FLAME RETARDANTS IN THE SERUM OF PET DOGS.

Marta Venier and Ronald A. Hites

School of Public and Environmental Affairs; Indiana University; Bloomington, IN 47405

Introduction

Flame retardants are added to several consumer goods (i.e. electronics, carpets, and upholstery) to reduce the spread of fire. Although the toxicological effects of these compounds are not yet well understood, they are ubiquitous in the environment, and they accumulate in biota, including humans. A previous study from our laboratory showed that pet cats had much higher blood levels of flame retardants compared to humans, which came as a surprise, given that pet cats share the same household environment as their owners.[1] In fact, pet cats had flame retardant concentrations comparable to those of wild animals located on top of the food web; for example, Verrault el al. reported total PBDE levels in the plasma of polar bears averaged 5.38 ± 0.54 ng/g ww, which is close to that in cats (10.2 ± 2.2 ng/g ww).[2]

Dogs on the other hand, although they also share the same living spaces as their owners, might be expected to have lower blood levels of flame retardants than cats because they are metabolically better equipped at degrading these compounds.[3] We hypothesized that dogs might be closer to humans in their response to these environmental stressors and be better indicators of human exposure to these contaminants.

Materials and Methods

Approximately 4-10 mL of blood was collected from the femoral or jugular vein of each dog at a veterinary clinic. The sample was centrifuged to yield about 2-5 mL of serum, which was denaturized with 2 mL of HCl and 5 mL of 2-propanol. This mixture was extracted with 12.5 mL of 1:1 hexane-methyl *t*-butyl ether. Lipids were removed from this extract using 2 mL of sulfuric acid. Samples were cleaned on 6% deactivated alumina columns capped with anhydrous sodium sulfate using hexane and 60% hexane/dichloromethane as eluents. The analytes of interest were mainly in the hexane fraction. Two procedural blanks were included in every batch of 4-6 samples. A total of 16 dog sera samples were extracted and analyzed.

The extracts were analyzed using gas chromatographic mass spectrometry on an Agilent 6890 GC linked to an Agilent 5873 MS. The target analytes were the major PBDE congeners and several emerging flame retardants; the latter included α-, β-, γ-, and δ-tetrabromoethylcyclohexane (TBECH), allyl-2,4,6-tribromophenyl ether (ATE), 2,3-dibromopropyl-2,4,6-tribromophenyl ether (DPTE), 2-bromoallyl-2,4,6-tribromophenyl ether (BATE), octabromotrimethylphenylindane (OBIND), and Dechlorane Plus (DP).

All of the dog owners completed a questionnaire providing information on their dog (age, weight, sex, diseases, etc.), on his or her eating habits (dry or wet food and brands), and on the house where the dog lived (including area, flooring type, and numbers of televisions, computers, sofas, and armchairs). This study was approved by Indiana University's Bloomington Institutional Animal Care and Use Committee (protocol number 10-006); all dog owners provided informed consent for their dog's participation.

Results and Discussion

The average concentration of total PBDEs in the dogs was 4.32 ± 2.50 ng/g wet weight (mean ± standard error, ww), and the median was 1.38 ng/g ww. The relatively high standard error was due to one particular sample in which the concentration of total PBDEs was 41.3 ng/g ww. When this outlier sample was excluded, the average decreased to 1.86 ± 0.44 ng/g ww and the median to 0.86 ng/g ww (see Figure 1, top). It is not clear why that particular dog had such a relatively high level of PBDEs, although we hypothesize that it might have been due to a relatively short time between the dog's last feeding and the blood collection. The concentrations of total PBDEs were not correlated with any of the animal-specific variables that were included in the questionnaire, with the exception of the dog's weight ($r = 0.60$, $p < 0.02$).

Significant amounts of BDE-209 were found in all of these samples with an average concentration of 0.35 ± 0.05 ng/g ww (median = 0.33 ng/g ww). We hypothesize two possible sources of BDE-209 for these dogs: (*a*) electronics present in the house, in particular, television sets; and (*b*) diet.

a. We found a statistically significant relationship between the serum concentration of BDE-209 and the number of televisions in the household ($r = 0.59$, $p < 0.05$). Conversely, no relationship was found between flame retardant concentrations in the dog's blood and the number of computers in the house. These results seem to confirm those of Allen et al., who showed that the content of BDE-209 in household dust was best predicted by the number of televisions in the house.[4]

b. Another possible source of BDE-209 for the dogs could be their diet. In this case, all of the dogs in our study ate dry commercial dog food. Interestingly, in a previous study on serum from pet cats, the presence of BDE-209 was significantly associated with a diet of dry cat food.[1] Hence, the presence of BDE-209 in the serum of dogs could be a result of their eating dry (as opposed to canned) dog food. Preliminary analyses of a few samples of dry dog food showed the presence of BDE-209 at levels ranging from 0.5 to 2 ng/g ww, which is similar to the concentrations found in dry cat food.[1]

