A RELATIONSHIP BETWEEN BLOOD LEAD LEVELS OF COMMON RAVENS AND THE HUNTING SEASON IN THE SOUTHERN YELLOWSTONE ECOSYSTEM

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ABSTRACT

We recently found evidence to support the supposition that Common Ravens (*Corvus corax*) were ingesting lead from hunter-provided offal in the southern Yellowstone Ecosystem. Since those data were analyzed, we have collected an additional 237 samples from ravens in the same study area spanning an additional two hunting seasons. In total, we collected 153 individual blood samples during the hunting seasons of 2006/07 and 2007/08. Those new samples exhibited a median level of 10.0 ug/dL with a range of 2.7-51.7 ug/dL. We also collected 84 additional samples during the non-hunting season which exhibit a median blood lead level of 2.2 ug/dL with a range of 0.0-19.3 ug/dL. Comparatively, 50% of the hunting season sample exhibited blood lead levels >10ug/dL, while only 3% were greater than 10ug/dL during the non-hunt. We will combine this new data with previous data collected to further understand the link between ingested lead and Common Ravens.

Key Words: Corvus corax, *lead poisoning, heavy metal, toxicosis*

There have been an increasing number of studies implicating lead-core rifle bullets as a point source for lead ingestion in bird species (e.g., Church et al. 2006, Craighead and Bedrosian 2008, Parish et al. 2007). Hunt et al. (2005) and Craighead and Bedrosian (2008) x-rayed offal piles left by hunters and they found hundreds of lead fragments large enough to be seen in radiographs. Many scavenging species are long-lived such as California Condors (*Gymnogyps californianus*), eagles, and Common Ravens (*Corvus corax*) and individuals within a population may be exposed to lead annually over their lifetime. After lead is ingested it moves from the blood through soft tissues and is eventually sequestered in bone tissue where it remains as a potential long-term source of toxicosis. There have been no long-term studies documenting the impact of lead on wild individuals and the possible influences on a population level.

We recently published data that implicated lead rifle bullet fragments causing increased blood lead levels (BLL) of Common Ravens during the hunting seasons in the southern Greater Yellowstone Ecosystem (Craighead and Bedrosian 2008). Those BLL data were gathered over a 15 mo period ending on 30 March 2006 that covered two hunting seasons and two non-hunting seasons. We continued this research (Craighead and Bedrosian 2008) for an additional 23 mo and combined those data with previously published data to obtain a more robust dataset and analysis of BLL of Common Ravens.

METHODS

We captured Common Ravens within the Jackson Hole valley of northwestern Wyoming, which is a part of the Greater Yellowstone Ecosystem. An elk (*Cervus canadensis*) and bison (*Bison bison*) hunt occurs annually within and surrounding the study area, but very little hunting (recreational or other) occurs outside of the hunting season due to the protection afforded by Grand Teton National Park and the National Elk Refuge. This makes for an ideal comparative situation to test the hunting seasons and non-hunting seasons for blood lead levels. See Craighead and Bedrosian (2008) for more details regarding study area and capture methods.

We captured Common Ravens from 14 December 2004 through 7 March 2008 [samples from 14 Dec 204 – 30 March 2006 published in Craighead and Bedrosian (2008)]. This increased the number of hunting and non-hunting seasons sampled to four each. We collected blood samples intravenously from the brachial vein of captured ravens and stored the whole blood samples in lithium heparin Microtainer® blood tubes (Becton Dickinson, Franklin Lakes, NJ). Blood samples were analyzed for lead content (ug/dL) within 24 hr of collection using a Leadcare® portable blood lead analyzer (ESA Biosciences Inc., Chelmsford, MA).

We first tested for differences between different hunting and non-hunting seasons using a Kruskal-Wallis ANOVA test and obtained 95% confidence intervals using Wilcoxon signed-rank tests. We followed the Kruskall-Wallis with Mann-Whitney tests on individual years to determine annual differences. We then combined years (2004-2008) and tested for differences between hunting and non-hunting season using Kruskal-Wallis tests due to non-normality. We tested for differences between sexes during both the hunting season and non-hunting season using Mann-Whitney tests (Craighead and Bedrosian 2008). We attempted to correlate median BLL during the hunting season with the combined harvests from the National Elk Refuge and Grand Teton National Park using linear regression. Sex was assigned with two separate discriminant functions using footpad length and mass (Bedrosian et al. 2008).

RESULTS

We gathered an additional 237 blood samples from ravens beyond those analyzed in Craighead and Bedrosian (2008), spanning an additional two hunting seasons. Of those, 153 samples were collected during the hunting seasons (109 and 44 during the 2006/07 and 2007/08 seasons, respectively) and 84 during the non-hunting seasons (59 and 25 in 2007 and 2008, respectively). In total, we collected 307 samples during four hunting seasons and 231 samples during four non-hunting seasons.

We detected a difference among years for hunting season samples ($P = 0.005$, $H = 13.03$). Specifically, the 2004/05 and 2007/08 hunting seasons exhibited higher median BLLs than the two middle years (Fig. 1). We found no differences between years of the non-hunting season samples ($P = 0.211$, $H = 4.52$). After pooling years, we found a median BLL of 10.0 ug/dL (SE = 0.528) for the hunting season (range = 1.0-55.5 ug/dL) and a median BLL of 2.0 ug/dL (SE = 0.151) for the non-hunt (range = 0.0-19.3). We detected a significant relationship between the annual median raven BLLs and the combined large-game harvest success from the National Elk Refuge and Grand Teton National Park ($P = 0.048$; Fig. 2).

