Lead: toxic effects and sources in wildlife

Philippe Berny, DVM, Ph D
Professor of Toxicology
Vetagro Sup – Campus Vétérinaire
Marcy l’étoile - France
Introduction

- Lead and wildlife
  - Many species, many places, many times
  - Waterfowl exposure
    - Thousands of birds killed every year
    - Population exposure may be very high
      - 7.5-50% mallards in Argentina (Ferreyra et al., 2014)
      - 25-33% mallards in Ebro delta (Spain) (Guitar et al., 1994, Mateo et al., 1998)
      - 45% mallards in Camargue, France (Pain, 1990)
Introduction

• Lead and wildlife
  ◦ Many species, many places, many times
  ◦ Birds of prey exposure
    • Often described in individuals (bird rescue centers)
    • Evidence of population exposure
      • Griffon vultures (*Gyps fulvus*)
      • Red kites (*Milvus milvus*)
      • California condor (*Gymnogyps californianus*)
      • Bearded vulture (*Gypaetus barbatus*)
      • (…)
## Introduction

<table>
<thead>
<tr>
<th>Species</th>
<th>Country</th>
<th>% (N)</th>
<th>Note</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Gyps fulvus</em></td>
<td>Spain</td>
<td>91%(23)</td>
<td>[Pb]&gt;200 µg.l⁻¹</td>
<td>Garcia-Fernandez et al., 2005</td>
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<tr>
<td></td>
<td>France</td>
<td>7%(92)</td>
<td>[Pb]&gt;6 mg.kg⁻¹ (dw, liver)</td>
<td>Berny et al., 2015</td>
</tr>
<tr>
<td></td>
<td>Israël</td>
<td>20%(25)</td>
<td>[Pb]&gt;200 µg.l⁻¹</td>
<td>Shlosberg et al., 2012</td>
</tr>
<tr>
<td><em>Gymnogyps californianus</em></td>
<td>USA</td>
<td>50-88%(150)</td>
<td>[Pb]&gt;100 µg.l⁻¹ [Pb]&gt;450µg.l⁻¹</td>
<td>Finkelstein et al., 2012</td>
</tr>
<tr>
<td></td>
<td>USA</td>
<td>47-92%(&gt;1500, 5 years)</td>
<td>[Pb]&gt;200 µg.l⁻¹</td>
<td>Kelly et al., 2014</td>
</tr>
<tr>
<td><em>Gypaetus barbatus</em></td>
<td>Spain</td>
<td>6%(87)</td>
<td>Pb]&gt;200 µg.l⁻¹ [Pb]&gt;6 mg.kg⁻¹ (dw, liver)</td>
<td>Hernandez et al., 2009</td>
</tr>
<tr>
<td></td>
<td>France</td>
<td>12,5%(8)</td>
<td>[Pb]&gt;6 mg.kg⁻¹ (dw, liver)</td>
<td>Berny et al., 2015</td>
</tr>
</tbody>
</table>
Lead toxicity in wildlife

- A high susceptibility?
  - Lead particles in gizzard
    - Mechanical digestion
    - Waterfowl+++ in hunting areas
    - Ingestion by birds of prey
  - Low pH
    - A Bearded vulture can digest bones in <48h
  - Persistence in gizzard folds
    - Pb(metal)\rightarrow[Pb^{++}] absorbed
Lead toxicity in wildlife

- Acute poisoning
  - Neurological and digestive signs
    - Weakness
    - Limb weakness
    - Limber neck
    - Blindness
    - Green diarrhea
    - Weight loss
  - Often (not always !) presence of lead particles
    - Gizzard/proventriculus
    - Whole body X-Ray
Lead toxicity in wildlife

- Chronic toxicity: Pb is cumulative
  - Weakness
  - Weightloss
  - Anemia (?)
  - Dilatation and impaction of proventriculus
  - Neurological / digestive disorders
    - Blindness
    - Behavioral disorders
  - Sub-clinical effects?
    - \([\text{Pb}]_{\text{liver}} \) 1.52\(>0.84\) if trauma
    - \([\text{Pb}]_{\text{kidney}} \) 2.44\(>0.86\) if trauma
Lead toxicity in wildlife

• A bad story...

Red kite found dead with...
- Broken wing
- Cachexia
- Lung hemorrhages
- Green diarrhea
- Lead bullets (thigh, wing)
- [Pb]Liver = 21.2 µg.g⁻¹ (dw)

Conclusion:
Shot, Pb poisoning, blindness
neuro-behavioral disorders, feeding?
- collision, broken bone...

Photos: Dr. L. Vilagines
Lead toxicity in wildlife

- Lesions
  - Macroscopic lesions
  - Acidophilic inclusions in liver/kidney

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Lead toxicity in wildlife

- Diagnostic testing
  - Blood lead:
    - Whole blood
      - >100 µg/L « exposure »
      - <250 µg/L « background »
      - >500 µg/L toxic
    - Dry Blood Spots
  - Liver:
    - <2 mg.kg\(^{-1}\) (ww)
    - > 6 mg.kg\(^{-1}\) (dw) Exposure
    - >15-20 mg.kg\(^{-1}\) (dw) Poisoning
    - /3.3 for ww
Lead sources

- From soil to trophic web...contamination of plants, herbivores, predators
- Aerial pollution? No evidence of impact
- Environmental (soil) lead (local issue)
  - Geological exposure: old mines, old mountain areas
  - Mining activities: active sites
  - Use of old mine wastes in fields
- Industrial sources (local issue)
  - Lead pipes (water)
  - Batteries
  - (Paints): cases in rehabilitation centers
  - (Leaded gas): not a concern in the EU
Lead sources

- Lead ammunition in feeds: major concern
  - First evidence in waterfowl: lead in gizzard/crop
  - In birds of prey
    - Lead ammunition in surviving preys/fragmentation
    - California condor 26 to 67% of identified cause of death (*Rideout et al.*, 2011)
    - Major source (Lead isotope analyses) (*Finkelstein et al.*, 2012)
      - Isotopes issued from other radio-active elements = geological source signature
    - Described/suspected in many species

- Lead isotope analyses (Finkelstein et al., 2012)
Lead sources

- Lead ammunition in feeds

Lead isotope ratios ($^{206/208}$Pb vs $^{206/207}$Pb) in birds of prey (liver) and from various published sources.

Open squares: [Pb]liver>2 µg.g$^{-1}$ (dry weight).

Rectangle: lead in European ammunition (Thomas et al., 2009);

Round-edge rectangle: lead in Pyrenean ancient mines (Cardellach et al., 1996);

Circle: lead in Basq county (Monna et al., 2004);

Line: lead in US ammunition (Lambertucci et al., 2011).

Leaded gas (<1.08 on X axis) could not be represented on this graph.
Lead sources

- Lead ammunition in animals shot
  - Supposedly harmless?
  - Evidence of clinical effects in individuals
    - Very few published data
    - One recent paper (LaDouceur et al., 2015)
    - 2 birds out of 14 (Lead shots) w/ high [Pb]liver = 14%
Lead sources

- Lead ammunitions in animals shot
  - Supposedly harmless?
  - Evidence of higher exposure in individuals
    - $[\text{Pb}]_{\text{liver}} > 0.92$ if shot
    - $[\text{Pb}]_{\text{kidney}} > 0.92$ if shot

![Box plot](image)
Conclusion

- Lead poisoning
  - Is a major concern worldwide for birds of prey
  - Is primarily related to
    - Food-exposure
    - Lead ammunition in preys
  - May also be linked to
    - Lead shots in the body
    - Less frequently: local/other industrial sources

Thank you for your attention