

**Pb** LEAD TASK TEAM  
South Africa



# LEAD EXPOSURE OF WILDLIFE IN SOUTH AFRICA: RISKS, IMPACTS AND SOLUTIONS

IAN RUSHWORTH

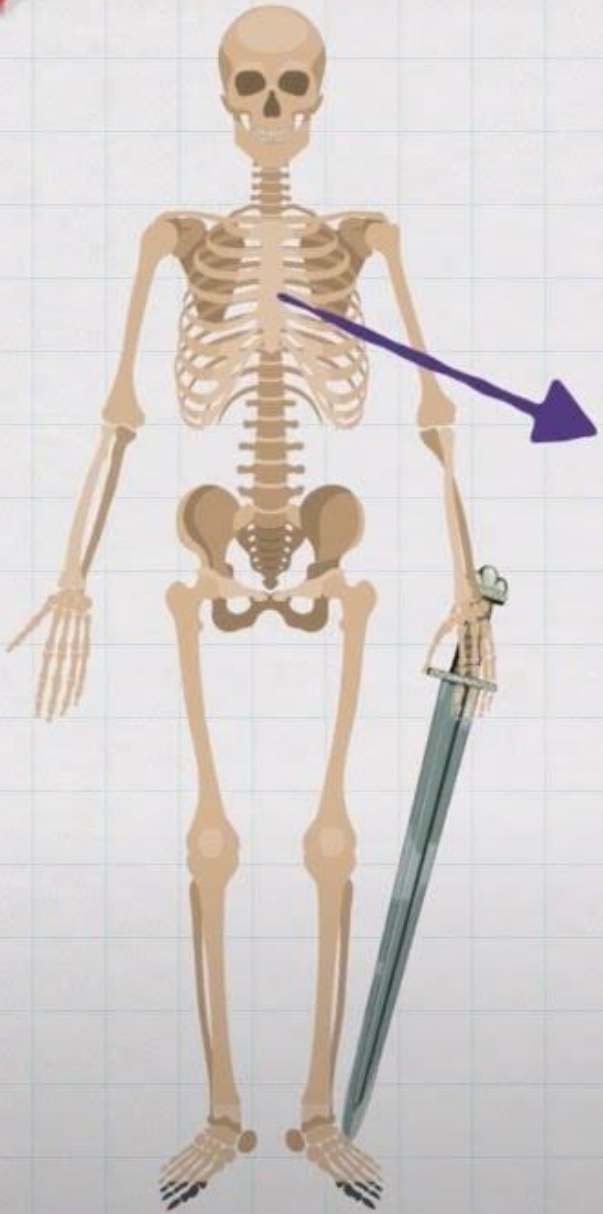
South African Lead Task Team &

Ezemvelo KZN Wildlife

Scientific Authority

22 October 2024

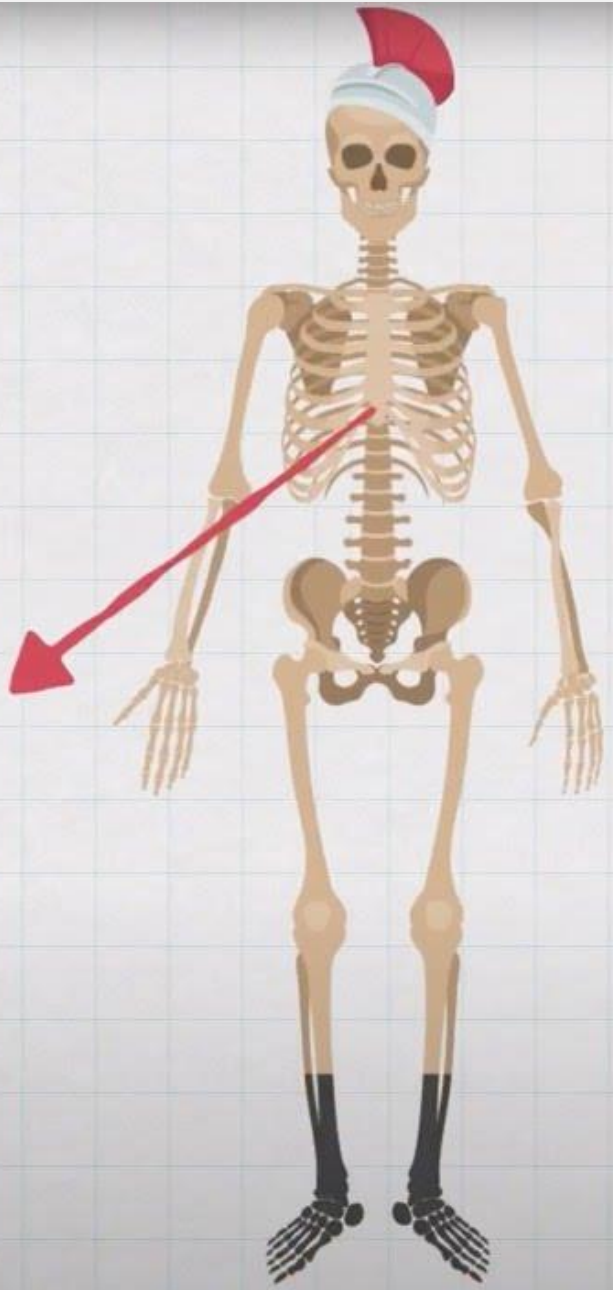




IRON AGE

0.3 - 2.9  $\mu\text{g/g}$

8 - 123  $\mu\text{g/g}$



ROMAN EMPIRE

# Human Impact of Lead

- Serves no useful purpose
- **143 000 human deaths per year**, childhood exposure results in **600 000 intellectual disabilities** per year
- Estimated **cost of lead exposure to world economy US\$ 1082 Billion\***
  - Low- to middle- income countries US\$ 977 Billion
    - US\$ 18-24 Billion southern Africa
  - USA US\$ 50 Billion
  - Europe US\$ 55 Billion
- WHO – lead (Pb) is one of **top ten chemicals of public health concern**
  - Expects Member States to protect people and develop strategies (World Health Assembly resolution 59.15)
- United Nations Environment Assembly (UNEA) - Resolution 2/7 Sound management of chemicals and waste
  - **“Significant risks to human health and the environment** arising from releases of lead ... into the environment”
- Strict regulations imposed (fuel, fertilizer, cosmetics, paint, toys etc.)
- However still some largely **unregulated sources of lead** into the environment (e.g. **bullets, sinkers, batteries, pollution**)
  - e.g. EU 20 000 t/annum

\* Attina TM, Trasande L. 2013. Economic costs of childhood lead exposure in low- and middle-income countries. Environ Health Perspect 121:1097–1102; <http://dx.doi.org/10.1289/ehp.1206424>

# OUTLINE

- Sources of lead exposure of wildlife in South Africa

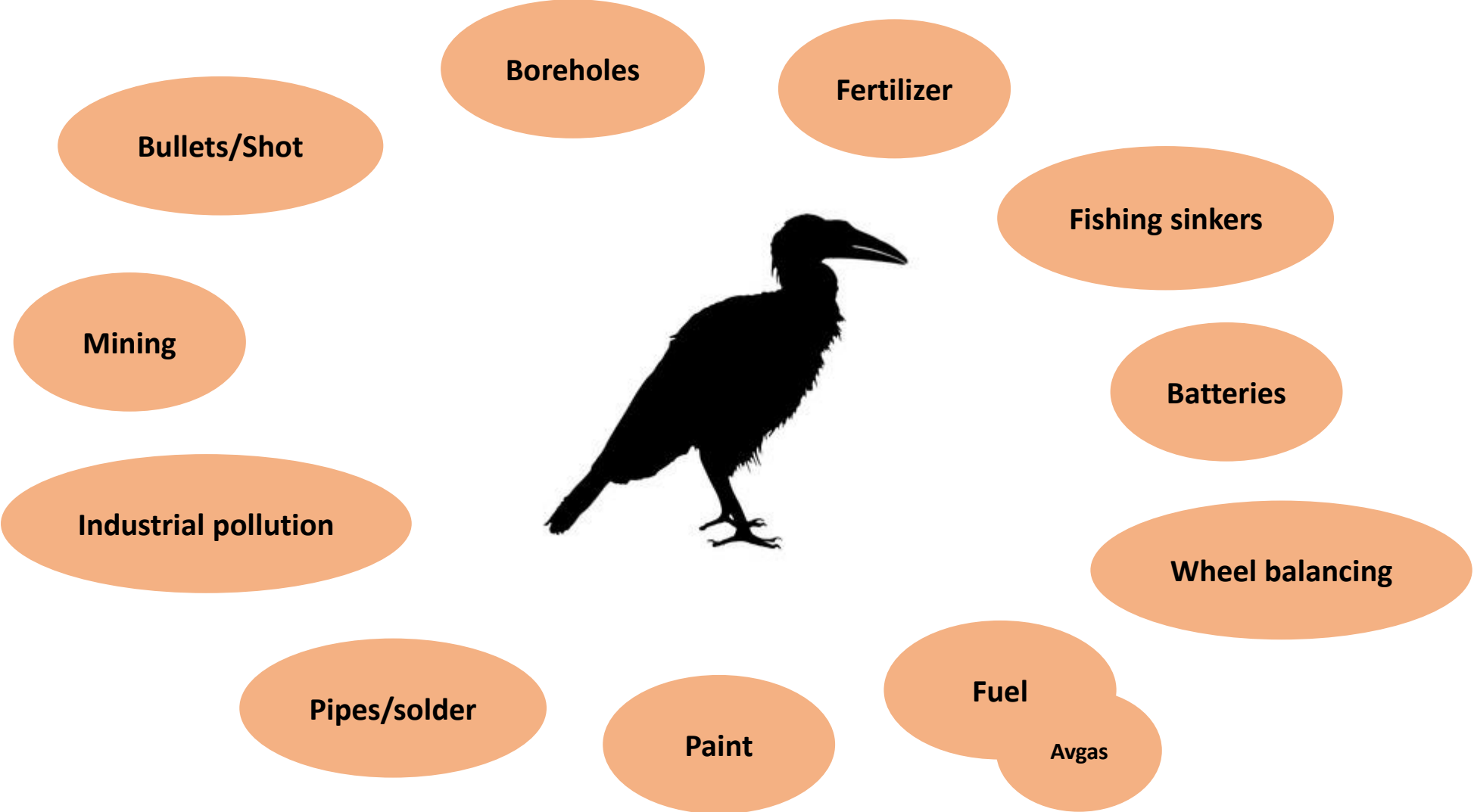


- The components of ammunition and how bullets are designed to work
  - Examples of bullet fragmentation

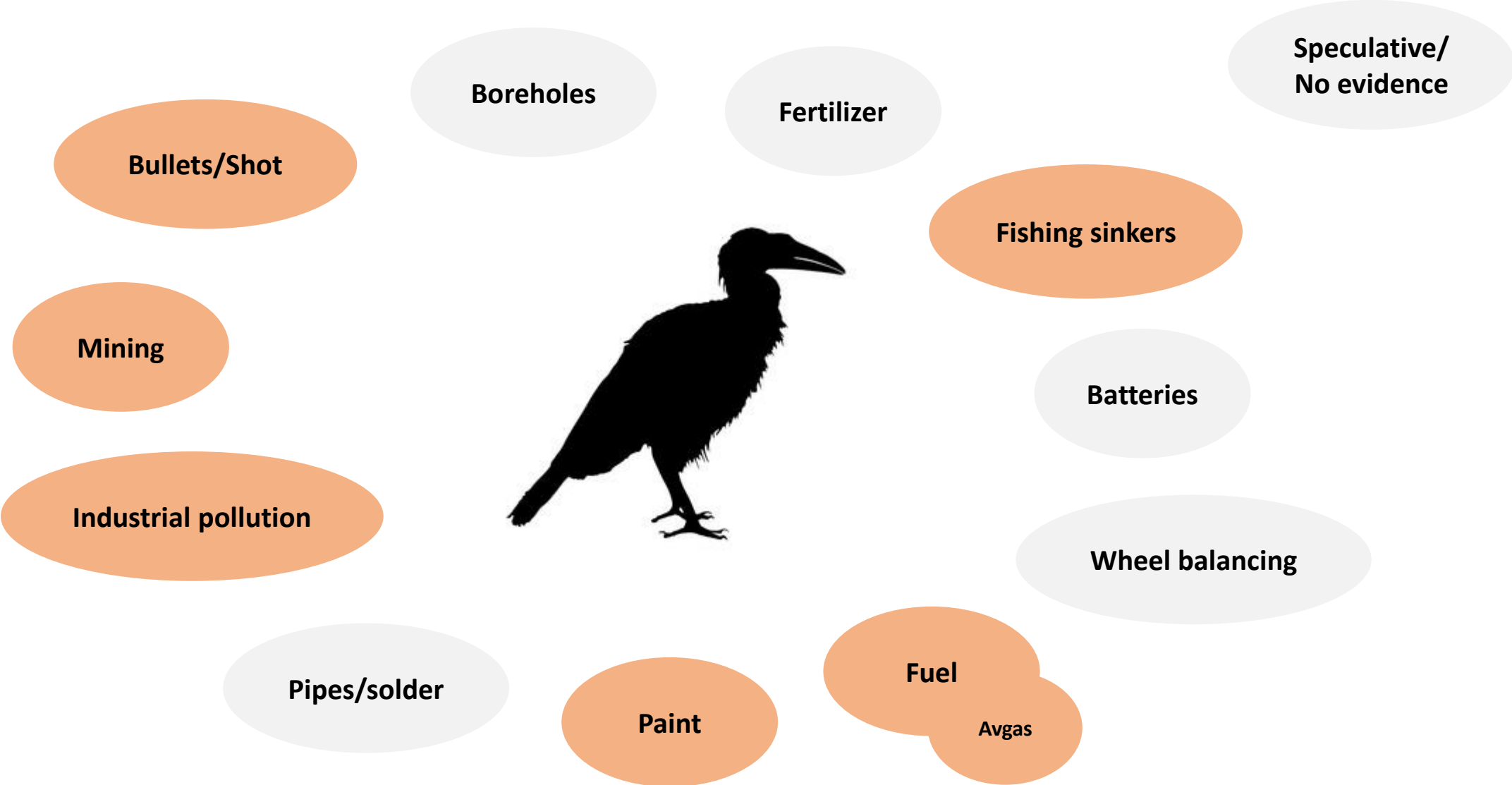


- What we know and are learning about lead in wildlife
  - Some research findings
  - Risk to people from eating game meat

