Comment on "Ammunition is the Principal Source of Lead Accumulated by California Condors Re-Introduced to the Wild"

I wish to comment on the article regarding condors and lead ammunition (*1*). In this article the authors present a hypothetical model and two tenuous assumptions based on limited data, which they then use to claim that the ^{207}Pb:^{206}Pb isotopic ratios of lead in the blood of condors tends to approach the ^{207}Pb:^{206}Pb isotopic ratios of ammunition. They conclude that ammunition is the principal source of lead in the blood of condors.

However, careful examination of the data presented, the references cited, plus additional reference material, shows that this conclusion is not supported by the data.

The authors assume that the isotopic composition of background lead in the diet of condors is very narrow, with ^{207}Pb:^{206}Pb ratios ranging from 0.8253 to 0.8394, based on the analysis of lead in the carcasses of four calves, two mule deer, and a California sea lion. The authors also present two selected data points from refs (*2*) and (*3*) to support this assumption, however, they fail to report the entire data sets from these same references that show that background lead has a much broader ^{207}Pb:^{206}Pb isotopic ratio range from 0.7541 to 0.8453.

There is ample evidence (*4*) that the California condor's diet is far more complex than the simple diet analyzed by the authors. Other documented food items include horses, burros, mules, pigs, sheep, goats, domestic dogs, domestic cats, jackrabbits, coyotes, bobcats, mountain lions, skunks, foxes, weasels, ground squirrels, and gophers. Furthermore, condors ingest numerous nonfood items, including plastic, glass, metal objects, and fossilized shells.

All these dietary items will contain background lead that will have the isotopic composition of the environment, which has been shown to have ^{207}Pb:^{206}Pb ratios ranging from 0.7541 to 0.8453 (*2, 3*). Thus, the data indicate that the background isotopic composition of the condor's diet lies within this broad range and there is little evidence to support the narrow isotopic range assumed by the authors for background lead in the diet of condors.

The authors further assume that the isotopic composition of Winchester and Remington ammunition accurately represents the isotopic composition of all ammunition available to hunters in central California, based on the analysis of only Winchester and Remington ammunition, obtained largely from Kmart and Big Five stores in central California. The authors report ^{207}Pb:^{206}Pb ratios of the lead in these two brands of ammunition ranging from 0.8054 to 0.8175, however, they fail to report the data in their reference 27 (*5*), that shows that 22 brands of ammunition available in the U.S. and Canada have a very broad ^{207}Pb:^{206}Pb isotopic ratio range from 0.7870 to 0.9330.

An Internet search for ammunition dealers revealed 104 gun stores supplying 33 different brands of ammunition, other than Winchester and Remington, to hunters in central California, all of which are available nationwide. Nine of these brands are imported from Italy, Belgium, Serbia, Russia, Sweden, and the Czech republic. In addition, a wide variety of ammunition is available from numerous gun shows in central California.

It has been shown (*5, 6*) that the ammunition available in the United States has a wide range of ^{207}Pb:^{206}Pb isotopic ratios, particularly from foreign sources, ranging from 0.7870 to 0.9330. It is therefore virtually certain that ammunition having a wide isotopic range is used to take game in areas where condors forage.

Therefore, the authors' assumption, that only ammunition of a very narrow isotopic range is available in central California, is strongly contradicted by the evidence.

Considering the fact that the ^{207}Pb:^{206}Pb ratios of background lead (0.7541−0.8453) overlap substantially with the ^{207}Pb:^{206}Pb ratios of lead from ammunition (0.7870−0.9330) and the fact that the reported ^{207}Pb:^{206}Pb ratios of blood lead in condors in the wild range from 0.8101 to 0.8402, it is clear that the substantial overlap of isotopic ratios of background lead and lead from ammunition makes it impossible to distinguish the origin of the lead in the blood of condors.

In fact, the authors note that the lead in condors with elevated blood lead levels tends to have a ^{207}Pb:^{206}Pb ratio approaching 0.81, which would actually tend to exonerate ammunition as the source of the elevated blood lead in condors. If condors were being exposed to lead from ammunition, one would expect to observe a very wide lead isotopic ratio range in condors with elevated blood lead levels, due to the very broad isotopic range of ammunition. However, instead of observing a broad isotopic ratio range, we see a very narrow isotopic ratio range. This narrow observed range indicates that the elevated blood lead is coming from a single source of lead with a narrow isotopic range and not from ammunition.

As to the nature of this source, there is ample evidence that condors consume a variety of diet items that have far higher levels of lead than the narrow diet reported by the authors. For example, a study of lead in carcasses within condor range (*7*) reported lead levels ranging from 1 to 17.5 ppm in the muscle tissue of 3 out of 19 deer carcasses examined. They also found 1.82 ppm of lead in one of two cattle placentae examined. These dietary lead levels are one thousand times higher than the levels reported by the authors for captive condors and could easily cause the elevated blood levels reported.

In addition, the authors' reference 12 (*8*) has reported that the blood lead levels of captive condors ranged as high as 37 μg per deciliter for a condor that had been in captivity for 17 years. As this elevated level is from a captive diet, it is clear that there are significant sources of lead in the environment that can lead to elevated blood lead levels in condors.

Literature Cited

(1) Church, M. E.; Gwiazda, R.; Risebrough, R. W.; Sorenson, K.; Chamberlain, C. P.; Farry, S.; Heinrich, W.; Rideout, B. A.; Smith, D. R. Ammunition is the principal source of lead accumulated by California condors re-introduced to the wild. *Environ. Sci. Technol.* **2006**, *40*, 6143–6150.

(2) Erel, Y.; Morgan, J. J.; Patterson, C. C. Natural levels of lead and cadmium in a remote mountain stream. *Geochim. Cosmochim. Acta* **1991**, *55*, 707–719.

(3) Dunlap, C. E.; Bouse, R.; Flegal, A. R. Past leaded gasoline emissions as a nonpoint source tracer in riparian systems: A study of river inputs to San Fancisco Bay. *Environ. Sci. Technol.* **2000**, *34*, 1211–1215.

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(4) Collins, P. W.; Snyder, N. F. R.; Emslie, S. D. Faunal remains in California condor nest caves. *The Condor* **2000**, *102*, 222–227.
(5) Scheuhammer, A. M.; Templeton, D. M. Use of stable isotope ratios to distinguish sources of lead exposure in wild birds. *Ecotoxicology* **1998**, *7*, 37–42.
(6) Buttigieg, G. A.; Baker, M. E.; Denton, M. B. Lead isotope ratio determination for the forensic analysis of military small arms projectiles. *Anal. Chem.* **2003**, *75*, 5022–5029.
(7) Wiemeyer, S. N.; Jurek, R. M.; Moore, J. F. Environmental contaminants in surrogates, food, and feathers of California condors (*Gymnogyps californianus*). *Environ. Monit. Assess.* **1986**, *6*, 91–111.
(8) Wiemeyer, S. N.; Scott, J. M.; Anderson, M. P.; Bloom, P. H.; Stafford, C. J. Environmental contaminants in California condors. *J. Wildl. Manage.* **1988**, *52*, 238–247.

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