



E²S²
Denver, CO
June 17, 2010

Lead Fragment Ingestion by Birds:

SHOOTING

Down Another Myth

Larry Tannenbaum

Senior Health Risk Assessor

U.S. Army Public Health Command (Prov.)



Report Documentation Page

Form Approved
OMB No. 0704-0188

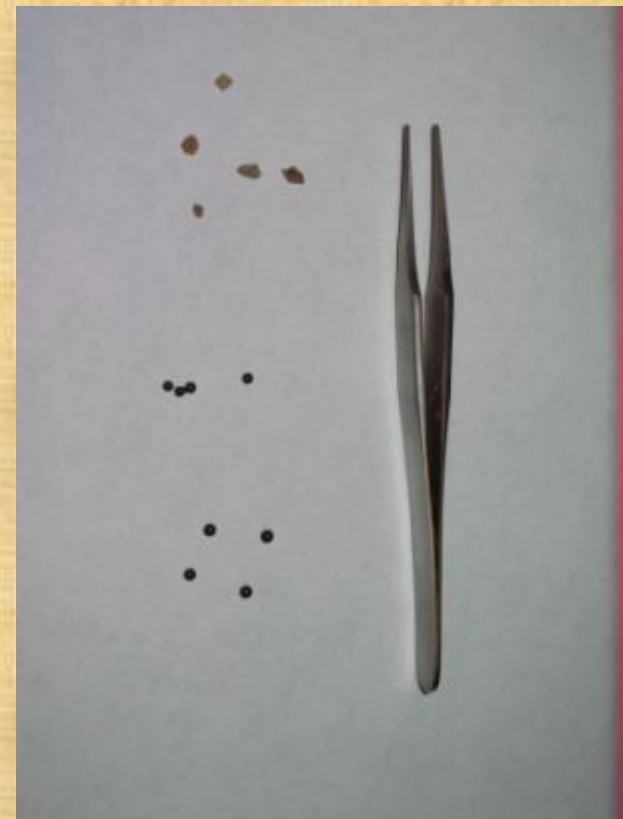
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE 17 JUN 2010		2. REPORT TYPE		3. DATES COVERED 00-00-2010 to 00-00-2010	
4. TITLE AND SUBTITLE Lead Fragment Ingestion by Birds: Shooting Down Another Myth				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Public Health Command (Prov),5158 Blackhawk Road ,Aberdeen Proving Ground,MD,21010-5403				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES Presented at the NDIA Environment, Energy Security & Sustainability (E2S2) Symposium & Exhibition held 14-17 June 2010 in Denver, CO.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 61	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