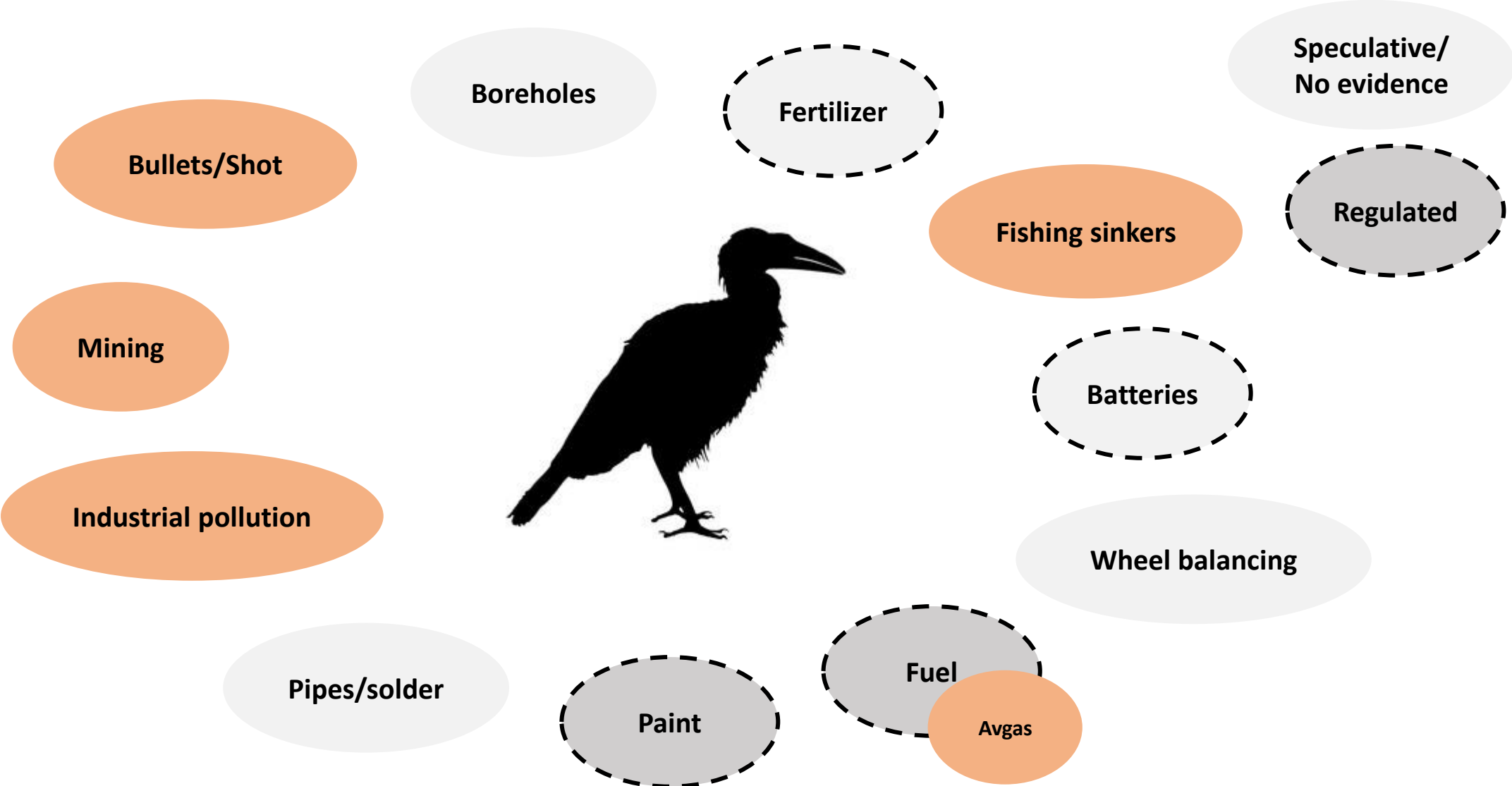
# Multiple potential sources of lead (Pb) to wildlife in South Africa (simplified)



# Multiple potential sources of lead (Pb) to wildlife in South Africa (simplified)

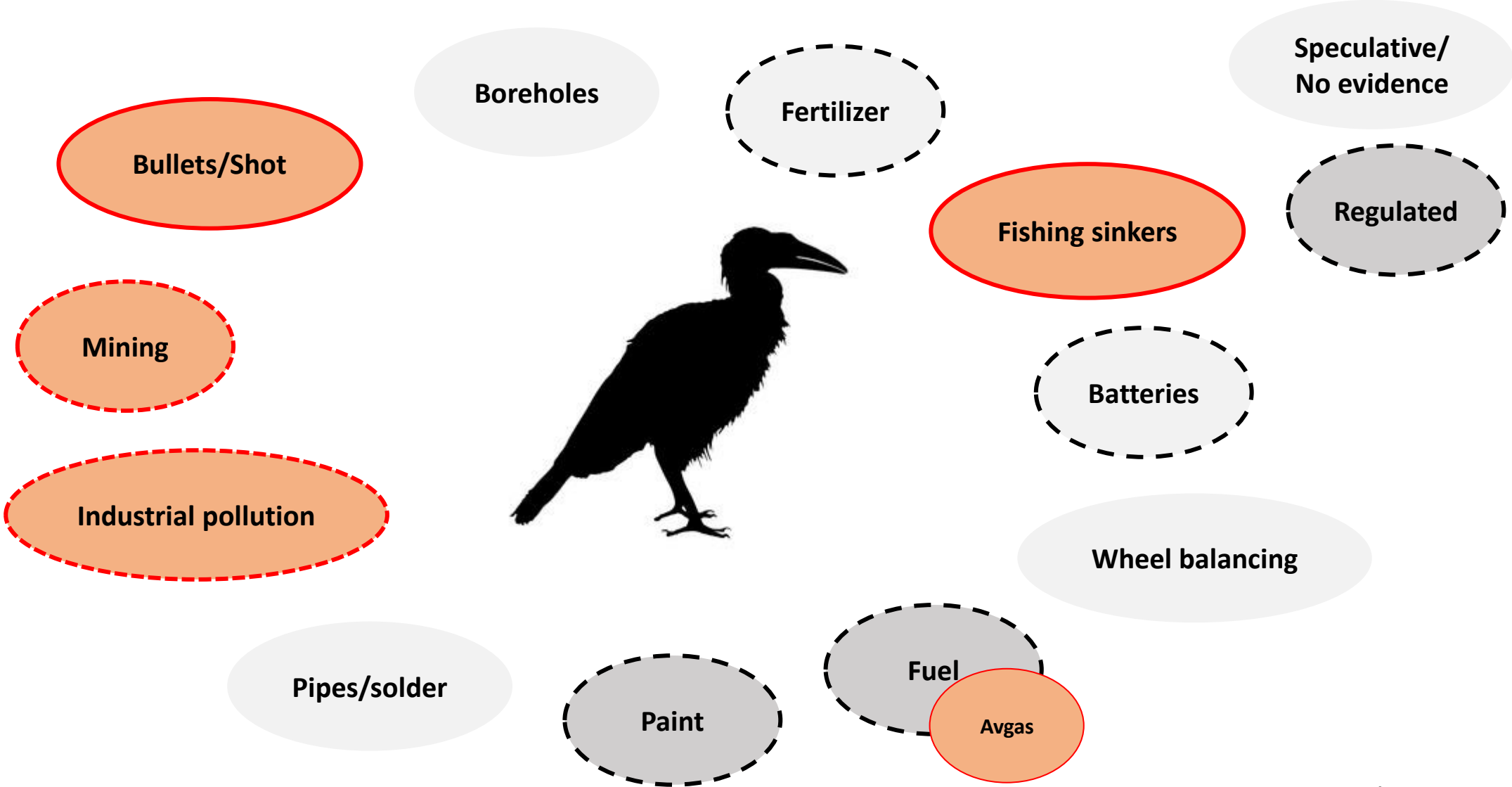


# Multiple potential sources of lead (Pb) to wildlife in South Africa (simplified)



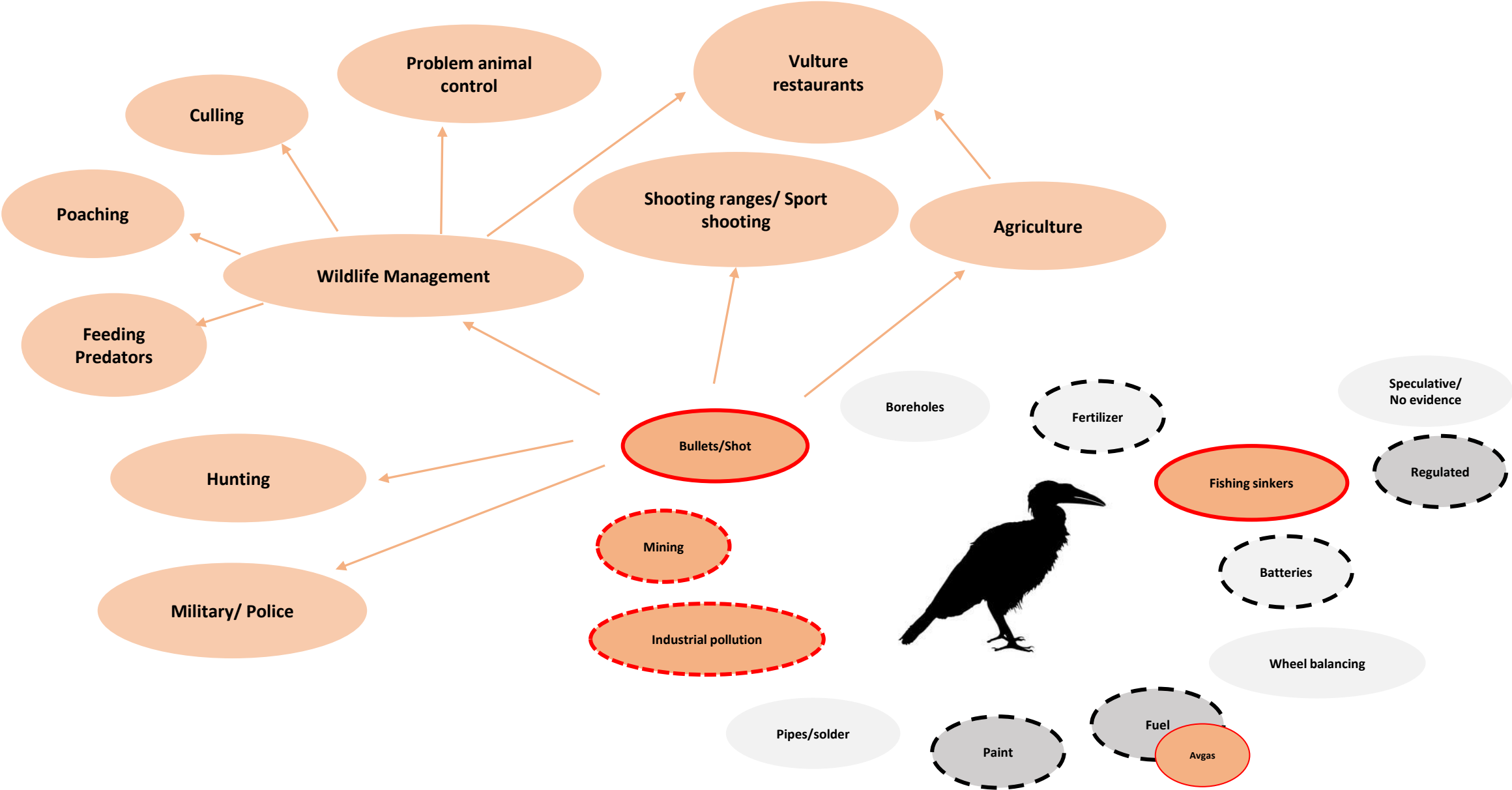


# Multiple potential sources of lead (Pb) to wildlife in South Africa (simplified)



>1000 tons/annum?

# Multiple potential sources of lead (Pb) to wildlife in South Africa (simplified)



A.





