Lead poisoning in birds of prey – an international problem
Overview

- species affected
- relevance
- proof
- solutions
- problems
Who is affected?

dabbling waterfowl ingest lead shot pellets
- mistaken as seeds
- as grid

birds of prey
- ingest lead shot pellets and bullet fragments
Spectrum of birds of prey

17 species from Europe

Blood > 100 μg/dl
Liver>15 μg/g dw
Bone >20 μg/g dw

Honey Buzzard
Red Kite
White-tailed Eagle
Egyptian Vulture
Bearded vulture
Griffon Vulture
Cinereous Vulture
Marsh Harrier
Eurasian Sparrowhawk
Northern Goshawk
Common Buzzard
Spanish Imperial Eagle
Golden Eagle
Peregrine Falcon
Barn Owl
Eagle Owl
Long-eared Owl

Mateo 2009, modified

least concern 14x
near threatened 1x
vulnerable 1x
endangered 1x

species affected relevance proof solutions
The reintroduction of the bearded vulture in Europe

- Lethal lead intoxication in 6 bearded vultures in the European reintroduction program (4 Andalusia, 2 Eastern Alps)
- >12 cases of lead intoxication in the breeding stock (Frey pers. comm.)
Survival of the Californian Condor

- > 18 indiv. † died since the 1980s (Cade 2007)
- high blood lead levels
  - Chelation therapy (Church et al. 2006)

lead-free hunting is crucial for the survival of the Californian Condor

Green et al. 2009
Steller sea eagle

- Lead poisoning of Steller’s Sea-Eagles first confirmed in 1996.
- Since then 129 Steller’s and White-tailed eagles have been diagnosed as lead poisoned, until 2007.
- primary cause of poisoning in eagles is by feeding on lead-contaminated Sika deer carcasses.
- Hokkaido government authorities announced a radical deer population control program in 1998 – 1999 to reduce the herd in eastern Hokkaido from the 200,000 to 30,000 animals within three years.

- Reacting to the eagle poisoning, a civic group, the “Eagle Lead Poisoning Network”, was established in 1998. Citizens, including students, teachers, company employees, hunters, and civil servants started to act for the prevention of lead poisoning.
- Investigation of large raptors in Hokkaido, investigation to understand lead poisoning occurrence in the environment, improvement of the wintering environment, activity to promote the shift to nontoxic bullets, educational activity.
- the Hokkaido local government has regulated the use of lead rifle bullets for Sika deer hunting since 2000, and required to use nontoxic rifle bullets. The regulation of lead rifle bullets and shotgun slugs for all big game hunting, including the brown bear, started in the winter of 2004.
- a nationwide ban of all lead ammunition is the only way to solve the problem of raptor lead poisoning.
- continued cooperation of government administrations, hunters, and civilians.
Sources of lead intoxications

Predators:
• hunting and feeding on shot but living (handicapped) waterfowl and game animals

Scavengers:
• feeding on shot game animals
• gut piles containing particles of lead ammunition
Causes of lead intoxications in Sea eagles

Sea eagle as predator:
hunting and feeding on shot but living (handicapped) waterfowl and game animals

Sea eagle as scavenger:
feeding on shot game animals or gut piles containing particles of lead ammunition
indirect and direct proof
(for lead intoxication due ingestion of lead particles from hunters ammunition)

• indirect
  – contamination of potential prey items
  – preclusion of lead accumulation in potential prey
  – low lead burden in food specialists (osprey)

• direct
  – toxicological lead values in organs
  – feeding experiments
  – identifying fragments of spent lead ammunition from the digestive system (morphological, element composition, isotope ratio)
Contamination of potential prey items

Semi-jacketed round nose, n=15
minimal number of fragments:
45, max.: 300, mean: 120

Semi-jacketed bullets
• high number of fragments
• irregular particles often < 1 mm

Barnes XLC and Lapua Naturalis,
n=122  min.: 0, max.: 0

Lead-free deforming bullets
• often no fragments
• some constructions leave few relatively large fragments
• no indications for lower killing efficacy

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species affected  relevance  proof  solutions
Preclusion of lead accumulation in potential prey

193 samples examined for Pb and Cd
no sample above benchmark

(Food-Monitoring 1998 by Federal Office of Consumer Protection and Food Safety)
Feeding experiments