An ecological risk assessment concern of considerable proportion



maybe



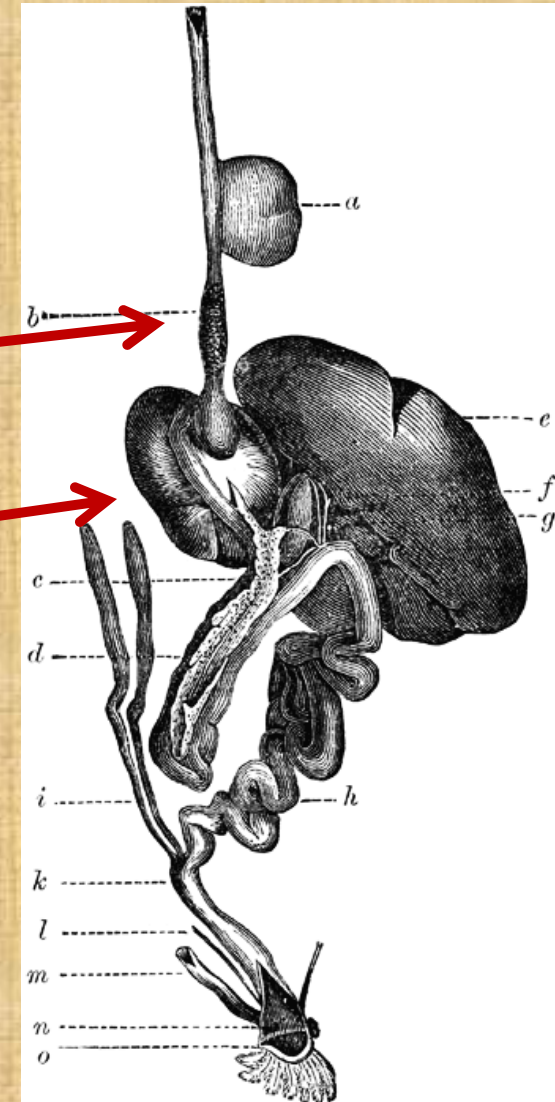
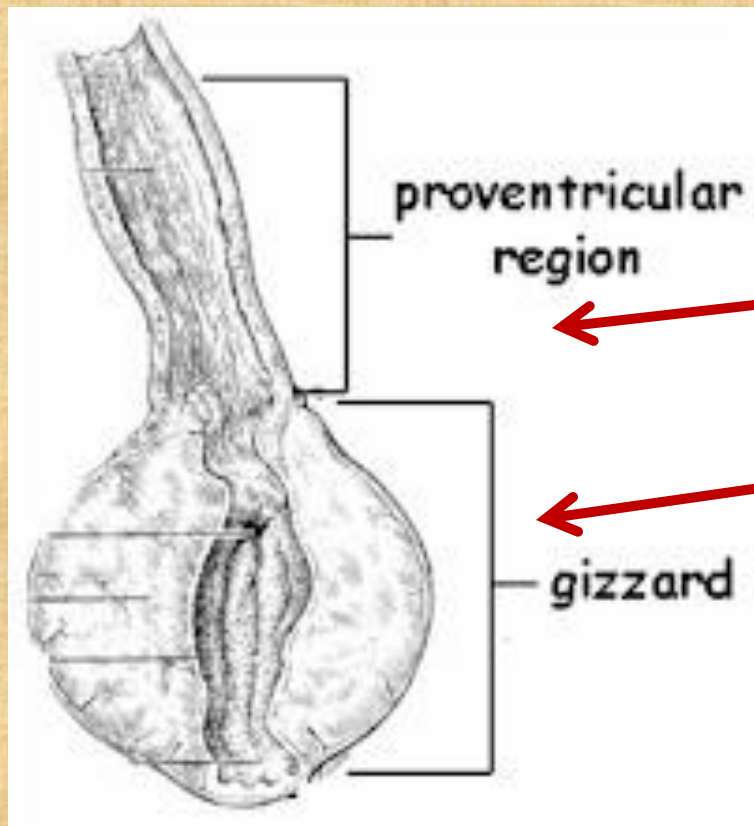


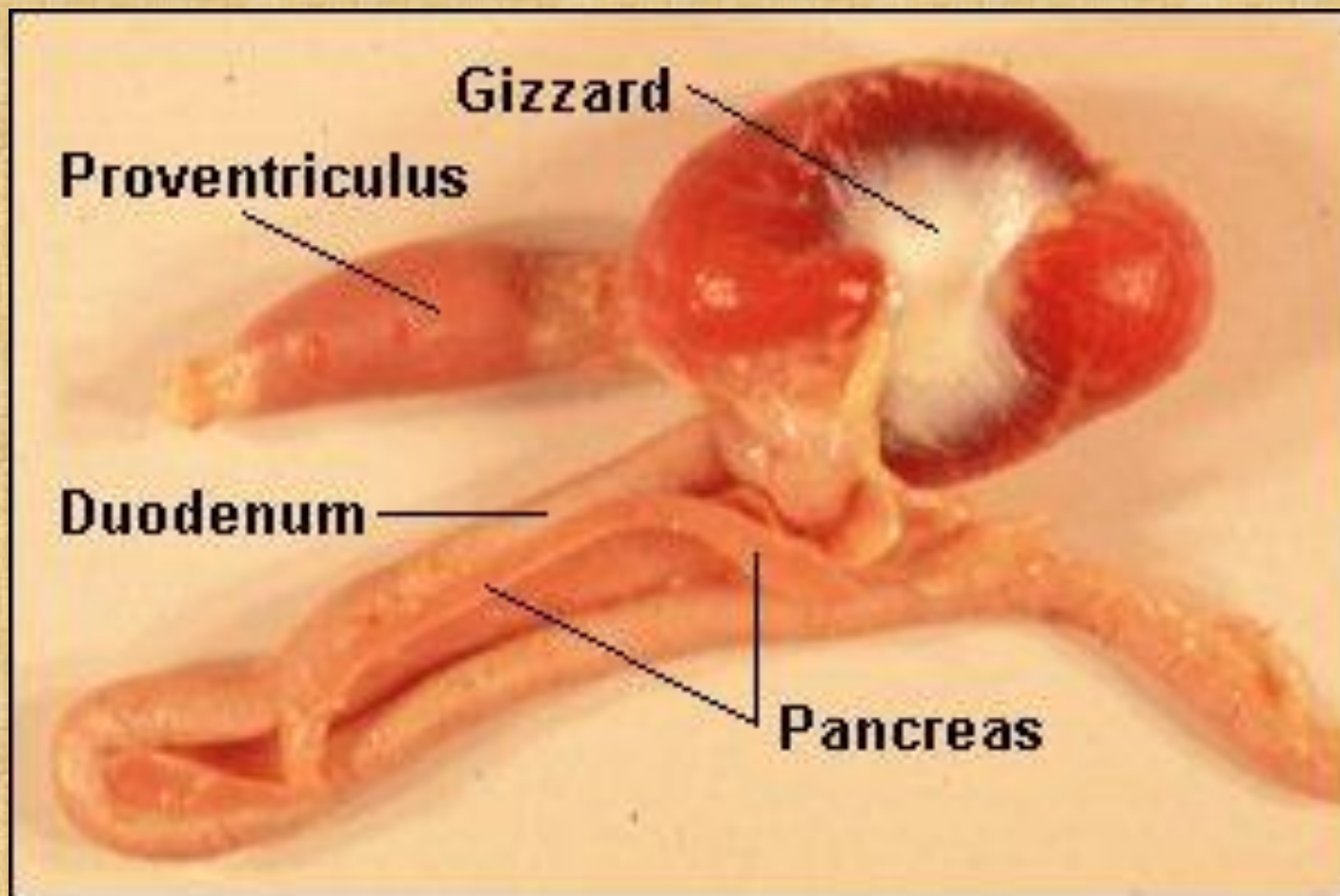
A brief background to the (perceived) “problem” . . .

