Dogs and goats as sentinels for environmental lead burden in Caribbean basin islands: Jamaica West Indies

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Abstract
Ingested/inhaled environmental lead (Pb) continues to pose a health risk to humans (children in particular) and animals. Automobile emissions from leaded gasoline combustion (less of a problem today with the phasing out of leaded gasoline), lead contaminated foods, soil and water, lead-based paints, ceramics, batteries (more frequently encountered today), and possible electronic waste, remain major sources of environmental lead. In a study carried out in Jamaica, West Indies, blood samples from dogs (n=63 at 5 locations) and goats (n=46 at 4 locations) were collected in lead-free (EDTA) tubes and analyzed by graphite furnace atomic absorption spectrometry (GFAAS) for lead. The analytical method detection limit was 0.24 µg/dl. Overall (blood lead) PbB concentrations were 2.83 ± 2.96 µg/dl (dogs), and 1.02 ± 0:10 µg/dl (goats). There were significant differences among locations, and in a location of high automobile and plant foliage/grass forage density, PbB levels were 7.03 ± 2.96 µg/dl (n=8) and 1.91 ± 0.83 µg/dl (n=10) in dogs and goats respectively. Although sample sizes are small the results suggest the use of dogs and goats as sentinels for evaluating environmental lead in developing countries.

Introduction
Environmental lead (Pb) continues to pose a health risk to both humans and animals. Its effects are multi-systemic – nervous, renal, hematopoietic, gastrointestinal, endocrine, cardiovascular, and reproduction/developmental1-10 of these the developing nervous and hematopoietic systems are the most sensitive. High levels of bone lead (body burden) and blood lead (PbB) in children have been reported to negatively affect the nervous system (reduced intelligence quotient (IQ), increased attention disorders, decreased learning ability, increased aggressive behavior and social problems, often resulting in violent and criminal behavior)11-12. These effects are today of greater concern and are associated with PbB levels of 10µg/dl, significantly below levels (35µg/dl) previously considered to be safe. Infants, children and pregnant women (significantly so since PbB readily crosses placental barriers) are at greater risk to these health effects than other segments of the population.

Jamaica’s current population is estimated to be 2,825,928; 53% of whom are urban dwellers13. With a median age of 23.7 years, coupled with an estimated 23.0% falling within age group 0-14 years (2009), the population can best be described as being young. The Kingston metropolitan area (largest center of population) is home to 27.34% of the population. Exposure to environmental Pb is without doubt, an important health concern in developing countries with young populations such as Jamaica.

The continued use of lead-based paints, improper disposal of leaded batteries and electronic components (computer monitors), and backyard recycling of leaded batteries14, 15, 16, 17, 18, a cottage industry which to a large extent is unregulated, are major contributors to Jamaica’s environmental lead burden. Automobile emissions, a source of environmental Pb resulting from leaded gasoline combustion, has been reported to be markedly decreased in developed countries where phased out use of leaded gasoline have been implemented. Jamaica is estimated to have 264,100 motor vehicles, approximately 86% of which are fueled by gasoline. The use of unleaded gasoline was introduced in 1990, with a scheduled 2001 target date for discontinuation of the use of leaded gasoline in
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Jamaica. Following incidences of severe lead exposures (2004 the most recent), assistance from the international community was requested (No National PbB screening program for sensitive populations (infants, children and pregnant women) has been instituted). Limited financial resources have precluded follow-up implementation of recommendations made by the international teams as a result of these investigations. Utilizing animals as sentinels could provide useful information in detecting areas of possible high lead (Pb) contamination. PbB levels in animals might be a useful means of evaluating environmental lead thereby leading to the adoption of appropriate preventive measures. Blood lead levels found in donkeys and mules were reported to be significant\(^{19, 20}\).

Low population density of these animals within the (Kingston Metropolitan) area covered in this study precluded these species as suitable candidates for this study. Goats (Caprines) spend approximately 30% of the day feeding (primarily browsing) readily on shrubs, bushes and trees. Their ability to climb enables survival on limited vegetation. Sheep (Ovines), unlike goats are primarily grazing animals (feeding at ground level) hereby having greater access to lead by ingesting lead contaminated soil\(^{21, 22}\). Whereas goat husbandry is culturally accepted in Jamaica, sheep husbandry is not, goats were the species of choice in this study. Animals in general roam freely in Jamaica and therefore have access to waste dump sites where potential for lead exposure is great. The main objective of this study is to assess environmental lead burden in Jamaica, West Indies (Kingston Metropolitan Area), utilizing blood lead (PbB) levels of dogs and goats as sentinels.

Materials and Methods

**Animals:** Blood samples were drawn from dogs (n = 63) and goats (n = 46) at 5 and 4 locations respectively, transferred and stored in lead-free EDTA sample tubes until stored and analyzed by graphite furnace atomic absorption spectrometry (GFAAS) for lead. The analytical method detection limit was 0.24 μg/dl. Precautions were taken to prevent sample contamination.

