Lead Compounds in Mule Deer and Vegetation Along I-80, Southeastern Wyoming

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The levels of lead compounds from automotive emissions were determined for organs of mule deer (Odocoileus hemionus) and for annual growth of two important forage species collected near Interstate-80 and a control area. Levels of lead in big sagebrush (Artemisia tridentata) up to 90 m from the highway were significantly higher than in those from an area 6.5 km north of the highway. Values ranged from 20.0 μg/g dry weight at 15 m to background levels (2.0 ± 1.8) at 90 m. Levels of lead compounds in true mountain mahogany (Cercopcarpus montanus) were not significant and were much lower than those in big sagebrush. Organs of three mule deer collected near the highway contained higher lead levels in each of 52 comparisons with organs of four deer collected from the control area, ranging from trace amounts in muscle to 10.8 μg/g in the antlers of a young male. Bones, kidneys, and livers accumulated most of the lead burden, and the deer were not hazardous for consumption by humans. Composite samples of fetuses from highway deer contained amounts equivalent to those in livers of their mothers, indicating that transplacental movement of lead occurred. Chronic lead poisoning is possible, particularly in fawns. Population indicators were adequate, but lead poisoning could be a significant problem in other populations in areas with higher traffic.

Studies of lead compounds from motor vehicle exhaust along major highways have shown significant levels in vegetation up to 91 m away (1-3), in small mammals (4,5), and in domestic livestock (6,7). However, little is known about levels in wild ungulates, such as pronghorn antelope (Antilocapra americana) or mule deer, which may use foraging and resting areas adjacent to highways. In national parks they appear less likely to avoid highways (8), and in other areas they spend significant time during winter within a few hundred meters from major highways.

Mule deer in the Telephone Canyon area of southeastern Wyoming spend about two-thirds of their time annually within 300 m of I-80, where radio-tagged deer rested in timber stands and fed in brushy openings, often inside the right-of-way fence (9, 10). Because lead is a cumulative poison and the highway has been at its present location for more than 50 years, there was concern for the welfare of deer that may inhale motor vehicle exhaust and ingest vegetation that may contain lead (Pb) compounds as dust on leaves or as constituents of internal tissues. In addition, those deer are subject to human consumption; hence, there was concern for human health.

This paper reports the incidence of Pb compounds in various organs of mule deer and important forage vegetation collected near I-80 and a control area some distance from I-80.

An area of known mule deer use along I-80 in Telephone Canyon was selected 12 km east of Laramie, Wyoming. A comparable, unroaded canyon was selected for a control 6.5 km north of I-80 and 7.5 km northeast of Laramie. The control area received only occasional seasonal use by off-road vehicles. Vegetational composition of the higher elevations in the study areas was dominated by conifers. At somewhat lower elevations and/or drier sites, a shrub-steppe vegetational type prevailed. In that type true mountain mahogany was most abundant, but concave slopes produced large amounts of basin big sagebrush. Both of the latter plants are important forage for mule deer in the area (11). In winter, prevailing west winds average about 35 km/h and combine with long periods of cold weather to pose serious obstacles for survival of mule deer. Domestic sheep graze on private lands along the highway in the canyon. Traffic averages about 5000 vehicles/day, according to the State of Wyoming Highway Department.

METHODS

Three transects 165 m in length were located: two were perpendicular to each side of I-80 and one was located in the control area. Ten collection stations were established at 15-m intervals on each transect. South of the highway a deep rocky ravine precluded samples closer than 45 m. All of the current annual growth of twigs from big sagebrush and mountain mahogany was collected at each station during July 1979. Ten plants per station were necessary for representation. Terminal shoots collected during each sample were dried in a forced-draft electrical oven at 62°C for 48 h and ground through a Wiley mill with a 20-mesh screen. A preliminary analysis of washed and unwashed sagebrush samples resulted in no significant differences in Pb compounds, so plant samples were not washed.