The concentrations of total PBDEs in dogs were higher than those found by our laboratory in women from Indiana, which averaged 0.31 ± 0.09 ng/g ww (n = 20).[5] Conversely, as shown in Figure 1, top, the concentration of total PBDEs in the dogs was significantly lower than that found in pet cats. These results suggest that cats biomagnify these compounds better than dogs or that dogs metabolize these compounds better than cats. A previous study in which the levels of several organochlorine pesticides and PCBs were measured in both animals showed that dogs have a cytochrome P450 enzyme that is especially efficient at degrading organochlorine pesticides.[3] The concentration of PBDEs in the dogs' serum was also lower than we measured in wild bald eagles, which averaged at 5.7 ± 1.9 ng/g ww (median = 2.7 ng/g ww).[6]

In addition to PBDEs, several new and emerging flame retardants were found in the dogs' serum. The most abundant one was BATE with an average concentration of 0.17 ± 0.05 ng/g ww (n = 13), followed by TBECH (reported as ΣTBECH, the sum of four isomers), with an average concentration of 0.52 ± 0.06 ng/g ww (n = 16). Traces of ATE were also found in the serum of dogs with an average concentration of 0.03 ± 0.01 ng/g ww (n = 13). Low levels of Dechlorane Plus (DP) were also detected, corresponding to an average concentration of 0.029 ± 0.006 ng/g ww (n = 13). The levels of DP in dogs, cats and, eagles were statistically indistinguishable from one another; see Figure 1, bottom.

Overall, these results suggest that the concentrations of flame retardants in pet dogs are significantly lower than those in pet cats but still higher than in people. This result is somewhat surprising since both dogs and cats tend to share the same household environment and both tend to spend most of their lives indoors. These differences between dogs and cats may suggest that dogs are metabolically better equipped than cats at degrading these halogenated compounds, perhaps making them a better sentinel of human exposure.

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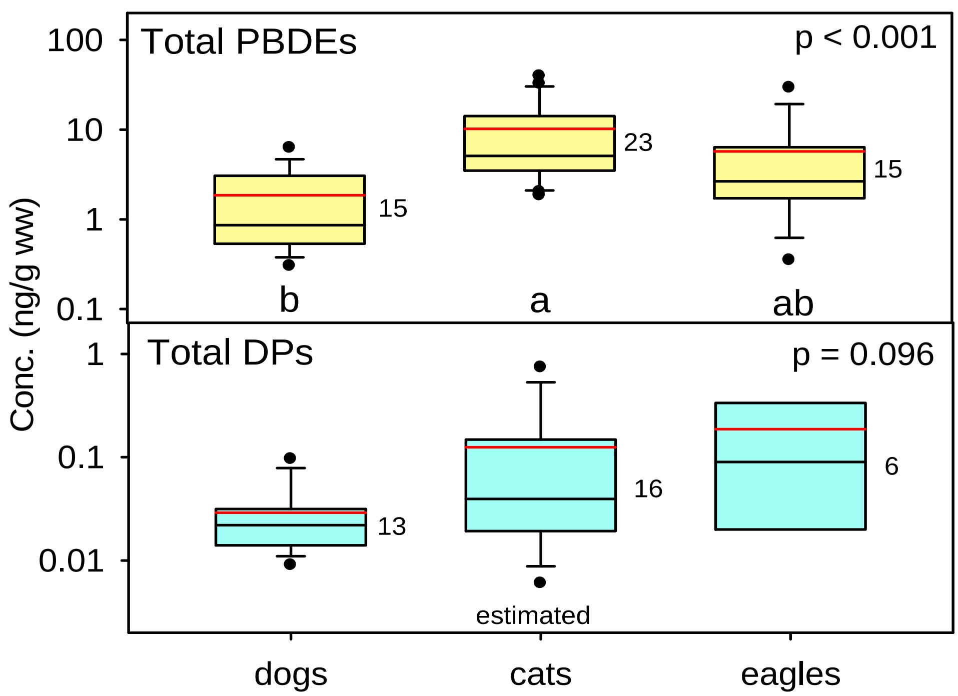

Figure 1 Box and whisker plots representing the concentration of (top) total PBDEs and (bottom) total Dechlorane Plus in ng/g wet weight for dogs (this study), cats,[1] and eagles.[6] Boxes with different letters are statistically significantly different at P < 0.05 based on an analysis of variance (ANOVA) using the Tukey ad hoc test. The DP levels in cats were estimated from our measurements of DP in cat food, assuming that PBDEs and DP had the same bioaccumulation factors. The numbers beside each box indicate the number of data in each category.