- Birds display grit-ingesting behavior.



Avian digestion in a snapshot

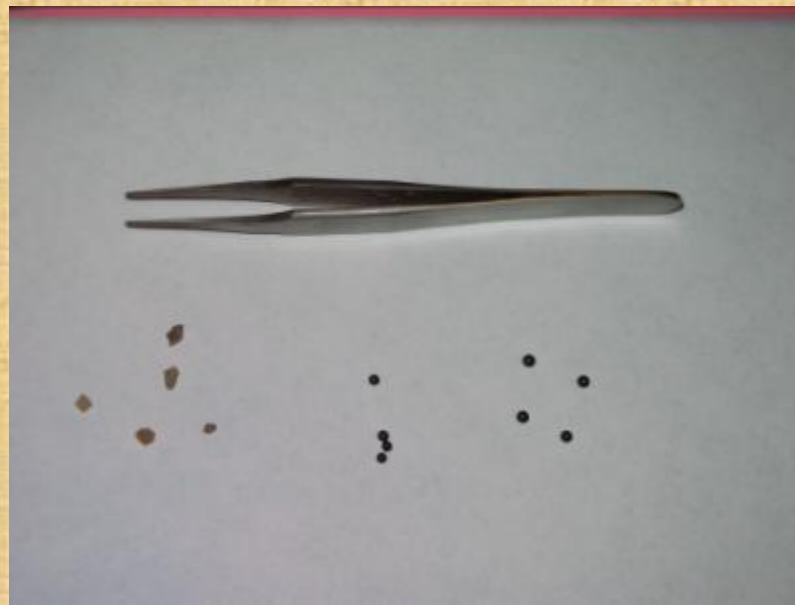






A brief background to the (perceived) “problem” . . .

- Birds display grit-ingesting behavior.
- Lead particles in the environment (e.g., spent shot, bullet fragments) approximate the size of “true grit” (1 - 4 mm in diameter).





left: ‘true grit’; right: ‘bullet fragments’



The concern is *seemingly* legitimate at . . . small arms ranges

Bullet fragments can approximate the size of grit selected by birds!





A brief background to the (perceived) “problem” . . .

- Birds display grit-ingesting behavior.
- Lead particles in the environment (e.g., spent shot , bullet fragments) approximate the size of “true grit” (1 - 4 mm in diameter).
- Birds can ‘mistakenly’ / ‘incidentally’ ingest lead particles *in place of* grit (say, at a trap & skeet range).