A collection permit was obtained to collect five mule deer. Three had histories from previous studies of being residents of Telephone Canyon and their range included very little area beyond 400 m of I-80. A 6-year-old doe carrying an inoperable heart-rate-monitoring telemetry system from another study (10) was collected within an hour after it was killed by a vehicle on I-80 on January 16, 1979. It was labeled D-1 and frozen until laboratory analysis. In spring 1979, a second adult female (D-2) and a two-year-old male (D-3) were collected 400 m and 100 m north of I-80, respectively. Doe (D-2) carried twin fetuses. The twin embryos found in the vehicle-killed doe (D-1) in January were too small for analysis.

In spring 1980, a two-year-old doe (D-4) carrying a fetus and a yearling buck (D-5) were collected from the control area. Also, parts of two adult males (D-6, D-7), collected at some distance from major roads by the Wyoming Game and Fish Department, were used as additional control animals. All deer (except for the vehicle kill) were shot with a high-powered rifle, usually in the neck region.

Whole deer organs and fetuses were dried in a forced-draft electrical oven at 70°C for one week, and ground through a Wiley mill with a 2-mm screen. Samples of plant and animal tissue were ashed in a muffle furnace at 490°C for 4 h, dissolved in 10 mL of 50 percent (V/V) nitric acid and 10 mL of 3 percent (V/V) hydrogen peroxide, filtered through Whatman No. 40 filter paper, rinsed with hot distilled deionized water, and brought to 10-mL volume with distilled deionized water. Lead content of 3-g samples of plant and animal tissue was determined by using atomic absorption spectrophotometry (Perkin-Elmer Model 403) and common procedures (12-14). Each sample was assayed three to five times. Lead content of collected and prepared samples was checked by using the standard addition test (dried orchard leaves from the National Bureau of Standards) and blanks. Concentrations of lead compounds in randomly selected samples were also verified by the Wyoming State Chemistry Laboratory. A paired difference test and paired t-tests (16) were used to statistically compare lead in deer and plant tissues, respectively. Statistical significance in this paper denotes comparisons at the 0.05 level of probability.

RESULTS

Levels of Pb in sagebrush up to 90 m from I-80 were significantly higher than in plants grown in an area 6.5 km north of the highway. Values ranged from a high of 20 μg/g dry weight 15 m from the Interstate, and decreased to control values at 90 m from the highway (Table 1). Baseline levels of lead in shrubs have been reported to be 1-4 μg/g (15). Other researchers (16) found 1-2 μg/g Pb in deer forage in an unroaded area in Montana. Perhaps the high winds contribute to lead being deposited further than 50 m, which is the figure most often given in the literature. There were no significant differences in levels of Pb in sagebrush plants growing on either side of the highway.

Levels of Pb in true mountain mahogany near I-80 were not significantly different from those found in plants from the control area, but they were much lower than those found in big sagebrush growing in similar sites. The finely pubescent leaves of big sagebrush possibly entrapped more Pb particulate matter than mountain mahogany.

It was found that deer from the I-80 area contained significantly more Pb than deer from the control area (Table 2). Levels of Pb in deer from the I-80 area ranged from trace amounts in hip muscle to 10.8 μg/g dry weight in the antlers of the young male. Bones, kidneys, and livers contained more Pb than other organs. Composite samples of the near-term fetuses contained amounts equivalent to those found in the livers of the adult deer. Thus, transplacental transfer of Pb appears probable.

Although the levels of Pb for deer in the I-80 area were significantly higher than in deer from the control area and in livers and kidneys from deer in an unroaded area in Montana (16), they were lower than levels that produced no signs of lead toxicosis in an experiment with domestic sheep (17). However, the length of exposure and relative ability of forage plants to entrap or absorb Pb would be factors for long-lived ungulates living near major highways. Lead is a cumulative poison, building up in bones and taking the place of calcium (18). Thus, the relatively higher levels found in the antlers of one of the deer in this study was not unexpected. Antler shedding could possibly be a pathway to rid the body of some of the lead burden. In bone salt form it is not toxic, but during high calcium metabolism, as probably occurs in growth of antlers or in development of deer fawns, skeletal Pb may be mobilized and acute lead toxicity may result.

