# Lead Levels in Small Mammals and Selected Invertebrates Associated with Highways of Different Traffic Densities

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## INTRODUCTION

For approximately 50 years alkyl lead compounds have been added to gasoline for knock reduction in engines. The resultant automobile exhausts contain particulate, inorganic lead compounds which are released over highways. The association between highways and lead levels in small mammals and invertebrates has previously been studied though differences in trophic levels and/or due to traffic volume have received little study. Lead levels in earthworms associated with highways were investigated (GISH and CHRISTENSEN 1973) as well as those in insects (WILLIAMSON and EVANS 1972, 1973). Lead levels in small mammals living along roadways have been studied (JEFFERIES and FRENCH 1972, QUARLES et al. 1974, MIERAU and FAVARA 1975, and WELCH and DICK 1975). Excess lead in mammals has been demonstrated to affect reproduction (VERMANDE-VAN ECK and MEIGS 1960, LACH and SREBRO 1972, and McCLAIN and BECKER 1972). Other physiological changes that can occur are intranuclear inclusion bodies in renal tubular lining cells, decreased body weight, increased $\delta$-aminolevulinic acid excretion, reticulocytosis, renal edema, and aminoaciduria (GOYER et al. 1970). Since most exhaust lead is deposited along or near highways, the purpose of this study was to determine the effect of various traffic densities on whole-body lead concentrations in small mammals and selected invertebrates collected near roadsides of different traffic densities. A related study was conducted to determine the effects of various traffic densities on soil and vegetation lead levels (GOLDSMITH et al. 1976).

## PROCEDURES

Three study areas were chosen on the basis of traffic densities. Three control areas, all a minimum of 500m from the nearest road, were located in the Jefferson National Forest near Blacksburg, Virginia. The traffic areas were labeled A, B, and C. These areas had daily traffic densities of 21,040, 8,120, and 1,085, respectively, in 1974 (VIRGINIA DEPARTMENT OF HIGHWAYS, 1975). Small mammals were sampled in all areas by intensive snap-trapping within twenty meters of the highway using peanut butter



Bulletin of Environmental Contamination & Toxicology, Vol. 17, No. 3 

and rolled oats as bait. Trapping was conducted between mid-September and the end of October 1974. Control animals were collected during November 1974 from each control area. Mammal carcasses were labeled, returned to the lab, and frozen in plastic bags until time of analysis. The frozen mammals were removed from the freezer and cut into several sections. The stomach contents were removed to prevent any contamination from trap bait. The sectioned frozen mammals were freeze-dried. The dried samples were chopped to a dust-like mixture by blending for two minutes in a blender equipped with a glass container and stainless steel blade, and placed in labeled air-tight jars to prevent moisture accumulation. With larger mammals two grams of the blended body was weighed into tared Coors crucibles and with smaller mammals the entire body was weighed. These samples were then ashed in a muffle furnace at 500 C for four hours. The ashed samples were dissolved in 10 ml concentrated nitric acid and allowed to stand for eight hours to assure complete digestion. These solutions were filtered and made to 25 ml with distilled water. Analyses were done with a model 290 Perkin-Elmer atomic absorption spectrophotometer incorporating a three slot burner head for greater sensitivity.

The sampling procedure for earthworms in areas A and B consisted of laying out lines parallel to the edge of the roadway at distances of 6, 12, and 18 meters. Earthworms were sampled along these lines and individuals were pooled to form one sample for each sample line. Earthworms were held in moist conditions for 24 hours to allow them to cast soil remaining in their bodies, then they were washed, and frozen for later analysis. Samples were not available at all distances because of gravel or asphalt road edges. Dry weather prevented sampling in one study area. Grasshoppers were sampled by netting within 20 m of the highways. Samples were pooled for each study area. No grasshoppers were recovered in Area B.

Earthworm and grasshopper tissues were prepared and analyzed for lead in the same manner as mammal bodies.

## RESULTS AND DISCUSSION

Grasshoppers collected in areas A and C had 3.84 and 3.35 μg/g lead, respectively. Low lead levels in grasshoppers may be a result of their short life span which allows minimal time for contamination.

Lead concentrations found in earthworms are given in Table 1. In Area A as distance from the highway increased lead levels tended to decrease. In Area C lead levels in earthworms were considerably lower than in Area A. GOLDSMITH et al. (1976) showed that soil lead levels increased

TABLE 1

Lead levels (μg/g dry wt.) in earthworms in traffic areas.

| Area | Vehicles per day | Distance (m) | | |
| --- | --- | --- | --- | --- |
| | | 6 | 12 | 18 |
| A | 21,040 | 51.01 | 50.31 | 32.10 |
| C | 1,085 | -- | 8.51 | 11.65 |

significantly with traffic volume and decreased with distance from the highway. Lead levels in earthworms reflect a similar trend.

Data are presented in Table 2 on species, number collected and mean lead concentrations of small mammals recovered from the six study areas. Individuals of 10 species were trapped. Statistical comparisons of lead levels were made among species from the same area and within species when found in two or more areas. Comparisons were made using the Kruskal-Wallis or Wilcoxon Rank Sum non-parametric tests. Dunn's test for multiple comparisons was used to determine order of significance when significant differences were indicated by the Kruskal-Wallis Test (HOLLANDER and WOLFE 1973).

