Toxic Effects of Lead on Condors and Other Wildlife
Michael Fry
Stratus Consulting, Boulder CO

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You are what you eat…
Condor Range in California

9-11 Counties now encompass the current condor range.

Redrawn from Wilbur 1978.
Radiography of a wild Condor with bullet fragment in the proventriculus, leading to acid mobilization of lead, and toxicity. 3 condors died from lead toxicity in 1980s, 5 have died since 1992, and 30 have recently been treated for high blood lead levels. Snyder and Snyder, 2000
Evaluating Toxic Effects of Lead

- Types of lead exposure
  - Acute high level exposure
  - Chronic low level exposure
  - Episodic exposure

- Data from Humans
- Data from lab animal experiments
- Data from birds
Clinical Effects of Lead Exposure

• Best data is for human exposures
• Humans are easiest to evaluate behaviorally
  – You can ask them questions
• Very large database of accidental, occupational and environmental exposures
• Children become exposed through drinking water, paint, dust, soil.
Human Acute Lead Exposure

• Human Clinical Symptoms:
  – Dullness, irritability, poor attention span, headache, muscular tremor, memory loss, hallucinations, delirium, convulsions, paralysis, coma, death

Average blood lead at death: **3.27 ppm**

327 ug/dl
Human Occupational Exposure

- Studies of workers at mines, battery plants
- Malaise, forgetfulness, headache, impotence, dizziness, weakness, paresthesia (levels 40-120 ug/dl, acute or chronic)
- Increased number of work related accidents
- Decreased performance on cognitive, visual-motor, and verbal reasoning tests (blood level range: 40-60ug/dl)
Lead Exposure to Children

- Many studies of pre-schoolers to teenagers
- Motor skill decrements, hearing losses, visual learning, language, math skills
- No apparent threshold,
  - 10-20ug/dl blood levels correlate with decrements.
Lead Exposure to Children

- IQ decreases correlated with tooth, bone or hair levels; blood levels less predictive.
- IQ loss of 1-3 points: ~10-20 ug/dl
- IQ loss of 5 points: ~40-60 ug/dl
- IQ loss of 16 points: 88ug/dl average

- Impairment of neurobehavioral function in young adults correlated with tooth lead at age 6.
Correlation of Animal and Human Studies

• Studies with Rhesus monkeys and lab rats show similar decrements at almost identical blood lead levels as human studies

• Studies with birds: gulls, terns
  – High level acute injections
  – Testing only a few days after exposure
  – Behavioral and motor skills impaired
Condor Management and Lead Monitoring

- Localized vs. multiple feeding sites
  - At Ventana, changing to a single feeding site did not alter lead exposure, but low anyway
- Trapping for radio replacement
- Trapping for lead monitoring
  - Routine: 1-2 times per year
  - Emergency-prophylaxis: When birds are found feeding on a suspicious carcass, as many as possible have been tested, both Hopper and Arizona
Lead Care® field monitoring
Range of instrument: 0.14-65µg/dl
Lead Exposure

- Define background: < 20µg/dl
- Exposed: 20-59 µg/dl
- Clinically affected: 60-99µg/dl
- Acute toxicity: > 100 µg/dl
- Percentages
  - Hopper: 61% exposed, 16% Clinically affected, 6% toxic
  - Ventana: 15% exposed, 3.3% clinically affected, 0% toxic
- # birds chelated: AZ 22, CA 8
Average blood level, excluding 5 highest values: 28.4 ug/dl
Condor Blood Lead Levels After Release to Wild
Ventana collections

Months in Wild

Blood Lead (ug/dl)

0 10 20 30 40 50 60 70

0 10 20 30 40 50 60
Trends in Blood Pb for Individual Condors
Ventana Birds

Blood Lead Level (ug/dl)

Months in Wild After Release

Blood Lead Level (ug/dl)

Trends in Blood Pb for Individual Condors
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Blood Lead Level (ug/dl)

Months in Wild After Release

Blood Lead Level (ug/dl)
Evaluation of Lead “Washout” from blood

- Depuration is loss of metal from body
- Kinetics indicate short exposure or bioaccumulation
- Lead depuration is complex, with different rates for blood, organs and bone
- Changes in blood levels are the most rapid
Lead Depuration in Condor Blood
Repeat samples without chelation

Depuration $T_{\frac{1}{2}} = 14$ days

Blood Lead (ug/dl)

Days after initial sample
Conclusions from depuration

• No long-term bioaccumulation in blood
• Blood level drops in clean environment
  – T ½ approx 14 days (range 3-22 days)
  – Exposure of 100µg/dl drops to background in 30 days
• 61% of Hopper birds exposed in random testing
• 16% Hopper birds clinically affected, 6% toxic
• These birds are exposed frequently
Lead Toxicity to Condors: rough estimates:

- 4-5 ppm blood lead is fatal concentration
  - 0.6 ppm is criterion for chelation therapy
- 4 ppm in an 8 kg condor is 32-40 mg lead.
  - Pattee et al. Bald Eagle mortality:
    - 19-42mg, one eagle survived 129mg (blind),
    - One eagle survived 125 days, solubilized 185 mg.
- #4 shotgun pellet weighs 209mg
- 30 caliber rifle bullet weighs 9.7g
  - .3% fragment solubilized is potentially fatal
Conclusions:

- Blood tests indicate that many condors are exposed in the field
- Depuration kinetics indicate frequent exposure, because $T_{1/2}$ is about 14 days
- Repetitive lead exposures may be permanently disabling
- Feather sampling could answer exposure questions
Feather studies for lead and other metals

• Feathers accumulate metals from blood
• Random condor feather measurements:
  – Document frequency, duration, and severity of exposures to lead
  – Confirm depuration kinetics
• Feathers from necropsy samples
  – 18 with toxicology; 17 with no residue analysis
  – Analysis would answer exposure questions
High Resolution Condor Feather Analysis: Demonstrate continuous transfer of lead from blood during feather growth.

Archive half, for isotope analysis. Cut feather into equal length segments, 60 gives ~2 day intervals.

Expected Results: Lead Exposure and Depuration. Isotope analysis on peaks could identify lead sources.