Symptoms of acute plumbism were not observed in this study, but these data suggest the possibility for chronic effects, compared with domestic sheep (19). The concept of a threshold value for chronic symptoms has been criticized (20,21), but high-normal values for livers of small mammals are accepted to be 3-6 μg/g (22). The data from mule deer in this study were within those values.

The data for fetuses (see Table 2) suggest an even stronger possibility for toxicity to mule deer

Table 1. Levels of lead compounds in unwashed mule deer forage plants along I-80, southeastern Wyoming.

Plant Type and Location	Distance from Highway (m) 15	30	45	60	75	90	105	120	135	150	165	180	Control Area[b] ($\bar{x}$ ± 95 percent C.I.)
Sagebrush													
North of highway	20.3	11.3	8.2	6.3	6.3	4.7	4.0	4.0	4.0	3.3			2.0 ± 1.8
South of highway[a]			7.0	8.3	5.7	3.3	2.7	3.3	2.7	2.0	1.0	1.7	
Mountain mahogany													
North of highway	2.7	2.3	1.7	1.3	0.0	0.0	0.0	0.0	0.0	0.0			1.0 ± 0.7
South of highway[a]			3.0	2.0	1.7	1.3	1.3	1.3	1.0	1.0	0.0	0.0	

Note: All data given in μg/g dry weight.
[a]South of highway no samples could be collected closer than 45 m.
[b]6500 m north of I-80.

Table 2. Levels of lead compounds in mule deer tissues, southeastern Wyoming.

Part	I-80 Area: Deer number, sex, and age D-3 (♂) 2	D-1 (♀) 6	D-2 (♀) 3-4	Comparison Area: Deer number, sex, and age D-4 (♀) 2	D-5 (♂)[a] 1	D-6 (♂)[b] <4	D-7 (♂)[b] <4
Hip muscle	1.0	1.0	0.2	0.0	0.0		
Brain	0.7		1.2	0.0	0.1		
Spleen	1.0	1.3	1.2	0.2	0.4		
Heart	0.8		1.6	0.2			
Lung	1.3	1.3	2.4	0.4			
Hair	2.4			1.6			
Fetus-1			2.0	0.3			
Fetus-2			2.3				
Rib	3.3			1.0	1.3		
Loin	3.0			0.0	0.0		
Liver	3.0	3.0	3.2	0.2		0.7	0.7
Kidney		4.0	2.2	0.2	0.7	1.0	1.7
Femur	4.4	9.7	4.9	0.0	0.5		
Antler	10.8				1.2		

Note: All data given in μg/g dry weight.
[a]Liver, heart, and lungs of D-5 contaminated by bullet.
[b]Kidneys and livers were only parts available and were provided by the Wyoming Game and Fish Department.

fawns, which apparently absorb lead across the placenta during fetal development. Transplacental transfer of Pb has also been observed in other mammals (20). In addition, a considerable part of the maternal dose can be transmitted via milk to suckling rate and mice (21), in which subclinically dosed mothers may give birth to chronically poisoned offspring.

Because lead is a cumulative poison, the possibility may exist for chronic Pb poisoning in deer fawns in the study area. The manifestations of such a problem for a wild ungulate population would likely go unnoticed because of the confounding effects of mortality due to other causes. However, data for population composition (9), which show doe-fawn ratios to be adequate, indicate that possible chronic effects of Pb may not be serious for deer populations along I-80. Also, the levels in deer tissue are not considered a threat for human consumption. However, the possibility may exist for lead poisoning of other wild ungulates in areas with higher levels of traffic.

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