Experimental lead-shot poisoning in handicapped bald eagles

<table>
<thead>
<tr>
<th>years in captivity</th>
<th>no. of shots</th>
<th>shot retention in days</th>
<th>lead eroded (mg)</th>
<th>days to death</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>10</td>
<td>2-20 (2)</td>
<td>19.4</td>
<td>20</td>
</tr>
<tr>
<td>7</td>
<td>30</td>
<td>1-7 (2)</td>
<td>37.8</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>20</td>
<td>1-7 (2)</td>
<td>42.3</td>
<td>12</td>
</tr>
<tr>
<td>6</td>
<td>156</td>
<td>1-37 (7)</td>
<td>184.9</td>
<td>125</td>
</tr>
<tr>
<td>9</td>
<td>80</td>
<td>½-48 (2)</td>
<td>129.0</td>
<td>133</td>
</tr>
</tbody>
</table>

Pattee et al. 1981
White-tailed sea eagle with metallic particles in the gizzard
Element analysis of metal fragments from the gizzards

- Lead
- Antimone
- Iron
- Copper

Species affected | Relevance | Proof | Solutions
NO access to contaminated food

1. viscera

2. lead shots in tissue of game animals (waterbirds, etc.)
   up to 40% of the goose are shot

3. shot but not retrieved animals (especially ungulates)
   
   3% of 1,800,000 shot ungulates in Germany = 54,000
Mandatory solution?

relativation of the problem
growing sea eagle population

White-tailed sea eagle as indicator:
• more birds (of prey) are effected
• mammals suffer lead intoxication
• lead exposure to humans
Informing the hunters

- internet homepage
- leaflet
- brochures
- workshops
- conference
## Hunting in Europe 2010

<table>
<thead>
<tr>
<th>country</th>
<th>hunters</th>
<th>pop./km²</th>
<th>ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ireland</td>
<td>120.000</td>
<td>58</td>
<td>1:12</td>
</tr>
<tr>
<td>Norway</td>
<td>190.000</td>
<td>14</td>
<td>1:24</td>
</tr>
<tr>
<td>Sweden</td>
<td>290.000</td>
<td>20</td>
<td>1:31</td>
</tr>
<tr>
<td>Denmark</td>
<td>165.000</td>
<td>120</td>
<td>1:33</td>
</tr>
<tr>
<td>Spain</td>
<td>980.000</td>
<td>85</td>
<td>1:41</td>
</tr>
<tr>
<td>Italy</td>
<td>750.000</td>
<td>85</td>
<td>1:41</td>
</tr>
<tr>
<td>Greece</td>
<td>235.000</td>
<td>84</td>
<td>1:45</td>
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<tr>
<td>Portugal</td>
<td>230.000</td>
<td>116</td>
<td>1:46</td>
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<tr>
<td>France</td>
<td>1.331.000</td>
<td>100</td>
<td>1:48</td>
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<tr>
<td>Bulgaria</td>
<td>110.000</td>
<td>69.5</td>
<td>1:70</td>
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<td>Austria</td>
<td>118.000</td>
<td>98</td>
<td>1:70</td>
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<td>UK</td>
<td>800.000</td>
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<td>Slovenia</td>
<td>22.000</td>
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<td>Hungary</td>
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<td>109</td>
<td>1:190</td>
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<td>Germany</td>
<td>351.000</td>
<td>230</td>
<td>1:233</td>
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<td>Switzerland</td>
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<td>1:253</td>
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<tr>
<td>Poland</td>
<td>106.700</td>
<td>123</td>
<td>1:363</td>
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<tr>
<td>Belgium</td>
<td>23.000</td>
<td>341</td>
<td>1:452</td>
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<tr>
<td>Netherlands</td>
<td>28.170</td>
<td>395</td>
<td>1:618</td>
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Source: [http://www.face.eu/huntingin_census-de.htm](http://www.face.eu/huntingin_census-de.htm)
1. workshop on lead intoxication in birds of prey

Stakeholders involved:
• Hunting organisations
• Foresters
• Ammunition industry
• Nature conservation agencies
• NGOs

booklet of the first workshop from April 2005

moderate belief of results

species affected relevance proof solutions
Catalogue of open questions

**sources of lead intoxications**
- shot game animals
- water fowl

**relevance on population scale**

**feeding behaviour of WTSE**
- avoidance of large metallic particles

**local aspects of lead intoxication of WTSE**
- home range size

**reduction of exposure**
- bury gut piles
- switch to lead-free ammunition

**lead-free ammunition**
- contamination of gut piles
- performance of killing game animals
- toxicity of alternative materials (copper, brass, zink)
natural science part