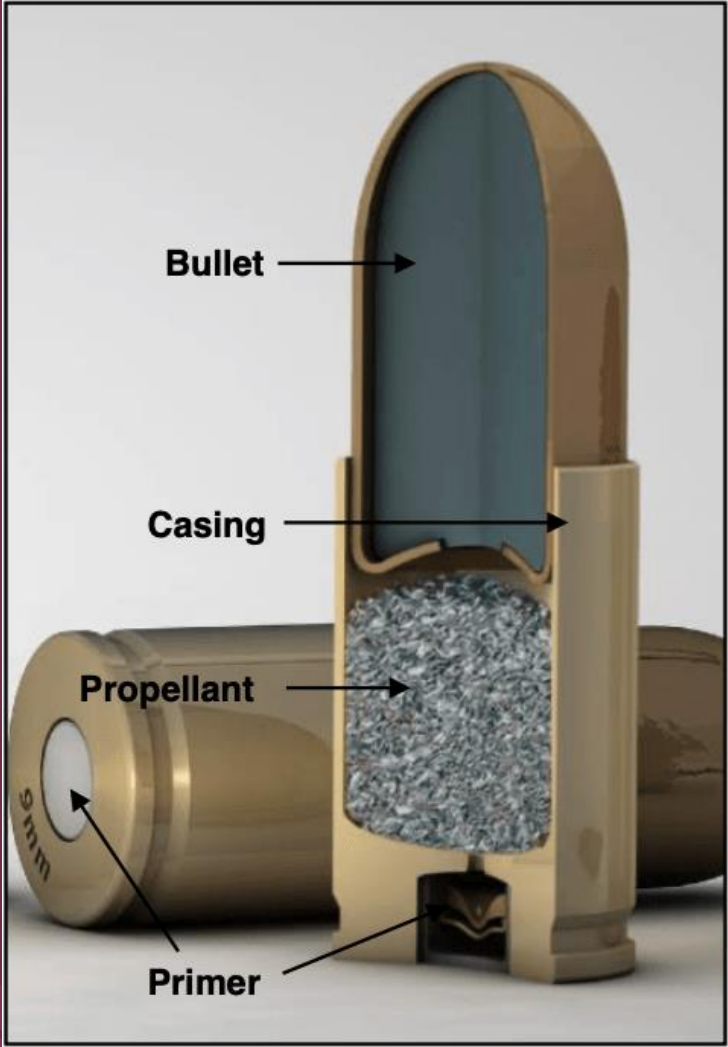
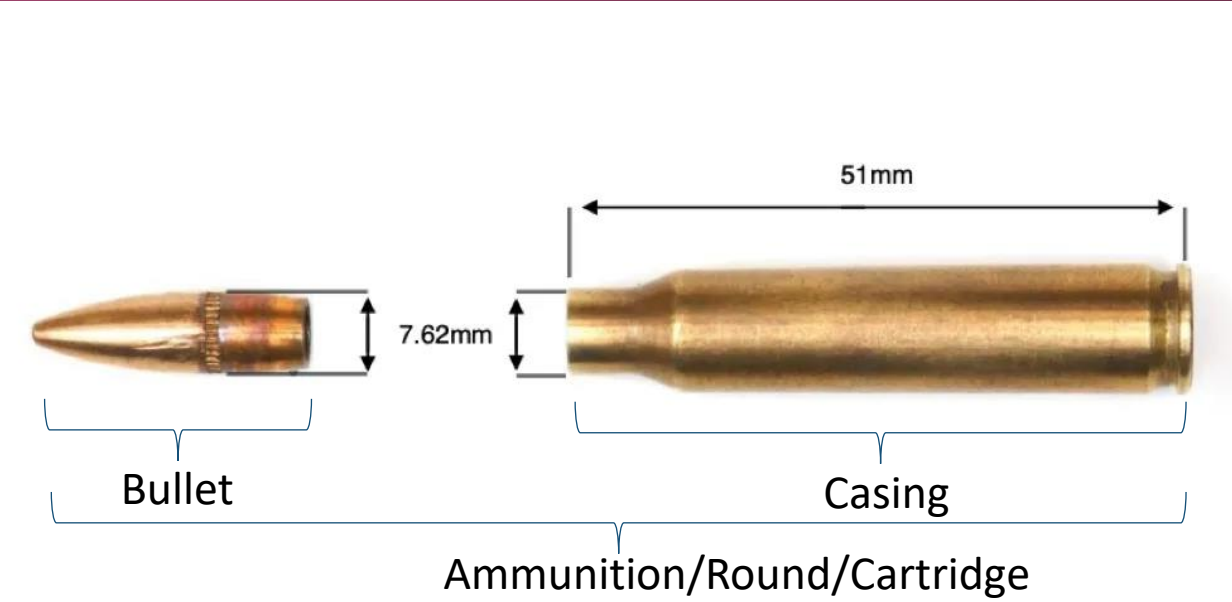
Lead is a Silent Killer

# BULLETS AND AMMUNITION

A QUICK OVERVIEW FOR CONTEXT



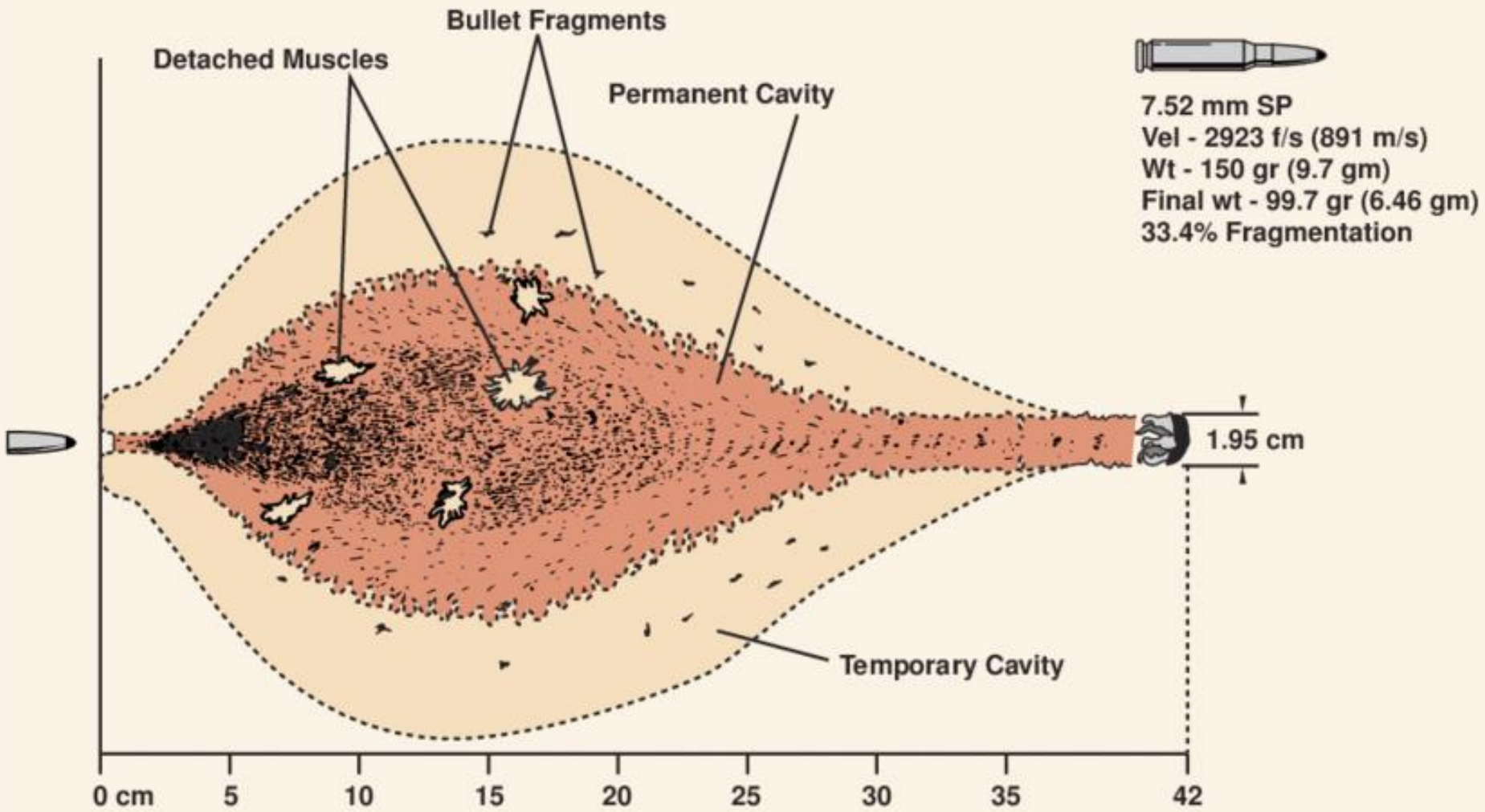
# TERMINOLOGY





### Why lead?

- Dense = heavy and more stable
- Melts at low temperatures, cools evenly
- Fragments on impact = more lethal
- Relatively cheap



7.52 mm SP  
 Vel - 2923 f/s (891 m/s)  
 Wt - 150 gr (9.7 gm)  
 Final wt - 99.7 gr (6.46 gm)  
 33.4% Fragmentation

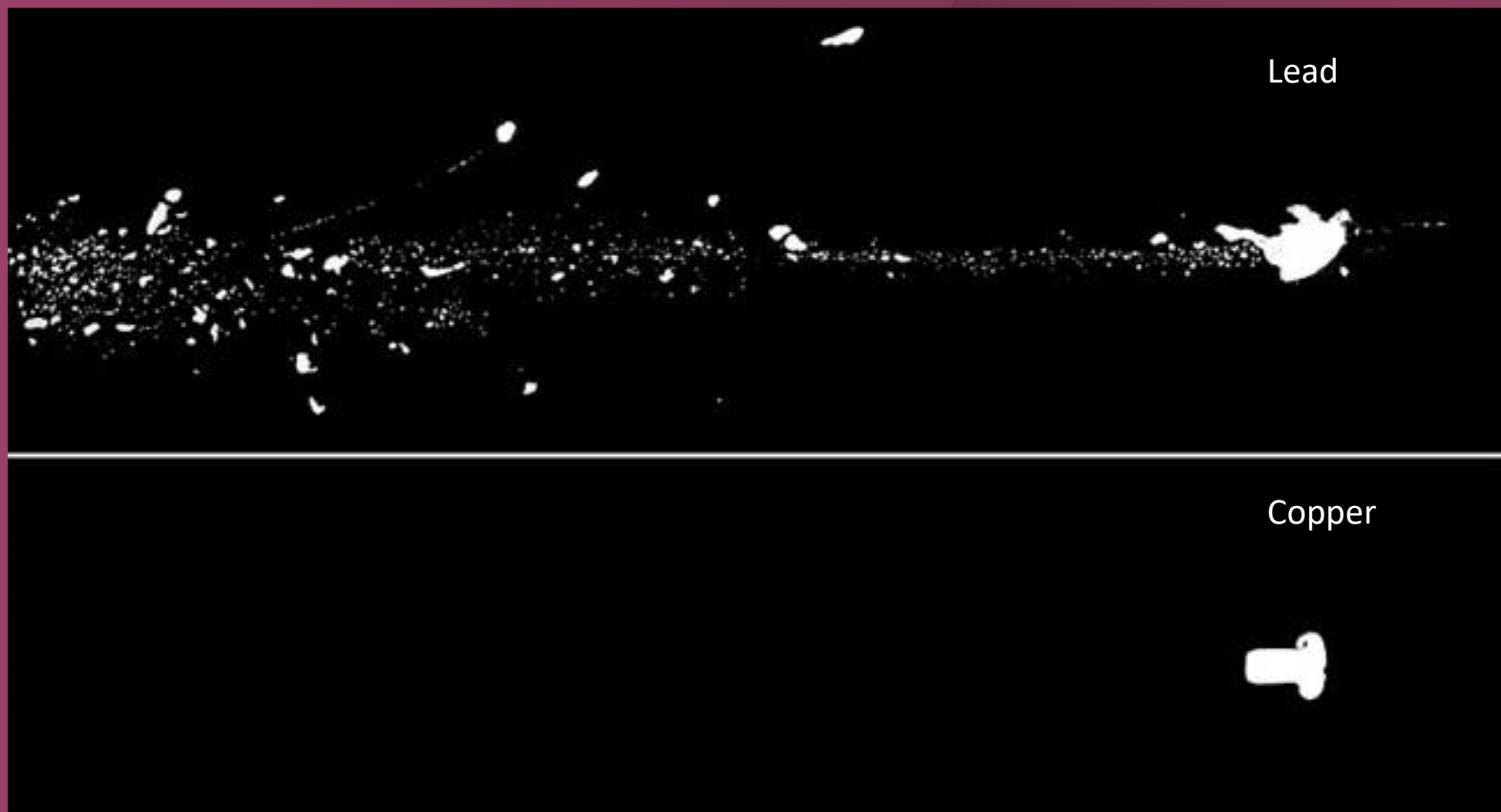


1.95 cm

Acknowledgement: United States Government Printing Office. Emergency war surgery. 3rd edition. Washington, DC: United States Government Printing Office; 2004



# X-Ray



X-ray images of lead (top) and non-lead (bottom) bullets shot into a ballistics gel – Photo Credit: Jeremy Roberts/Conservation Media.