Approximate Number of Pellets In A Given Charge

Shot size	Ounces										
	2	1-7/8	1-5/8	1-1/2	1-3/8	1-1/4	1-1/8	1	7/8	3/4	1/2
#2	180	169	158	135	124	113	102	90	79	68	45
#4	270	253	221	202	185	169	152	135	118	101	67
#5	340	319	277	255	234	213	192	170	149	128	85
#6	450	422	396	337	309	281	253	225	197	169	112
#7-1/2	700	656	568	525	481	437	393	350	306	262	175
#8	820	769	667	615	564	513	462	410	359	308	205
#9	1170	1097	951	877	804	731	658	585	512	439	292





Approximate Number of Pellets In A Given Charge

Shot size	Ounces										
	2	1-7/8	1-5/8	1-1/2	1-3/8	1-1/4	1-1/8	1	7/8	3/4	1/2
#2	180	169	158	135	124	113	102	90	79	68	45
#4	270	253	221	202	185	169	152	135	118	101	67
#5	340	319	277	255	234	213	192	170	149	128	85
#6	450	422	396	337	309	281	253	225	197	169	112
#7-1/2	700	656	568	525	481	437	393	350	306	262	175
#8	820	769	667	615	564	513	462	410	359	308	205
#9	1170	1097	951	877	804	731	658	585	512	439	292





Let's do the math . . . for a very cautious yearly loading estimate:

$$400 \times 25 \times 2 \times 5 \times 2 \times 36 = \dots$$

shot/charge

charges/trap & skeet round

(trap - 8 stations;
skeet - 5 stations)

of rounds/shooter/day
(recreational)

of shooters/day

days/week that range is open

weeks/year that range is open

7,200,000 shot pellets/year!! Ouch.





A brief background to the (perceived) “problem” . . .

- Birds display grit-ingesting behavior.
- Lead particles in the environment (e.g., spent shot , bullet fragments) approximate the size of “true grit” (1 - 4 mm in diameter).
- Birds can ‘mistakenly’ / ‘incidentally’ ingest lead particles *in place of* grit.
- **If ingested (*and retained*), dissolving lead can cause a host of toxic effects, including lethality.**





And one more point. . .

There are some

9,000

trap & skeet ranges in the United States!





Q. Just how far have we taken the ‘concern’?

A. Enter the age of ‘grit ingestion models’ . . .
as in: the 2000 Peddicord and LaKind Model

Peddicord, R.K. and LaKind, J.S. 2000.

Ecological and Human Health Risks at an
Outdoor Firing Range.

Environ Tox and Chem, 19:2602-2613.





Are we being careful with the application of these models?

- The Peddicord and LaKind Model estimates the probability of a bird ingesting a single (spent) shot pellet in the bird's lifetime.

Q. Why would anyone want to calculate such a probability?

A. It must be that people think that a single shot pellet ingestion event is lethal!



Consider . . .



- No one has ever asked about modeling multiple pellet exposures with the P & L model, or attempted such a thing.
- Those who apply the P & L model do not understand it; **for instance** - model output DOES NOT indicate the probability of a bird dying.
 - To estimate bird deaths, you'd need to know the size of the exposed population at a site. (No one seems to gather this information at trap & skeet ranges and the like.)
 - To make the point that shot pellet ingestion at trap & skeet ranges is decimating bird populations, we need to know the % of a population that must die off from range exposures to cause such a thing. Anyone know the answer to that one?



Consider . . .

- And you'll love this next one . . .

A mistake in the P & L model was only recently discovered -- 10 years after publication! **Ouch!**





Let's complete this thought together . . .

If the P & L model was developed only to estimate the probability of a bird ingesting a single shot pellet, and the powers-that-be believe/assume that a single pellet ingested is lethal . . . then the essential study to run is one that . . .

exposes birds to
a single shot pellet.





Let's briefly review the literature . . .