– home range size and habitat utilisation
– diet and feeding behaviour
– population dynamics
– sources of lead intoxication (waterfowl monitoring)
– toxicity and efficiency of lead-free ammunition

species affected  relevance  proof  solutions
Joined research and communication project

social science part

– survey on knowledge of lead intoxication in raptors and acceptance of lead-free ammunition
– discourse analysis
– conflict analysis
informing the hunters

leaflet

project homepage

www.seeeadlerforschung.de

species affected

relevance

proof

solutions
2. workshop  March 2007

discussion with stakeholders (hunting organisations, ammunition industry, ammunition suppliers, forest owners, nature conservationists)

lead intoxication in white-tailed sea eagles: Causes and approaches to solutions

agreement on

• the causes of lead intoxication of raptors

• need for action

species affected  relevance  proof  solutions
Local aspects of lead intoxications

common argument: sea eagles use very large home ranges, which they often leave to roam around for food

- backpack transmitters: GPS/ VHF, data transfer via GSM, 170 g
- one position/day for 2 years

Home range sizes (km$^2$):

<table>
<thead>
<tr>
<th>collar</th>
<th>sex</th>
<th>N</th>
<th>100% MCP</th>
<th>Kernel 95%</th>
<th>Kernel 50%</th>
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</thead>
<tbody>
<tr>
<td>655</td>
<td>W</td>
<td>570</td>
<td>10,7</td>
<td>1,3</td>
<td>0,1</td>
</tr>
<tr>
<td>992</td>
<td>W</td>
<td>105</td>
<td>15,4</td>
<td>7,5</td>
<td>0,8</td>
</tr>
<tr>
<td>472</td>
<td>W</td>
<td>472</td>
<td>27,4</td>
<td>3,8</td>
<td>0,5</td>
</tr>
<tr>
<td>964</td>
<td>M</td>
<td>235</td>
<td>24,2</td>
<td>7,2</td>
<td>0,4</td>
</tr>
<tr>
<td>2907</td>
<td>W</td>
<td>81</td>
<td>62,3</td>
<td>41,4</td>
<td>6,2</td>
</tr>
<tr>
<td>2906</td>
<td>W</td>
<td>119</td>
<td>13,2</td>
<td>2,4</td>
<td>0,3</td>
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<tr>
<td>2905</td>
<td>W</td>
<td>75</td>
<td>14,9</td>
<td>26,4</td>
<td>6,7</td>
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<tr>
<td>2355</td>
<td>M</td>
<td>123</td>
<td>83,6</td>
<td>15,5</td>
<td>2,5</td>
</tr>
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⇒ Association of lead-poisoned adult and territorial sea eagles to local hunting activities is possible
Selective feeding behaviour of WTSE

1) ratio of inserted/ avoided nuts

- carcasses were prepared with iron nuts of different sizes
- feeding behaviour observed by video surveillance
- x-ray of the carcasses/ use of a metal detector

2) proportions of avoided nuts of different diameters

species affected
relevance
proof
solutions
1. Science as an own actor in policy field: **knowledge transfer**
2. Creation of **awareness** by informing hunters and other stakeholders about:
   - scientific results of the project
   - trends in ammunition development
   - trends on governance in other countries
3. **Dialogue-oriented research**: all results will be published in journals and presented at workshops
4. Stakeholder dialogues as an instrument of **transdisciplinary discussion** of knowledge from natural and social sciences and different stakeholder communities
Hunters taking action

results and public awareness

realisation of lead-free hunting

in the Ecological Hunting Organisation,
8 forestry districts in 4 federal states
and one National Park
Lead-free bullet types

Species affected: Hornady GMX, Brennecke TIG nature

Relevance:
- Hornady GMX: 2009
- Brennecke TIG nature: 2009

Proof:
- Hornady GMX: 2009
- Brennecke TIG nature: 2009

Solutions:
- Sellier & Bellot eXergy: 2010
Regression

• statement letter from a German association for technical inspection of ammunition and weapons (DEVA) suspecting a dangerous ricocheting behaviour of copper bullets
• resulted in the ban of lead-free ammunition in two federal states
Consequences