**Copper**

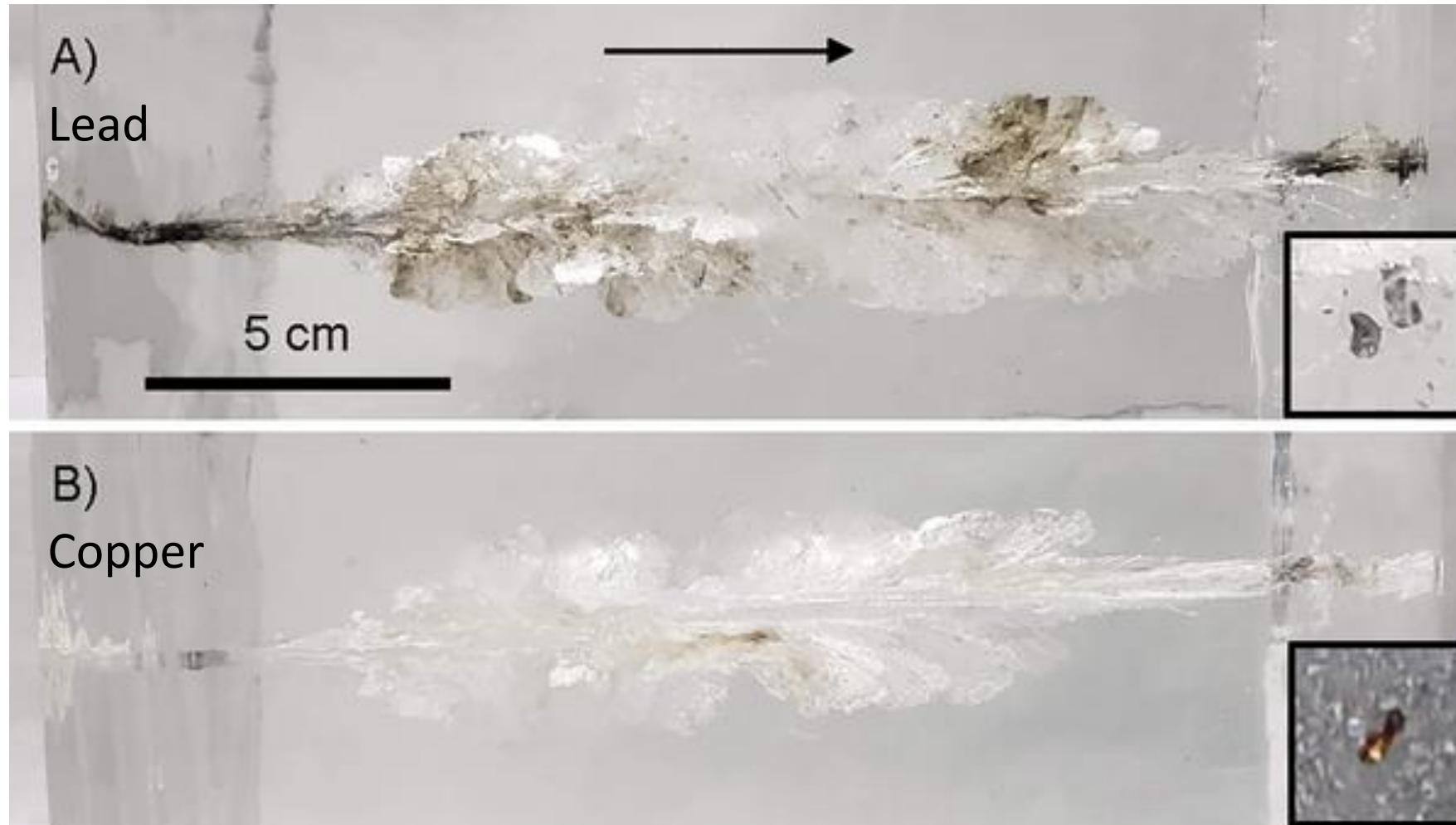


**Lead**



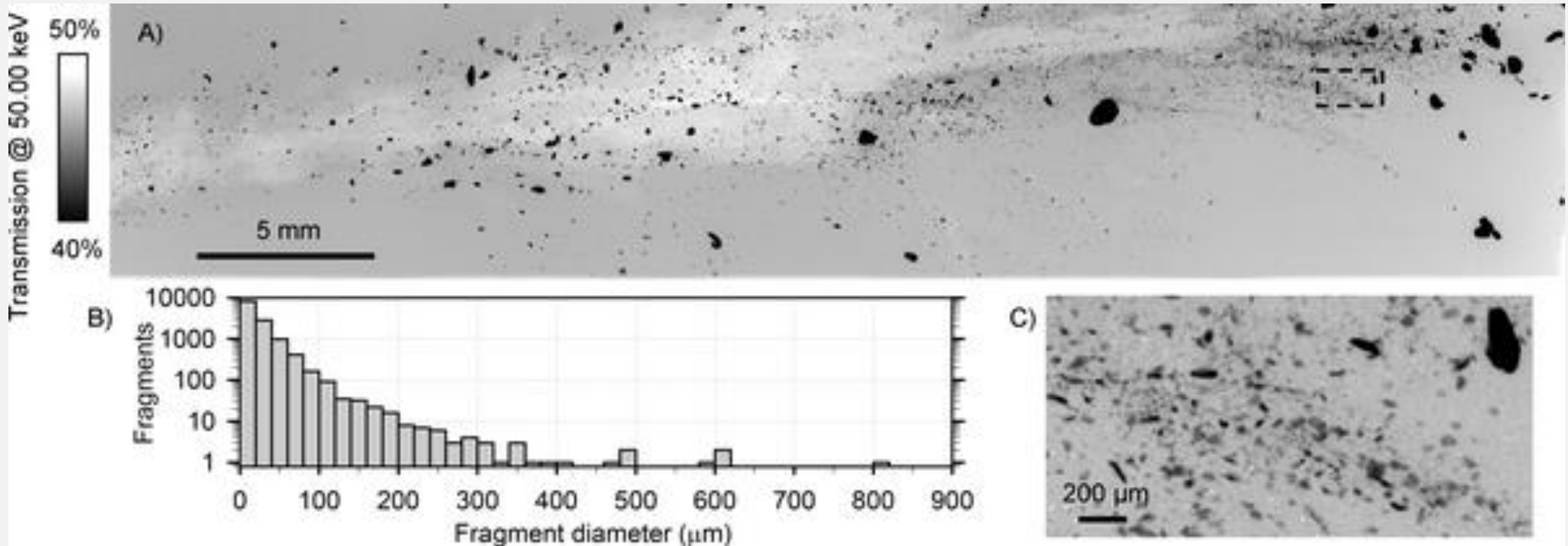
# Synchrotron radiation

Fig 1. Photographs of ballistic gelatin block samples.



Leontowich AFG, Panahifar A, Ostrowski R (2022) Fragmentation of hunting bullets observed with synchrotron radiation: Lighting up the source of a lesser-known lead exposure pathway. PLOS ONE 17(8): e0271987. <https://doi.org/10.1371/journal.pone.0271987>  
<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0271987>

Fig 5.



12667 out of 12784 fragments (c. 99%) NOT visible in X-rays

Leontowich AFG, Panahifar A, Ostrowski R (2022) Fragmentation of hunting bullets observed with synchrotron radiation: Lighting up the source of a lesser-known lead exposure pathway. PLOS ONE 17(8): e0271987. <https://doi.org/10.1371/journal.pone.0271987>  
<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0271987>

# BULLET FRAGMENTATION



## Skull

Register: #02 / #02  
Springbok Male 27kg (avg)  
164m  
R Head (through)  
.303Br  
150gr Hornady Interlock  
Speed @ crown 2,587 fps  
Speed @ impact 2,247 fps  
Energy transfer 1,567 ft/lbs

## *Lead-core Bullet*

200x PPTX Zoom  
TOTAL  
Fragments:

**321**

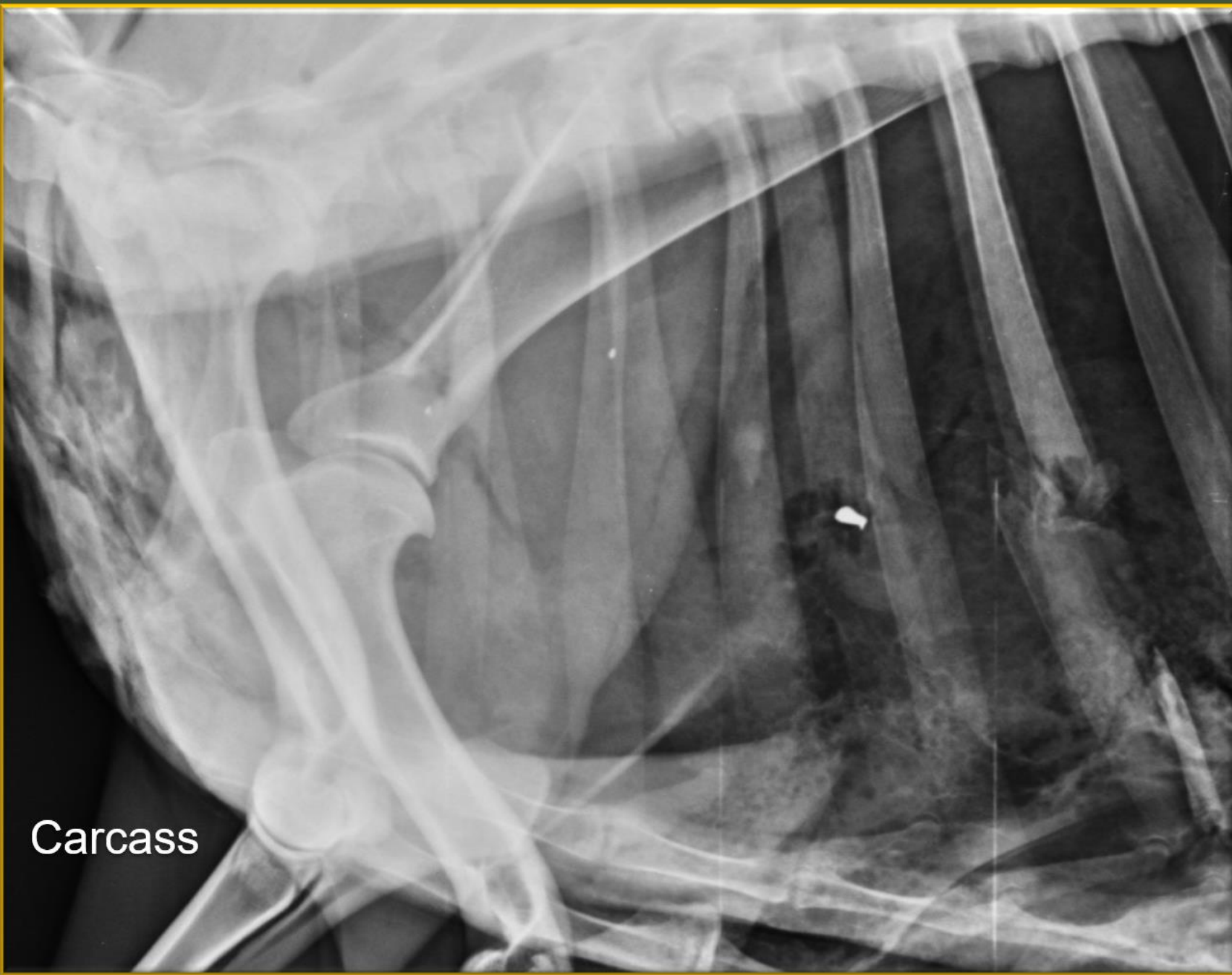


Register: #07 / #01  
Springbok Female 22kg (avg)  
150m  
Left flank (through)  
.243 Win  
95gr Berger Classic Hunter  
Speed @ crown 3,084 fps  
Speed @ impact 2,799 fps  
Energy transfer 1,652 ft/lbs

### *Lead-core Bullet*

200x PPTX Zoom  
TOTAL  
Fragments:

**449**



Carcass

Register: #06 / #02

Springbok Female 22kg (avg)

160m

Left flank exit stomach (through)