Significant ($P<0.05$) differences among areas were found in lead levels in three species (Cryptotis parva, Microtus pennsylvanicus, and Peromyscus leucopus). In all instances higher lead levels were found in these animals from the higher traffic density areas. No significant ($P<0.05$) differences were found among areas in lead levels of Blarina brevicauda though differences among traffic areas ($P<0.09$) and between pooled traffic versus pooled control areas ($P<0.14$) approached significance. A higher (N.S.) lead level was found in Sorex cinereus from the 7-year-old clearcut than from Area B.

Significant ($P<0.05$) differences in lead levels were found between B. brevicauda and P. leucopus from Area A and all control areas. A significant ($P<0.05$) difference was found between B. brevicauda and M. pennsylvanica in Area C. In all cases the higher lead levels were found in B. brevicauda. In Area C the difference in lead level between B. brevicauda and C. parva approached significance ($P<0.06$).

Those small mammals recovered from the study areas in numbers adequate for statistical tests represent two trophic levels. These were species which are primarily plant eaters (P. leucopus, P. nuttalli and M. pennsylvanicus) and those which are carnivores--the shrews (B. brevicauda, C. parva and S. cinereus). Four

TABLE 2

Mammal species and mean lead concentrations in μg/g d.w. ± S.E. (with number of small mammals trapped in parentheses) in all study and control areas.

| Species | Area: A | B | C | Forest | 2-year-old clear cut | 7-year-old clear cut |
|---|---|---|---|---|---|---|
| B. brevicauda | 34.8±9.5(3)$^{ax}$ | 15.8±3.3(2)$^{ax}$ | 11.6±0.6(5)$^{ax}$ | 14.1±3.8(3)$^{ax}$ | 14.6±0.6(2)$^{ax}$ | 13.9±1.2(8)$^{ax}$ |
| C. parva | (0) | 10.4±0.4(8)$^{ax}$ | 6.5±1.4(2)$^{bxyz}$ | (0) | (0) | (0) |
| G. volans | (0) | (0) | (0) | 7.8±0.02(2) | (0) | (0) |
| M. pennsylvanicus | (0) | 12.1±0.2(2)$^{ax}$ | 6.9±0.6(5)$^{by}$ | (0) | (0) | (0) |
| P. breweri | (0) | (0) | 15.8 (1) | (0) | (0) | (0) |
| P. leucopus | 15.6±1.2(10)$^{ay}$ | 9.7±0.9(5)$^{bx}$ | (0) | 5.0±0.6(4)$^{ey}$ | 7.6±0.4(16)$^{cy}$ | 6.4±0.2(30)$^{dy}$ |
| P. nuttalli | (0) | (0) | (0) | (0) | (0) | 6.7±0.4(7)$^{y}$ |
| S. cinereus | (0) | 13.7±1.1(4)$^{ax}$ | (0) | (0) | (0) | 16.6±2.6(8)$^{ax}$ |
| T. striatus | (0) | (0) | (0) | (0) | (0) | 6.7 (1) |
| Z. hudsonius | 9.1 (1) | (0) | (0) | (0) | (0) | (0) |

a,b,c,d,e Means with different superscripts in the same row are significantly (P<0.05) different, the order of significance being a>b>c>d>e.

x,y Means with different superscripts in the same column are significantly (P<0.05) different, the order of significance being x>y.

z Difference between B. brevicauda and C. parva in Area C approached significance (P<0.06).

other species (Glaucomys volans, Parascalops breweri, Tamias striatus, and Zapus hudsonius) were recovered in too few numbers to provide data for statistical analysis. In general, higher or significantly higher levels of lead were found in shrews than in the Peromyscus spp. or in M. pennsylvanicus. This was true for both traffic areas and control areas and was in general agreement with the results of QUARLES et al. (1974).

The results in this study showed a higher level of lead in those mammals at the higher trophic level. This was the case in spite of the fact that there were very low lead levels in the insects studied. Available information on food habits of the shrew species studied in this report indicate that insects comprise a high proportion of their diets. Hamilton (1930) found that the stomach contents of B. brevicauda consisted of 47.8% insects and those of S. cinereus consisted of 63.5% insects. Hamilton (1944) considers that food habits of C. parva are essentially similar to Blarina and found a majority of insect remains in stomach contents of C. parva he studied. The source of the higher level in shrews must come from the non-insect component of their diets.

## SUMMARY

Lead levels in small mammals were studied in 6 areas - 3 associated with highways of different traffic densities, and 3 control sites in forested areas. Lead levels were also studied in insects from 2 traffic areas and in earthworms from different distances from 2 traffic areas. Lead levels were low in insects ranging from 3.84 μg/g to 3.35 μg/g. Lead levels in earthworms were highest in those recovered closest to highways and from the area with the higher traffic volume. Lead levels in mammals generally was highest in mammals from areas of higher traffic densities. Higher levels of lead were found in shrews than in Peromyscus and Microtus.

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