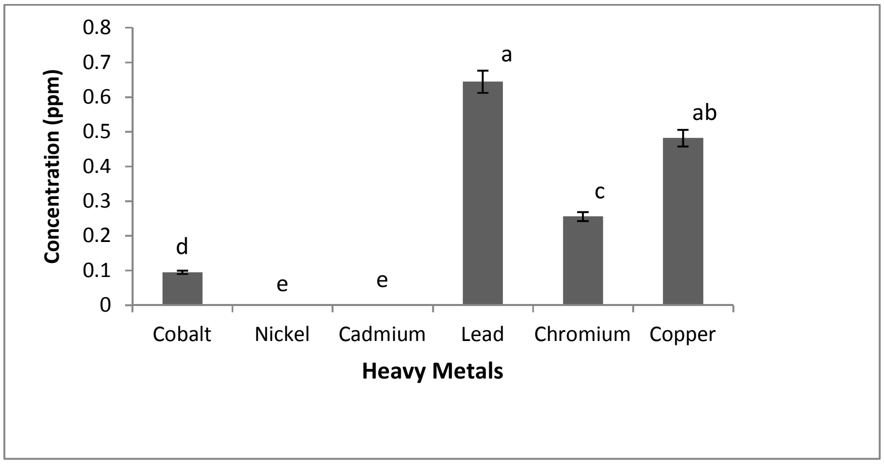

Fig. 8. Comparative analysis of some heavy metals in the liver of rabbit fed diet contaminated with crude oil

4. DISCUSSION

The dose-related concentration of heavy metals found in the tissues under study indicated a direct physiological movement of these metals from contaminated feed and was consequently stored or incorporated in the living tissues of the animals. Reports have shown that with increasing industrialization and pollution, more and more metals are entering into the environment [11,12]. These metals obviously enter into the food materials and from there they ultimately make their passage into the tissues. Jung [13] however highlighted that as an indicator of environmental pollution, the metallic pollution substances which are found in living organisms reach to a high level of contamination in the tissues of animals that are nourished by contaminated feeds and grazed on pasture at contaminated fields.

Although cobalt is not a component of the crude oil, the result of the study showed an increasing concentration of the metal with increasing dosage. It should be noted on one hand that heavy metals are constituent of natural components of the earth's crust [14]. The increasing concentration of cobalt may not be unconnected with the proposition by Nwande et al. [7] of a possible correlation between the concentration of one metal and the absorption and accumulation of another. The result from the study showed that there was no trace of nickel and cadmium in any of the tissues of the rabbit analysed. Jung [13] reported that cadmium absorption by animal bodies is dependent upon absorbing animal type, the structure of cadmium component, amount ingested, age and effects of other food substances.

Lead and copper had a higher concentration in the thigh with increasing dosage of crude oil. The highest concentration of lead was 0.134 ppm and copper was 0.142 ppm in the thigh at a dosage of 45 ml of crude oil. The World Health Organisation [15] defined the weekly lead absorption level as 3 mg/person.

In most of the heavy metals studied, there were higher significant($p<0.05$) concentration in the kidney and liver when compared to other tissues. This may not be unconnected with the physiological functions of the kidney and liver.

Davies and Berndt [16] reported that the inability of the kidney to excrete excess accumulation of heavy, metals could lead to damage to the kidney and liver parenchyma. Kato et al. [17] however observed that the absorption of lead by ingestion or inhalation rapidly transported by the bloodstream to the internal organs like kidney and liver excreted extremely slowly from the body while concentration resulted to abnormalities in the liver and acute renal toxicity.

5. CONCLUSION

The level of the heavy metals in the tissues of the rabbits as observed in the study varied with the concentration of crude oil in the diet. Continuous exposure of the rabbit to excessive contamination of crude oil through feed could exert a toxic effect as well as leaving heavy metal residues which are above the recommended limit of safe consumption of such meat products. Preventing the intake of contaminated diets, absorption and accumulation of the resultant heavy metals are not so probable. Avoiding crude oil spillage and discharge on the ecosystem as a result of oil exploration and exploitation which is a common phenomenon in the Niger-Delta region of Nigeria is the only solution.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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