.25-06 Rem

**90gr Hornady GMX**

Speed @ crown 2,961 fps

Speed @ impact 2,527 fps

Energy transfer 1,276 ft/lbs

***Copper-based Bullet***

200x PPTX Zoom

TOTAL

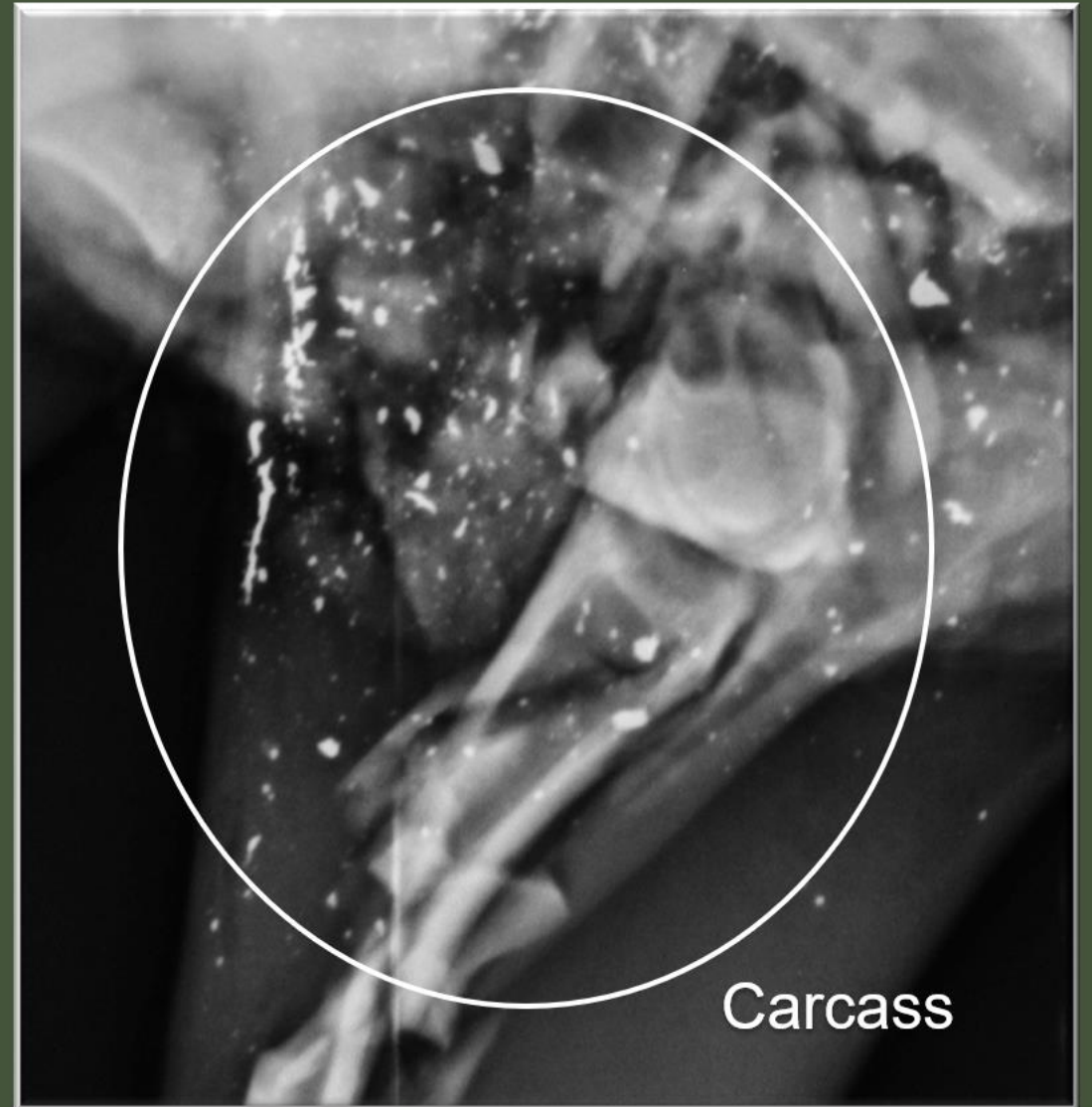
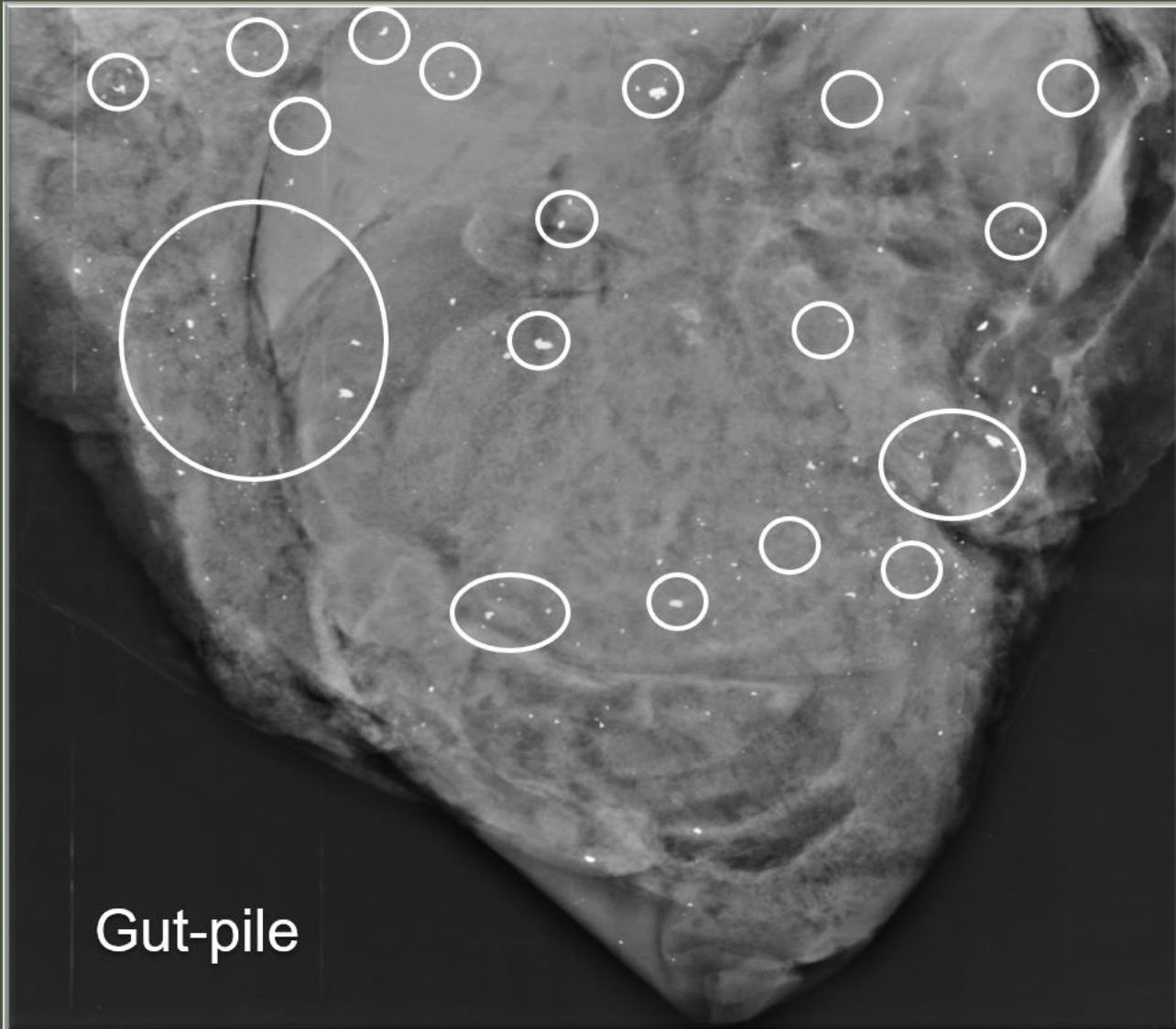
Fragments:

**5**

Acknowledgement: CHASA and NATSHOOT

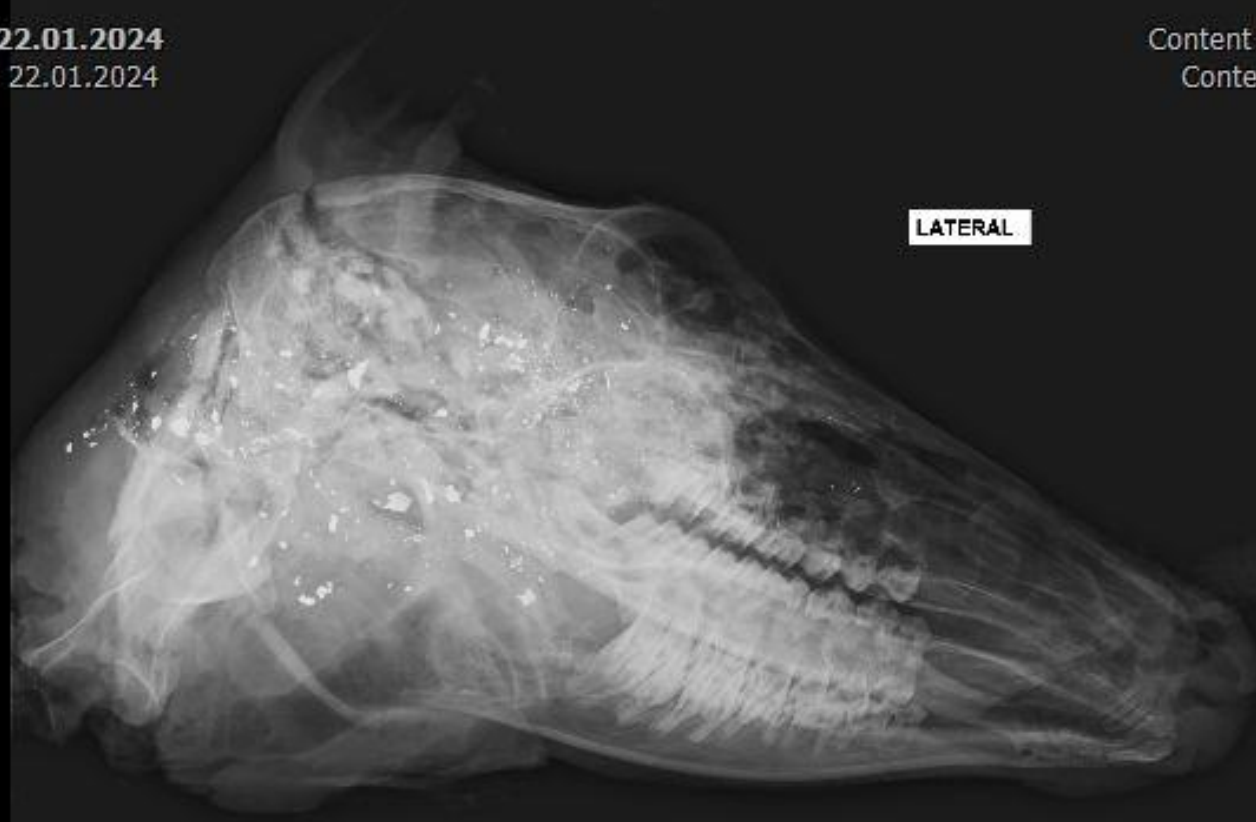


# This is the Danger



PB1, head  
0  
ID: 22.01.2024  
Acc: 22.01.2024

VRYHEID  
Ref: / Perf:  
Content date: 2024/01/22  
Content time: 11:12:01



LATERAL



W1024 / C512  
Sensitivity: 9  
Plate: a56543957c  
S-Value: 9

HEAD

1002 IMA 1002  
Zoom factor: 0.28

PB3, head  
0  
ID: 22.01.2024  
Acc: 22.01.2024

VRYHEID  
Ref: / Perf:  
Content date: 2024/01/22  
Content time: 11:21:47

LATERAL



W1024 / C512  
Sensitivity: 7  
Plate: a56543995c  
S-Value: 7

HEAD

1002 IMA 1002  
Zoom factor: 0.28

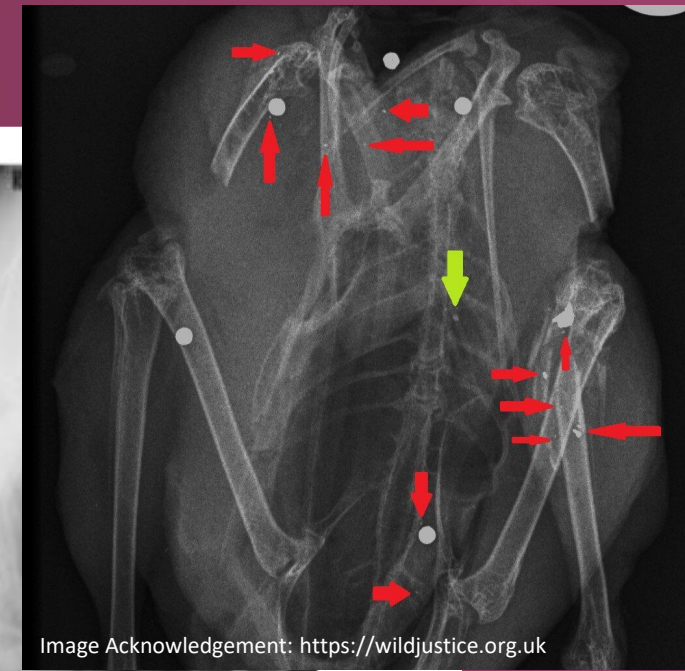


Image Acknowledgement: <https://wildjustice.org.uk>

**Figure 3.** Impala head (left) and impala neck (right) showing the spread of shotgun lead bullets fired from a helicopter during a commercial harvest. **R** = Picture taken from the right side when facing the animal.

Nkosi, D. V., Bekker, J. L., Gower, L. A., Van der Watt, M., & Hoffman, L. C. (2022). Physical Hazards in *Aepyceros melampus* Carcasses Killed for Meat Purposes by Aerial and Thoracic Shots. *Applied Sciences*, 12(14), 6861.