• prohibition of lead-free ammunition in the forests of two federal states (Bra, M-V) including the Müritz NP
• fear of violating the duty of care in the national forest administration when switching to lead-free ammunition
• many private hunters were feeling uncertain and switched back to lead-based bullets
Causes of hunting accidents

from 1961 - 1992  
n = 334

<table>
<thead>
<tr>
<th>Cause</th>
<th>Percentage</th>
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<tr>
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<td>37%</td>
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<tr>
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<td>13.6%</td>
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<tr>
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<tr>
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<td>6.6%</td>
</tr>
<tr>
<td>Violation of agreements</td>
<td>6.6%</td>
</tr>
<tr>
<td>Defective firearm or ammunition</td>
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</tr>
<tr>
<td>Incorrect ammunition</td>
<td>1.2%</td>
</tr>
<tr>
<td>Unsuccessful coup de grace</td>
<td>0.8%</td>
</tr>
<tr>
<td>Telescopic sight misused as binoculars</td>
<td>0.8%</td>
</tr>
<tr>
<td>Miscellaneous (e.g. firing from a driving car)</td>
<td>2.0%</td>
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Karger et al. 1996
## Causes of hunting accidents

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Karger et al. 1996
Conference and 3. workshop  April 2009

presenting the results from the natural and social scientific parts of the project and discussion with the stakeholders and the public

call to the ministries
1) to support all safety related (deflecting bullets) tests
2) to evaluate the eco-toxicology of alternative bullets

joined declaration
Recent situation

The Federal Ministry of Food, Agriculture and Consumer Protection announced a request for tender regarding the deflecting and ricocheting behaviour of different bullet types

→ DEVA won the tender
Projectile deflection

- performed by the German experimental and testing institute for hunting and sporting weapons (DEVA)

- evaluated by Dr. sc. forens. Dr. med. h.c. Beat Kneubühl, University Bern, Switzerland

by February 15th 2011

by April 5th 2011
selected bullets and calibres

projectile „A“ - Kegelspitz-Geschoss (KS)
fragmenting with thinn mantle

projectile „B“ - Nosler Partition-Geschoss (NP)
partly fragmenting with bridge and 2 lead cores

projectile „C“ - Torpedo-Optimal-Geschoss (TOG)
deforming with thick mantle

projectile „D“ - Barnes TSX-Geschoss
lead-free deforming

projectile „E“ - Reichenberg Geschoss (HDBoH)
lead-free partly fragmenting

projectile „F“ - Lapua Naturalis-Geschoss
lead-free deforming

selected calibres
- .243 Win. with E0 of ca. 2.500 J
- .308 Win. with E0 of ca. 3.600 J
- 9,4x74 R with E0 of ca. 4.500 J.

Wild ungulates are shot in Germany at an average distance of 80 m und 100 m erlegt. During driven hunts distances are shorter. Therefore shooting distances were set at 25 m, 50 m und 100 m.
Design of experiments

1) NATO bush consisting of common beech (Ø 6 mm)
2) trunk of a tree European spruce (Ø 30-35 cm)
3) ricochet experiment to test back bouncing bullets after shooting through an animal using ballistic soap and a truck or granit Rückprallversuch
4) hard soil
   „natural path“ with sandy limestone gravel
5) stone slab
6) soft soil top soil with humus layer of 5cm
Main results

The threats are equal for both bullet types within the vicinity of the point of impact (area of danger for persons attending hunting).

Lead-free bullets have a significant larger range compared to lead-based bullets. Within an open terrain the danger zone increases to the same amount as the probability of hitting decreases. A preference for one of both types can not be told.

A larger threat is only given for persons not involved in hunting if frequently used paths or roads or settlements are found within the danger zone. The maximum technical range (single value) is 1521m in lead-free and 1470m in lead based projectiles. The differences between the two bullet types are therefore minimal.

The main difference between lead-free and lead-based bullets is the remaining weight of deflecting lead-free bullets. But this is more related to the construction of the projectile than to the material.

Finally, considering all results no larger threat can be attribute to lead-free bullets.
Human health issues

- A current report of the European Food Safety Authority (EFSA CONTAM 2010) identified low lead levels being responsible for lower intelligence quotient (IQ) levels in infants and high blood pressure and nephrotoxicity in adults.
- A new threshold level could not be established since the smallest amount of lead can result in the previous mentioned effects.
Suggested reading

Proceedings of the conference:


www.seeadlerforschung.de
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