All dog locations (Veterinary Clinics) were within the Kingston Metropolitan area. Location #4 represents downtown Kingston, an area of high automobile density, and poor inner city economy. Efforts were made to exclude blood samples from dogs within the Kentyre, St. Andrew area, which has been in the past, but is not currently, an area where lead mining was operational.

For the goats location #1 represents animals having free access to good forage and in close proximity to high traffic density; Locations #2 and #3 represent animals having free access to good forage and very low traffic density; Location #4 represents animals that roam freely in high traffic density areas and scavenge dumpsites in downtown Kingston.

**Results**

Overall PbB concentrations were 02.83 ± 00.40 μg/dl (63 dogs), and 01.02 ± 0.10μg/dl (46 goats). Pooled PbB values for individual animal species were low. Blood lead (PbB) levels are reported in Tables 1 and 2. Analysis of variance on log transformed values showed significant differences among locations, and in a location of high automobile concentrations, PbB levels were 7.03 ± 2.96 μg/dl (Table 1, #4) and 1.91 ± 0.83 μg/dl (Table 2, #4) in dogs and goats respectively. The fairly high PbB values in goats in location 1 (Table 2, #1) were also of interest, in that this location is an area of high automobile activity.

**Table 1:** Blood lead (PbB) levels of Dogs (63) in five (5) locations.

<table>
<thead>
<tr>
<th>Location</th>
<th>PbB Levels (μg/dl)</th>
<th>Range (μg/dl)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.159 ± 0.117</td>
<td>0.00 - 0.390</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>0.235 ± 0.265</td>
<td>0.03 - 0.750</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>0.260 ± 0.427</td>
<td>0.30 - 1.95</td>
<td>24</td>
</tr>
<tr>
<td>4*</td>
<td>0.0703 ± 0.296</td>
<td>0.375 - 1.200</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>0.0183 ± 0.078</td>
<td>0.030 - 0.675</td>
<td>12</td>
</tr>
</tbody>
</table>

All five locations were from the Kingston Metropolitan area. Location * #4 is Downtown Kingston, an area of high automobile density and poor inner city economy.
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Jamaica, like many developing countries, lacks the resources necessary for whole-scale monitoring of environmental contaminants. Illnesses, and at times, possibly deaths (people and animal alike) associated with exposures to some environmental contaminants are left undiagnosed. Throughout history, one such environmental contaminant has been lead. In developed countries such as the United States and United Kingdom, governmental regulations (reduced levels of lead in paints and the phasing out of leaded gasoline for automobiles) have resulted in marked reduction in environmental lead levels. At the time of this study (2000) leaded gasoline remained the primary source of environmental lead.

Toxic blood lead levels (Dogs: 0.3-0.8 µg/dL; Goats: 0.9-1.0 µg/dL) were not found in animals selected. As seen in both Tables 1 (location 4) and 2 (locations 1 and 4), those animals that reported with the highest blood lead levels were from locations with high automobile traffic. Lead particles were deposited on the plants.

Table 2: Blood lead levels (PbB) of Goats (46) in four* locations.

<table>
<thead>
<tr>
<th>Location</th>
<th>Mean ± SD µg/dL</th>
<th>Range µg/dL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.138 ± 0.94µg/dL; range 0.15 - 0.34µg/dL (n = 11)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.40 ± 0.32µg/dL; range 0.00 - 0.15µg/dL (n = 16)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.70 ± 0.43µg/dL; range 0.00 - 0.10µg/dL (n = 9)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.91 ± 0.83µg/dL; range 0.05 - 0.79µg/dL (n = 10)</td>
<td></td>
</tr>
</tbody>
</table>

*1- Clarendon; 2 and 3 - Border regions of St. Andrew/St. Thomas; 4 - Downtown Kingston. Locations 1 and 4 have the highest automobile traffic. Goats being primary browsers were quite likely exposed to higher Pb levels from this characteristic. Lead particles were deposited on the plants.

Discussion

Toxic blood lead levels (Dogs: 0.3-0.8 µg/dL; Goats: 0.9-1.0 µg/dL) were not found in animals selected. As seen in both Tables 1 (location 4) and 2 (locations 1 and 4), those animals that reported with the highest blood lead levels were from locations with high automobile traffic.

In reported lead poisoning cases in children, cottage industry associated with batteries has been implicated as the primary source of lead. The developing nervous system (the brain in particular) is quite sensitive to lead exposure (sensitivity levels are now < 10 µg/dL). The disposal of computer monitors (each estimated to contain 5 pounds - approx. 2kg. Pb - ) at unregulated waste/dump sites, will potentially add to environmental Pb. This furthers support for the use of sentinel animals in monitoring of environmental lead. Although the information presented is quite limited; it demonstrates the potential for utilizing dogs and goats as sentinels for evaluating environmental lead burden.

References


12. Earlier research supported study links lead to criminal behavior. The News and Observer. 1996 Feb 8; Sect. 10A: Health.


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Acknowledgements

The authors are appreciative of the contributions (selection of animals and collection of Blood samples) made by members (Drs. Franz Alexander, Franchott Chang, George Hylton, and Candice Phipps) of the Jamaica Veterinary Medical Association (JVMA) throughout the project.