## Lead shot in soil contributing to lead on food crops??

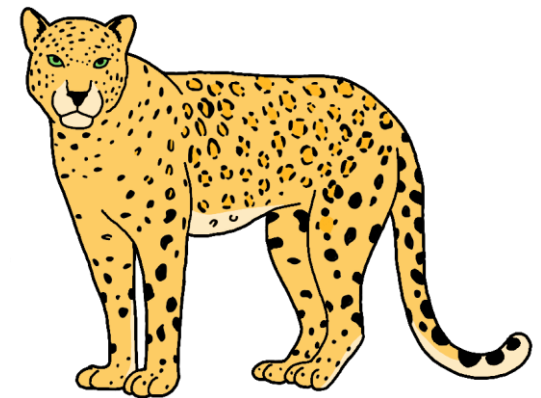
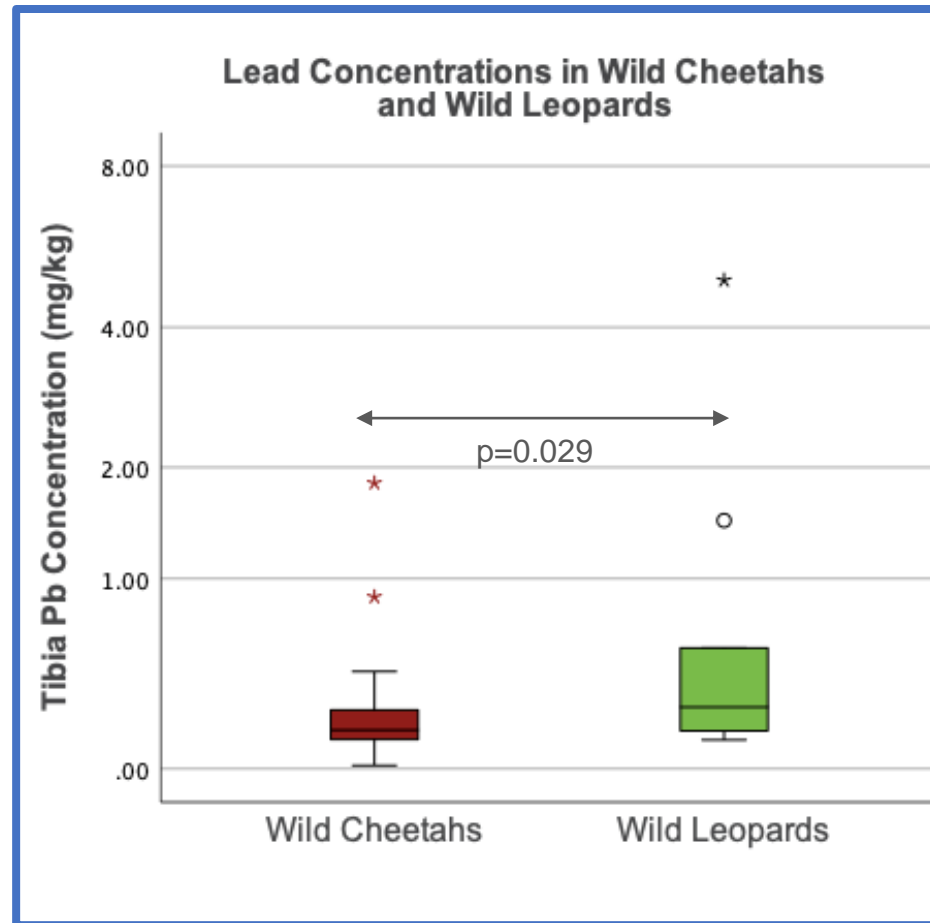
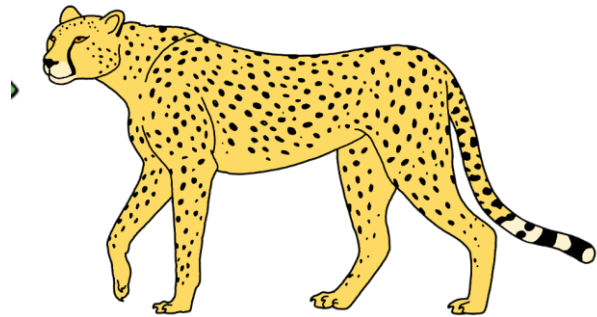
Lewis and Legler (1968) - prehunt levels of 27,225 lead shot pellets/ha and posthunt levels of 108,900 pellets/ha (Tennessee); Best et al. (1992b) - prehunt lead shot 167,593 pellets/ha and posthunt 231,731 to 860,185 pellets/ha (New Mexico).

# LEAD (Pb) IN WILDLIFE



# 1) Bone lead concentration (BLC) of wild leopards is higher than in wild cheetahs

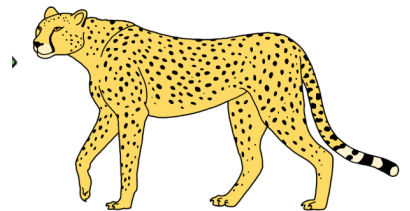
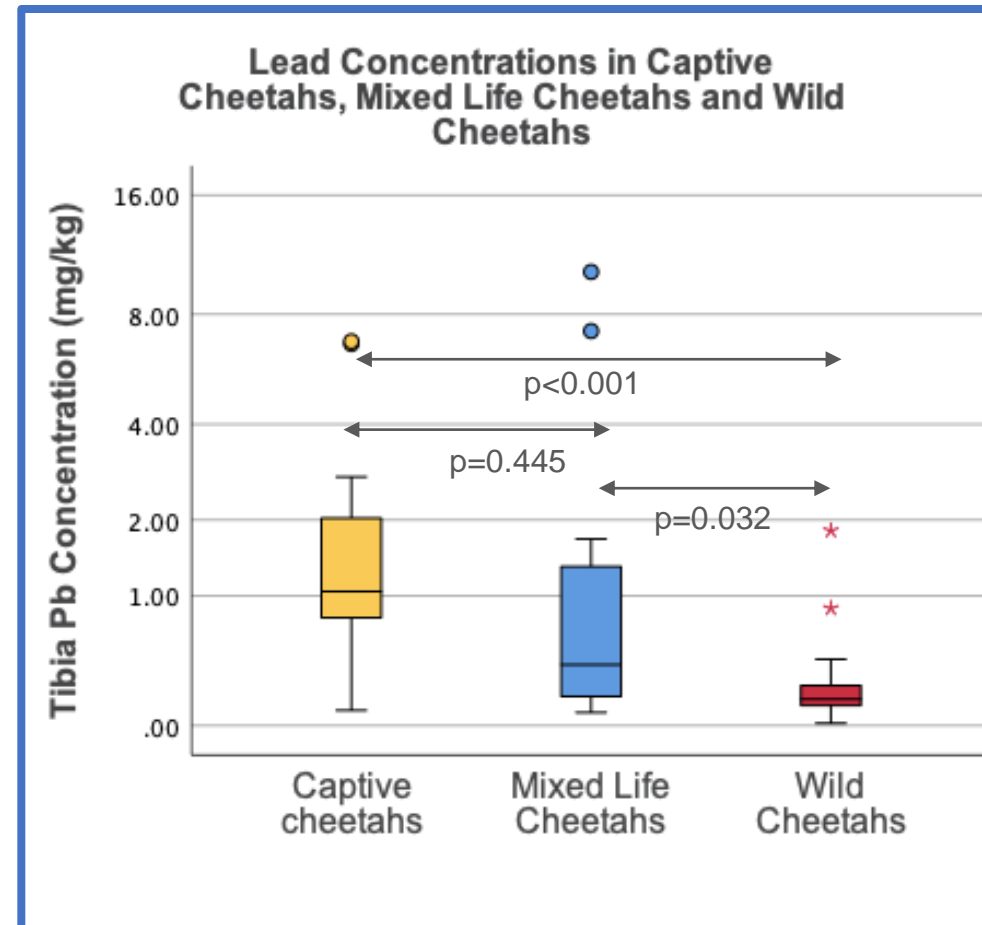
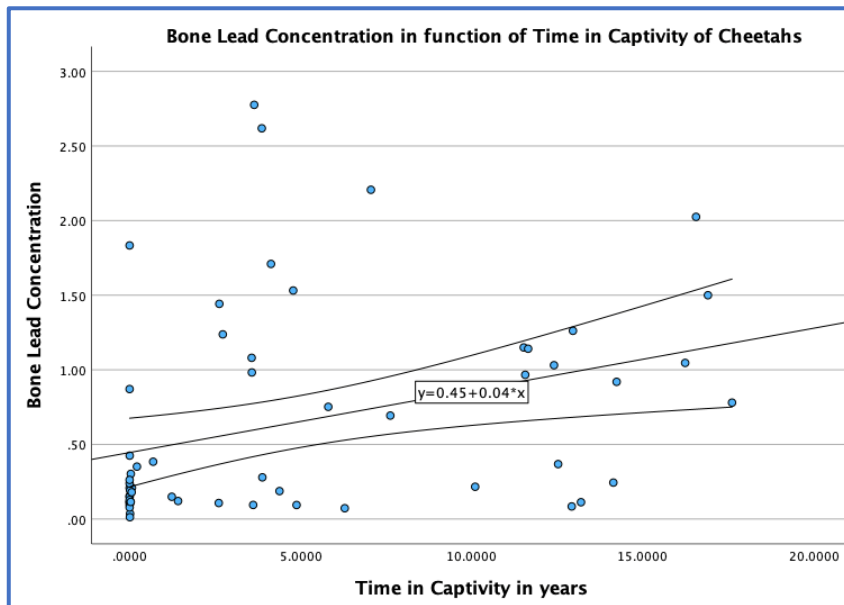
**Wild Cheetahs:** 0.27mg/kg  
**Wild Leopards:** 0.83mg/kg

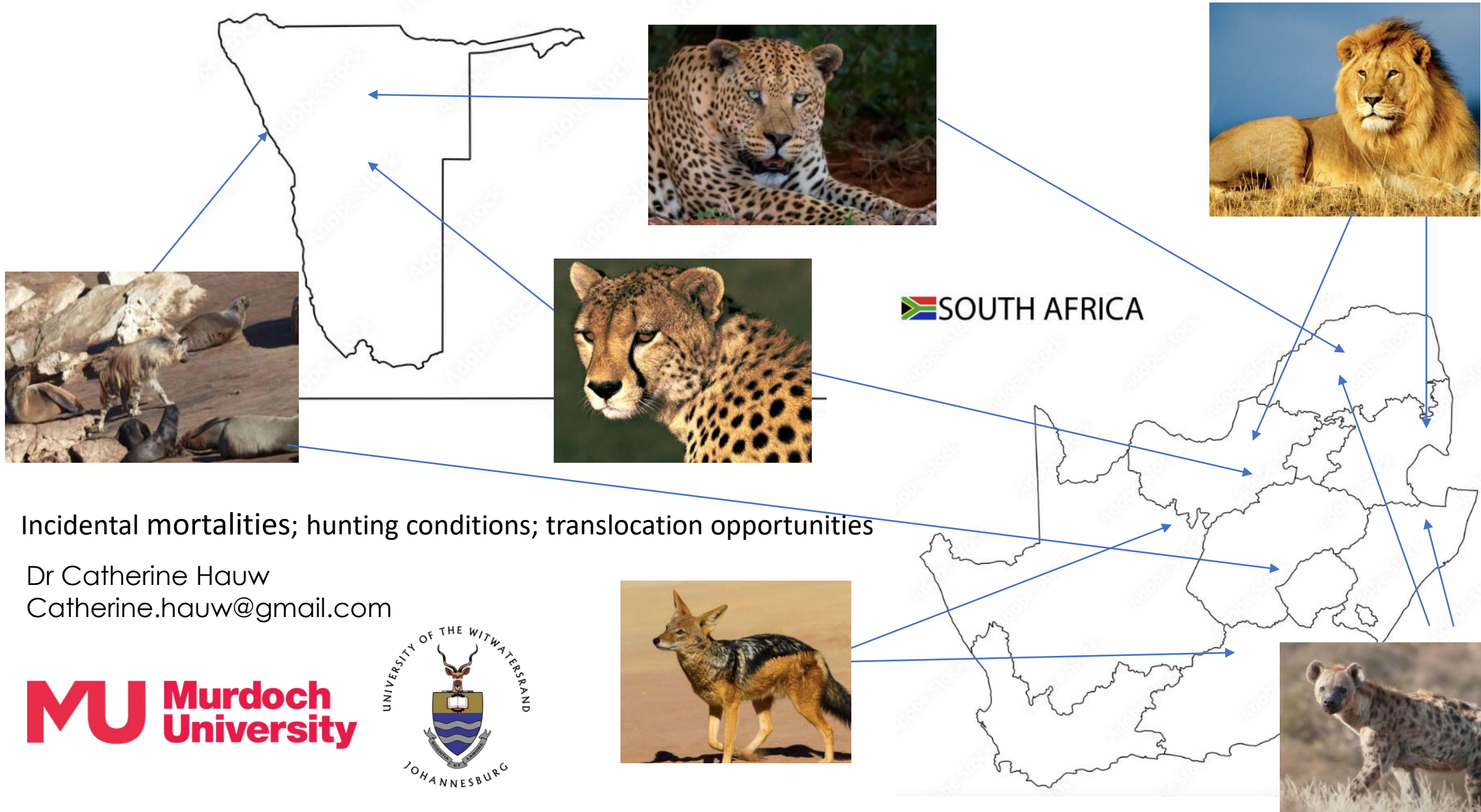


## 2) BLC of captive cheetahs is higher than in wild or mixed-life cheetahs

**Captive Cheetahs:** 1.66mg/kg  
**Mixed Life Cheetahs:** 1.47mg/kg  
**Wild Cheetahs:** 0.27mg/kg

**Time in captivity had a significant effect on BLC:  $p < 0.001$**

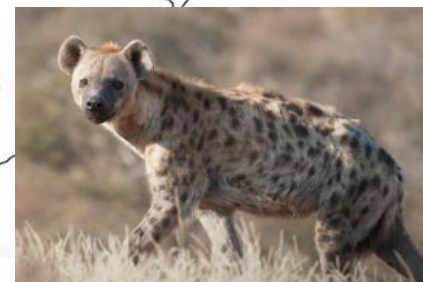




 SOUTH AFRICA

Incidental mortalities; hunting conditions; translocation opportunities

Dr Catherine Hauw  
 Catherine.hauw@gmail.com





**Table 5**

Comparative statistics between this study and previous studies conducted on vulture species both in southern Africa and abroad.