Using discriminant functions (Bedrosian et al. 2008), we were able to classify 413 individuals as male or female. We classified 125 individuals as male and 107 samples as female during the hunting seasons and detected no difference in median BLLs between sexes ($P = 0.220$; $W = 13937.5$). Of non-hunt samples, we classified 69 males and 112 females and similarly found no difference between sexes ($P = 0.248$, $W = 6675.0$).

DISCUSSION

Our additional data with the combination of data in Craighead and Bedrosian (2008) provides more robust and defendable conclusions concerning lead ingestion in Common Ravens residing in the southern Greater Yellowstone Ecosystem. Notably, larger sample sizes negated our previous findings that females ingest greater amounts of lead during the hunting season. However, over 150 additional blood lead samples gathered during two additional hunting seasons did not alter our original conclusions that ravens' blood lead levels increased significantly during the hunting seasons.

With additional data across years, we detected differences in hunting season median BLLs among years. We found that ravens exhibited more elevated BLLs in the 2004/05 and 2007/08 hunting seasons, when compared with the 2005/06 and 2006/07 seasons (Fig. 1). While there are only four years of data, we found that the median BLL in Common Ravens could be predicted by the large-game harvest rates on the National Elk Refuge and Grand Teton National Park (Fig. 2). While there are many other animals harvested in the surrounding national forests and wilderness areas that ravens have access to, the harvest rates in the valley are likely indicative of harvest proportions in the surrounding areas.

Our data clearly indicate that ravens are being exposed to a lead source during the hunting season that is not present at other times of the year. Given the foraging behavior of ravens and their affinity for hunter provided offal (Wilmers et al. 2003), gut piles are the likely source of ingested lead (Hunt et al. 2004). Given the annual deposition of lead from spent rifle bullets and the long lifespan of ravens (Boarman and Heinrich 1999), there are many negative implications for the cumulative, lifetime impacts on the raven population in this, and other, regions. Similarly, other scavenging species are likely ingesting lead at similar, or higher, rates than ravens (Wilmers et al. 2003, unpubl. data). We suggest using alternative, non-lead rifle bullets to reduce the incidence of scavenging wildlife ingesting lead.

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Figure 1. Median blood lead levels (open squares) of Common Ravens during the hunting seasons in Jackson Hole, Wyoming. Closed diamonds are Wilcoxon signed-rank estimated medians with 95% CI bars. A and B designate statistical similarities and differences tested with Kruskall-Wallis ANOVA (*P* = 0.005) and individual Mann-Whitney tests (α = 0.05).

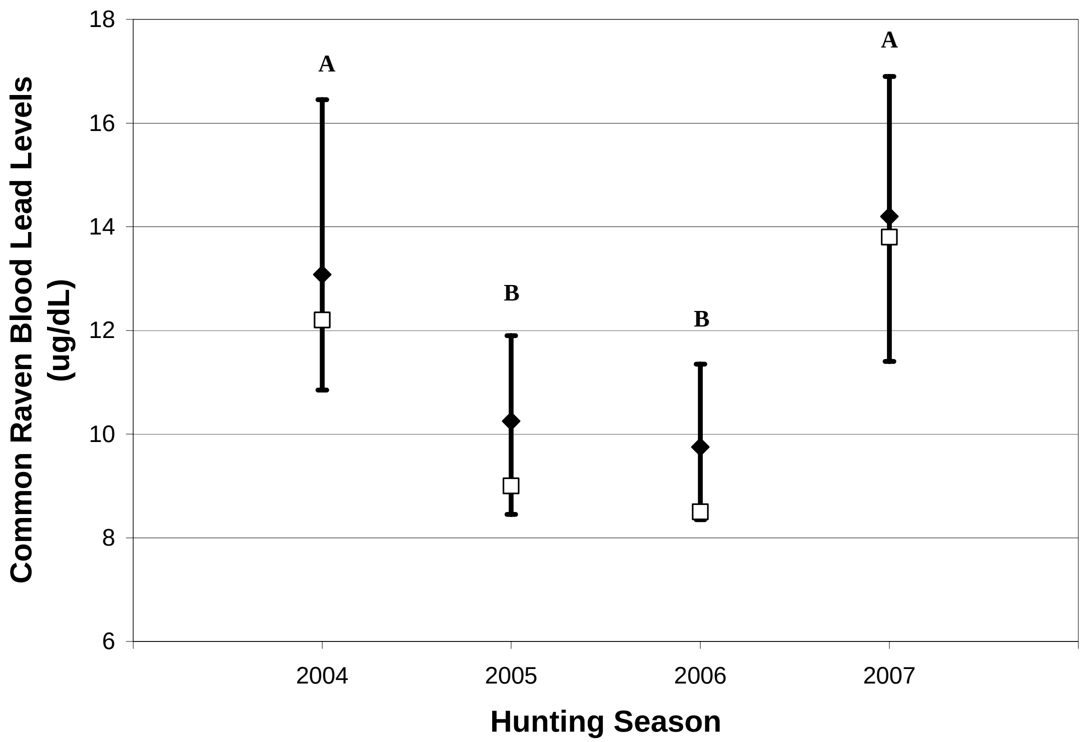

Figure 2. Regression analysis of median blood lead levels of Common Ravens during the hunting seasons in Jackson Hole, Wyoming and total large-game harvest rates (elk and bison) within Grand Teton National Park and the National Elk Refuge for the respective season ($P = 0.048$). Median blood lead level for all years combined with an assumed harvest of zero.