Species	Country	>10 µg/dL	Mean blood [Pb] (µg/dL)
<u>Vulture, White-backed</u>			
This study	South Africa	66%	15.4 ± 21.0
Naidoo et al. (2017)	South Africa	55%	16–28
Garbett et al. (2018)	Botswana	32%	10.7 ± 11.0
<u>Vulture, Cape</u>			
This study	South Africa	80%	29.7 ± 37.6
Naidoo et al. (2017)	South Africa	40%	11–14
<u>Vulture, Bearded</u>			
Krüger and Amar (2018)	South Africa/Lesotho		0.6 ± 0.8
<u>Vulture, Griffon</u>			
Garcia-Fernandez et al. (2005)	Spain		43.07
Carneiro et al. (2015)	Portugal		29.7 ± 13.2
<u>Condor, Andean</u>			
Wiemeyer et al. (2017)	Argentina	36%	15.5 ± 21.2



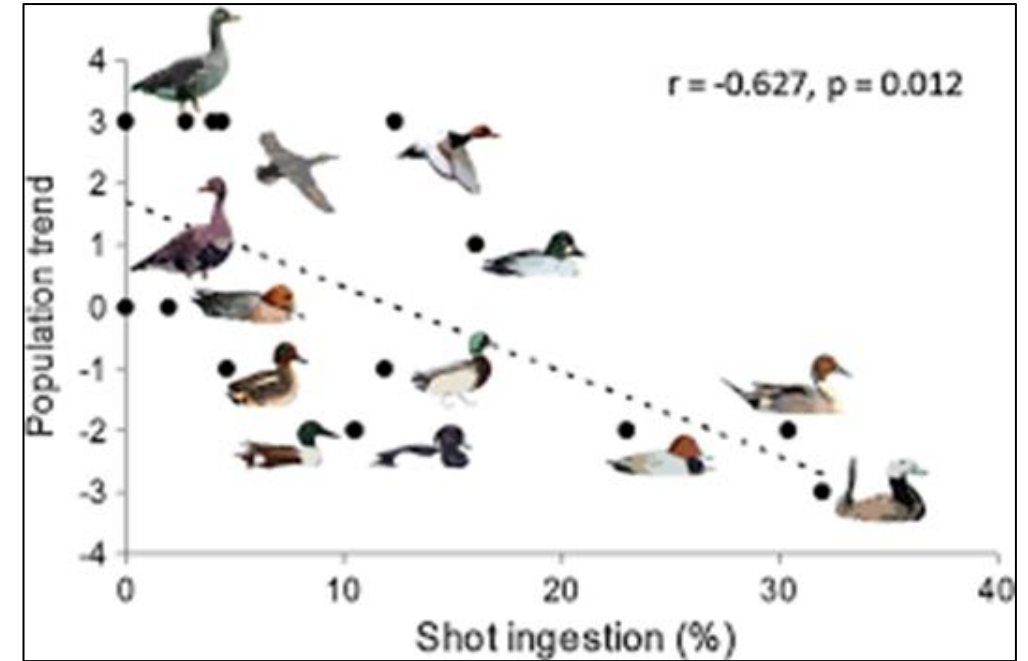
## Mallard Ducks

One #8 lead shot (73 mg Pb) caused 35% mortality

More than one #8 shot caused 80-100% mortality (Finley & Dieter, 1978)

Eight #6 shot caused 96% mortality (Irby, Locke & Bagley, 1967)

60-80% of adult Mallard with one ingested lead pellet succumbed (Olney, 1960)



Alaska: 10 birds die for every 1 taken back by the hunter  
Europe: 4 million birds die from lead poisoning every year



## Free State Pigeon Shooting

10 x shooters for 10 days,  
averaging 100 shots per day

	Total discharged	Left in environment
Weight (kg)	300	240
Number of pellets	3 500 000	2 800 000 (plus embedded shot in wounded birds)

### RISKS

Soil contamination, absorbed by crops?,  
**ingested by ground-feeding birds**

**Ingested by predatory birds (live) and scavengers (dead)**





© Stephen Hammer



# Crocodiles

- Average blood Pb concentration in KwaZulu-Natal (St. Lucia/Kosi Bay/Ndumu) (2010, n = 34)
  - Females – 8.15 µg/dL
  - Males – 98.10 µg/dL
  - St Lucia
    - 11 out of 18 had blood Pb concentration >20 µg/dL
    - >1000 µg/dL – highest level for any vertebrate ever recorded
  - Concern for reproduction, teeth
- Source of lead?
  - Lead sinkers from recreational fishing
    - Unlikely to be from soil, shooting, mining or industrial pollution
  - All crocodiles examined (n = 8) had lead sinkers in their stomachs

Source:

Blood lead concentrations in free-ranging Nile crocodiles (*Crocodylus niloticus*) from South Africa

Jonathan Warner, Xander Combrink, Jan Myburgh and Colleen Downs (2016)



**Blood lead concentrations in free-ranging Nile crocodiles (*Crocodylus niloticus*) from South Africa**

Jonathan K. Warner<sup>1</sup> · Xander Combrink<sup>1</sup> · Jan G. Myburgh<sup>2</sup> · Colleen T. Downs<sup>1</sup>

Accepted: 26 March 2016  
© Springer Science+Business Media New York 2016

**Abstract** Generally crocodylians have received little attention with regard to the effects of lead toxicity despite their trophic status as apex, generalist predators that utilize both aquatic and terrestrial habitats, thereby exposing them to a potentially wide range of environmental contaminants. During July–October 2010 we collected whole blood from 34 sub-adult and adult free-ranging Nile crocodiles (*Crocodylus niloticus*) from three separate populations in northeastern South Africa in order to analyze their blood lead concentrations (BPb). Concentrations ranged from below detectability (<3 µg/dL, n = 8) to 960 µg/dL for an adult male at the Lake St Lucia Estuary. Blood lead concentrations ranged from 15 µg/dL (SD = 7.47) for females

represents the most elevated BPb recorded to date for a free-ranging vertebrate. Although we suggest adult Nile crocodiles are likely tolerant of elevated Pb body burdens, experimental studies on other crocodylian species suggest the BPb levels reported here may have harmful or fatal effects to egg development and hatchling health. In light of recent Nile crocodile nesting declines in South Africa we urge further BPb monitoring and ecotoxicology research on reproductive females and embryos.

**Keywords** Crocodile · *Crocodylus* · Heavy metal · Lead · Ecotoxicology · South Africa



Source and acknowledgement:  
Blood lead concentrations in free-ranging Nile crocodiles (*Crocodylus niloticus*) from South Africa  
Jonathan Warner, Xander Combrink, Jan Myburgh and Colleen Downs (2016)



**Fishing sinkers**



Bullet fragments from crocodile stomach  
Pongolapoort Dam, 2021  
Ferdie Myberg



# LEAD IN GAME MEAT AND FISH

WHAT EVIDENCE? WHAT RISKS?



# Lead Bullet Fragments in Venison from Rifle-Killed Deer: Potential for Human Dietary Exposure

W. Grainger Hunt<sup>1\*</sup>, Richard T. Watson<sup>1</sup>, J. Lindsay Oaks<sup>2</sup>, Chris N. Parish<sup>1</sup>, Kurt K. Burnham<sup>1</sup>, Russell L. Tucker<sup>3</sup>, James R. Belthoff<sup>4</sup>, Garret Hart<sup>5</sup>

<sup>1</sup> The Peregrine Fund, Boise, Idaho, United States of America, <sup>2</sup> Washington Animal Disease Diagnostic Laboratory, Pullman, Washington, United States of America, <sup>3</sup> Department of Veterinary Clinical Sciences, Washington State University, Pullman, Washington, United States of America, <sup>4</sup> Department of Biology, Boise State University, Boise, Idaho, United States of America, <sup>5</sup> School of Earth & Environmental Sciences, Washington State University, Pullman, Washington, United States of America



International

“We conclude that people risk exposure to bioavailable lead from bullet fragments when they eat venison from deer killed with standard lead-based rifle bullets and processed under normal procedures. At risk in the U.S. are some ten million hunters, their families, and low-income beneficiaries of venison donations.”

Hunt, W. G., Watson, R. T., Oaks, J. L., Parish, C. N., Burnham, K. K., Tucker, R. L., ... & Hart, G. (2009). Lead bullet fragments in venison from rifle-killed deer: potential for human dietary exposure. *PloS one*, 4(4), e5330.



- Numerous studies from North America, Europe, Australia and elsewhere
  - Many but not all found lead in packaged game meat; traditional hunting communities at risk, e.g. Canada
- Millions of regular consumers of game meat in USA and Europe at risk<sup>1</sup>
  - At least five million people in the EU may be high-level consumers of lead-shot game (i.e. at least once a week), and tens of thousands of children in the EU (estimated at 83,000 or more) may be consuming such meat sufficiently frequently to result in deleterious effects on their cognitive development<sup>2</sup>
- Evidence contributed to current restriction proposals to phase out lead ammunition across Europe



- 1. Thomas, V. G., Pain, D. J., Kanstrup, N. and Cromie, R. (2022). Increasing the Awareness of Health Risks from Lead-Contaminated Game Meat Among International and National Human Health Organizations. *European Journal of Environment and Public Health*, 6(2), em0110. <https://doi.org/10.21601/ejeph/12043>
- 2. Green, R. E. and Pain, D. J. (2019). Risks to human health from ammunition-derived lead in Europe. *Ambio Special Issue*, 48(9), 954-968. <https://doi.org/10.1007/s13280-019-01194-x>

Article

# Toxic Metals in Meat Contributed by Helicopter and Rifle Thoracic Killing of Game Meat Animals

Davies Veli Nkosi <sup>1,\*</sup> , Johan Leon Bekker <sup>1</sup> and Louwrens Christiaan Hoffman <sup>2,3</sup> 

<sup>1</sup> Department of Environmental Health, Tshwane University of Technology, Pretoria 0183, South Africa

<sup>2</sup> Department of Animal Sciences, University of Stellenbosch, Stellenbosch 7602, South Africa

<sup>3</sup> Centre for Nutrition and Food Sciences, Queensland Alliance for Agriculture and Food Innovation (QAAFI), The University of Queensland, St. Lucia 4072, Australia

\* Correspondence: nkosidv@tut.ac.za; Tel.: +27-12-385-5283



South Africa

“The number of samples per metal with levels above the EU products’ limits were Pb = 18/18 [100%] samples from both killing methods,.....”

Some significantly above: 2000-4000 mg/kg vs 0.1 mg/kg

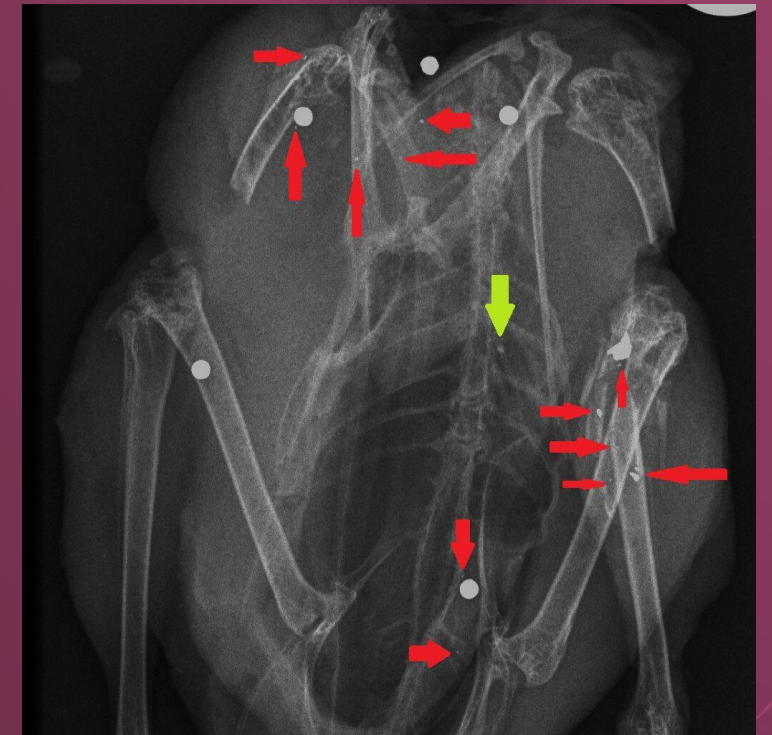
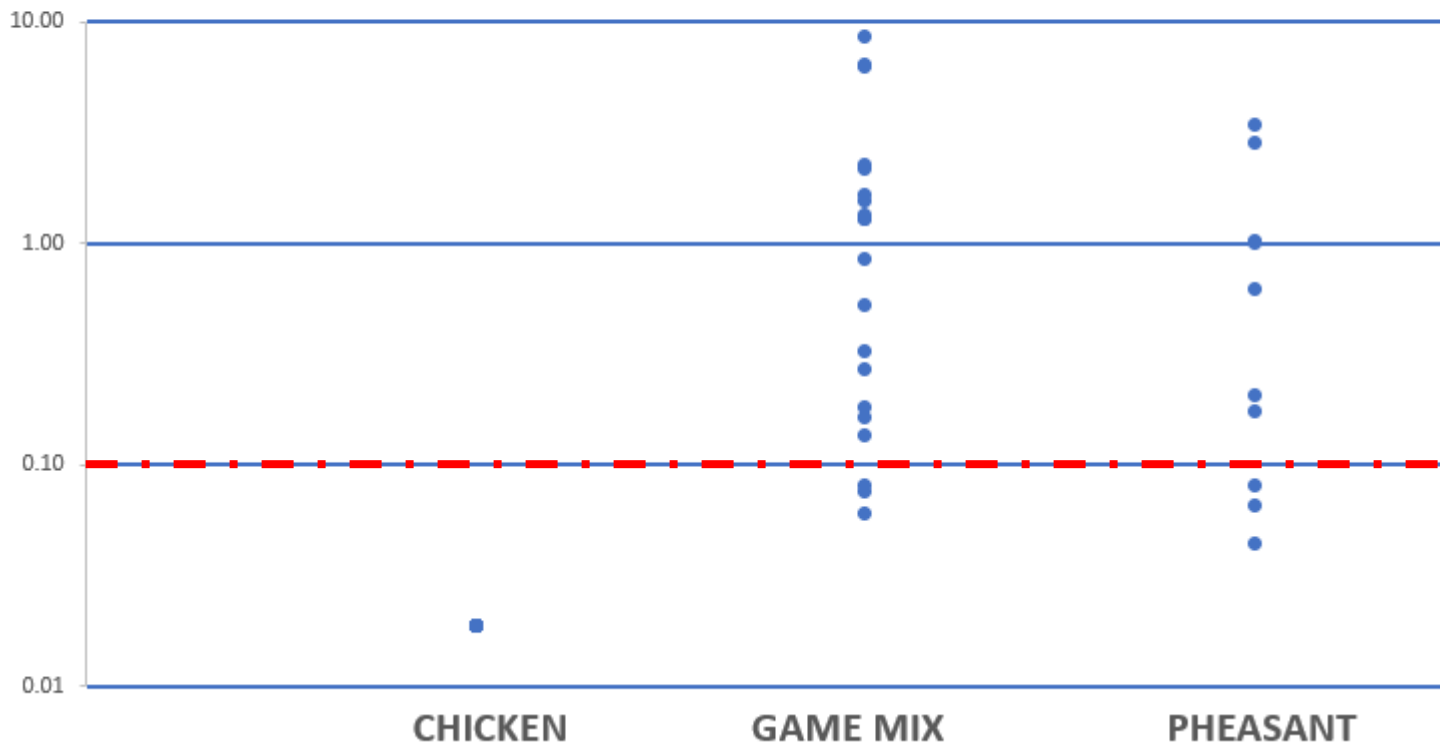
“...while visible affected areas could be removed during dressing and inspection, extensive traces of Pb could be picked up from areas that were generally not affected by bullets thus posing a risk to consumers.”

Nkosi, D. V., Bekker, J. L., & Hoffman, L. C. (2022). Toxic metals in meat contributed by helicopter and rifle thoracic killing of game meat animals. *Applied Sciences*, 12(16), 8095.

## Lead levels in Sainsbury's meat (mg/kg wet weight)

Note: the scale of Y-axis is logarithmic

mg/kg WW



<https://wildjustice.org.uk/general/sainsburys-game-meat-has-high-lead-levels/>



# Ambio



KUNGL.  
VETENSKAPS-  
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A Journal of the Human Environment



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Vernon G. Thomas 1072–1078

**Transitioning to non-toxic ammunition: Making change happen**

Ruth Cromie, Julia Newth and Emily Strong 1079–1096

**Transition to lead-free ammunition benefits all**

Jon M. Arnemo, Ruth Cromie, Anthony D. Fox, Niels Kanstrup, Rafael Mateo, Deborah J. Pain and Vernon G. Thomas 1097–1098

**Instructions for Authors** for Ambio are available at <http://www.springer.com/13280>

**Foreword**

Niels Kanstrup, Vernon G. Thomas and Anthony D. Fox 923–924

**The transition to non-lead sporting ammunition and fishing weights: Review of progress and barriers to implementation**

Vernon G. Thomas, Niels Kanstrup and Anthony D. Fox 925–934

**Effects of lead from ammunition on birds and other wildlife: A review and update**

Deborah J. Pain, Rafael Mateo and Rhys E. Green 935–953

**Risks to human health from ammunition-derived lead in Europe**

Rhys E. Green and Deborah J. Pain 954–968

**Wildlife, human and environmental costs of using lead ammunition: An economic review and analysis**

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**Lessons learned from 33 years of lead shot regulation in Denmark**

Niels Kanstrup 999–1008

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**Lead pollution from hunting ammunition in Argentina and current state of lead shot replacement efforts**

Marcela Uhart, Hebe del Valle Ferreyra, Marcelo Romano, Ayelén Muchiutti, Silvia Alzuagaray, Martín Santiago and Andrea Caselli 1015–1022

**Lead poisoning from ingestion of fishing gear: A review**

Tiffany Grade, Pamela Campbell, Thomas Cooley, Michelle Kneeland, Elaine Leslie, Brooke MacDonald, Julie Melotti, Joseph Okoniewski, Elizabeth Jane Parmley, Cyndi Perry, Harry Vogel and Mark Pokras 1023–1038

**Availability and prices of non-lead gunshot cartridges in the European retail market**

Niels Kanstrup and Vernon G. Thomas 1039–1043

**Unleaded hunting: Are copper bullets and lead-based bullets equally effective for killing big game?**

Sigbjørn Stokke, Jon M. Arnemo and Scott Brainerd 1044–1055

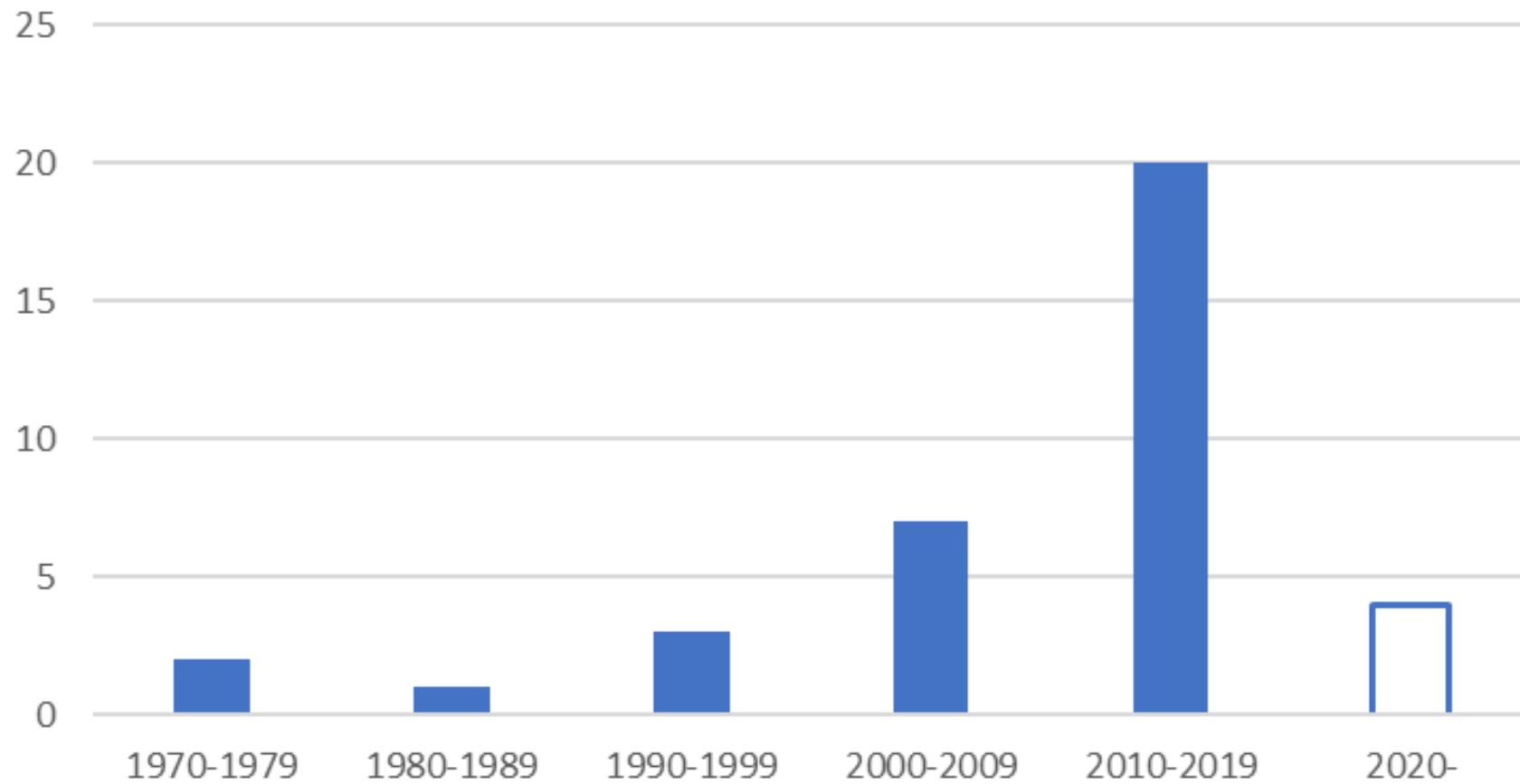
**Fragmentation of lead-free and lead-based hunting rifle bullets under real life hunting conditions in Germany**

Anna Lena Trinogga, Alexandre Courtiol and Oliver Krone 1056–1064

**Comparing erosion and organ accumulation rates of lead and alternative lead-free ammunition fed to captive domestic ducks**

Oliver Krone, Norbert Kenntner, Nicole Ebner, Claudia A. Szentiks and Sven Dänicke 1065–1071

## Lead (Pb) Publications - wildlife, southern Africa



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# Recent research

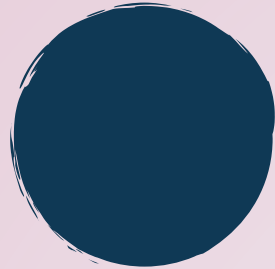
Title	Researcher	Status	Institution
Effects of lead on avian thermoregulation in the heat: An experimental test with pied crows ( <i>Corvus albus</i> )	Prof Andrew McKechnie	Published	University of Pretoria
Lead in mammalian predators and scavengers in South Africa	Dr Catherine Hauw	PhD project registered	WITS
Preliminary results of an experimental study investigating the effects of ingested lead (Pb) in captive Nile crocodile ( <i>Crocodylus niloticus</i> )	Fortunate Davhana & Dr Xander Combrink	Fieldwork complete	Tshwane University of Technology
Validation of LeadCare II System for Cape Vultures ( <i>Gyps coprotheres</i> ) in comparison to ICP-MS	Prof Vinny Naidoo	Published	Faculty of Veterinary Sciences, University of Pretoria; VulPro
Metal transfer from hunted game carcasses to blowflies (Calliphoridae) in KwaZulu-Natal, South Africa	Dr Kurt Jordaens	Thesis complete	AfricaMuseum; Ezemvelo; SAHGCA
Sub-lethal impacts of lead poisoning on blood biochemistry, immune function and delta-aminolevulinic acid dehydratase ( $\delta$ -ALAD) activity in Cape ( <i>Gyps coprotheres</i> ) and white-backed ( <i>G. africanus</i> ) Vulture chicks	Dr Linda van den Heever	Published	WITS; BirdLife SA

# Information needs (What don't we know)



## How much and where?

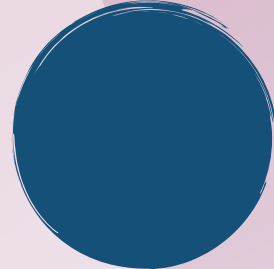
What is the mass of lead discharged into the environment from shooting and fishing; what is the trend?



## Extent of exposure

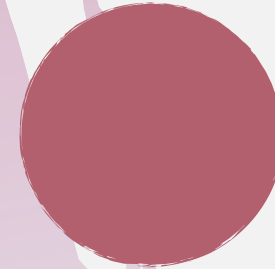
What species and level of exposure; population level impacts?

Sublethal impacts?



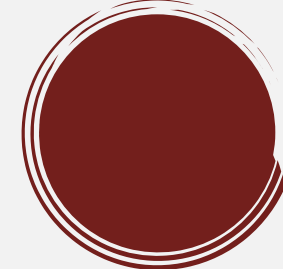
## Alternatives

Availability, price



## Venison

Extent of risk from eating game meat and fish



## Human exposure

Farm workers, skinners, hunters & their families



# LEAD TASK TEAM


## South Africa

24 members  
16 organisations





# THANK YOU

Ian Rushworth 

+27 82 940 1462 

ian.rushworth@kznwildlife.com 