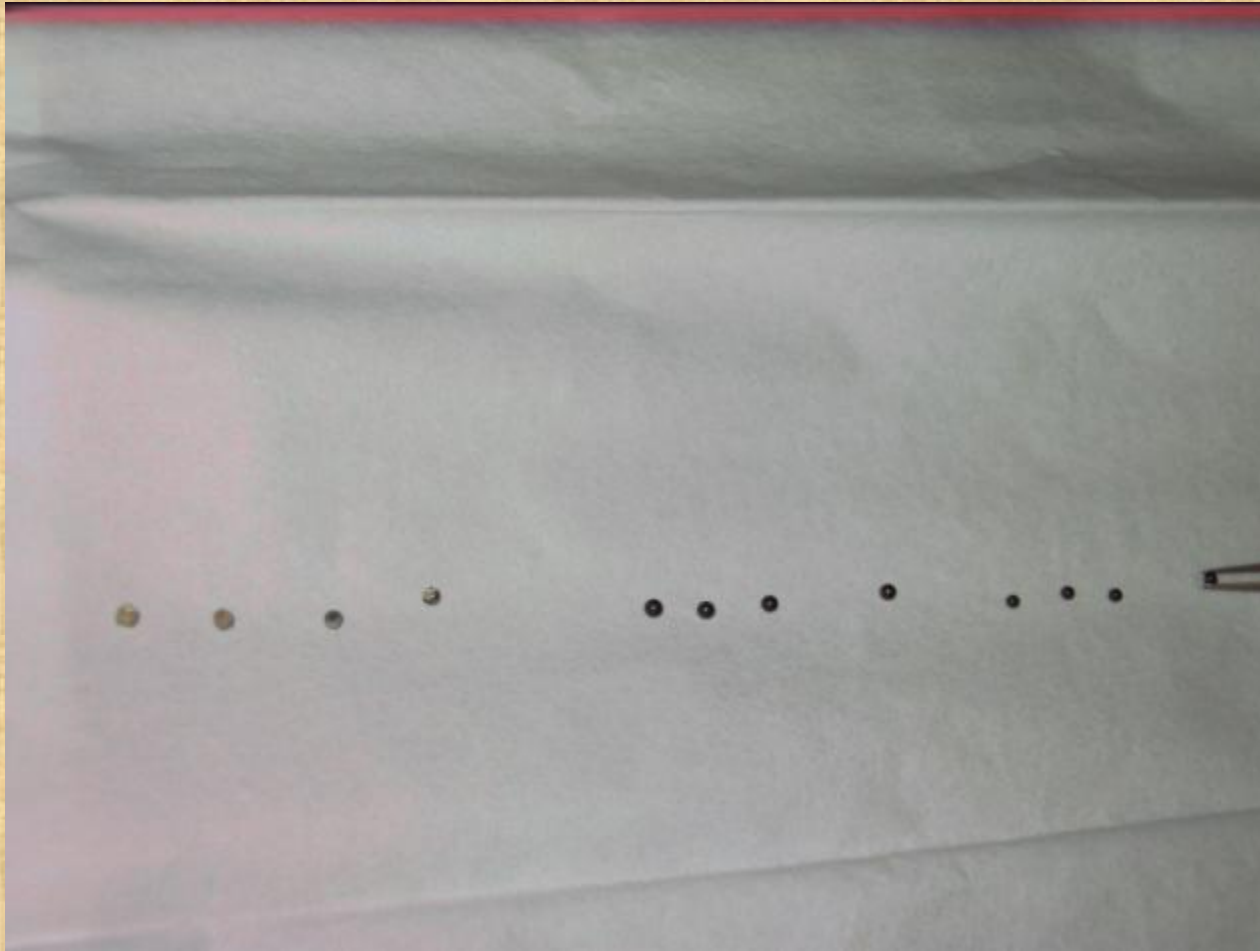
- There are very few pellet-dosing studies in the literature, with upland birds, where **1 shot** was administered.
- No one on the planet has ever tested with **spent shot** (aka “**environmental shot**”) in a systematic way.
- Prior to our USPHC study, no one ever systematically tracked the positioning of gavaged shot over the time course of a dosing study. We though, used radiography!!



Investigators	Dosing approach/mechanism	Species	Notes
Rocke et al., 1997	random ingestion in 1.6 ha enclosures with counts as high as 2,000,000/ha	sentinel mallards	
Pattee et al., 2006	dosed with 0, 2 , or 6 pellets; re-dosed if regurgitated	Andean condors	
Buerger et al., 1986	dosed with 0, 2, 4 #8 pellets; delivered orally by dropping to back of mouth	captive mourning doves	
Carrington, et al., 1989	dosed with 0 and 1 pellet; force-fed; released to wild and tracked for 21 days	free-ranging mourning doves	similar mortality rates in controls and treated birds
Castrale and Oster, 1993	dosed with 0, 1, 2, 4 #8 Pb pellets	mourning doves	Mortality: 1 shotters - 1/10 2 shotters - 0/10 4 shotters - 4/10
Marn et al., 1988,	0 or 1 shot pellet	captive mourning doves	no mortality
McConnell et al., 1967	0 to 100 shot (new and some left on ground for 2-weeks); force fed	bobwhite quail and mourning doves	decreased egg production ; decreased hatchability
Kendall and Scanlon, 1982	0 or 1 shot pellet; looked only at decreased ALAD	mourning doves	decreased ALAD

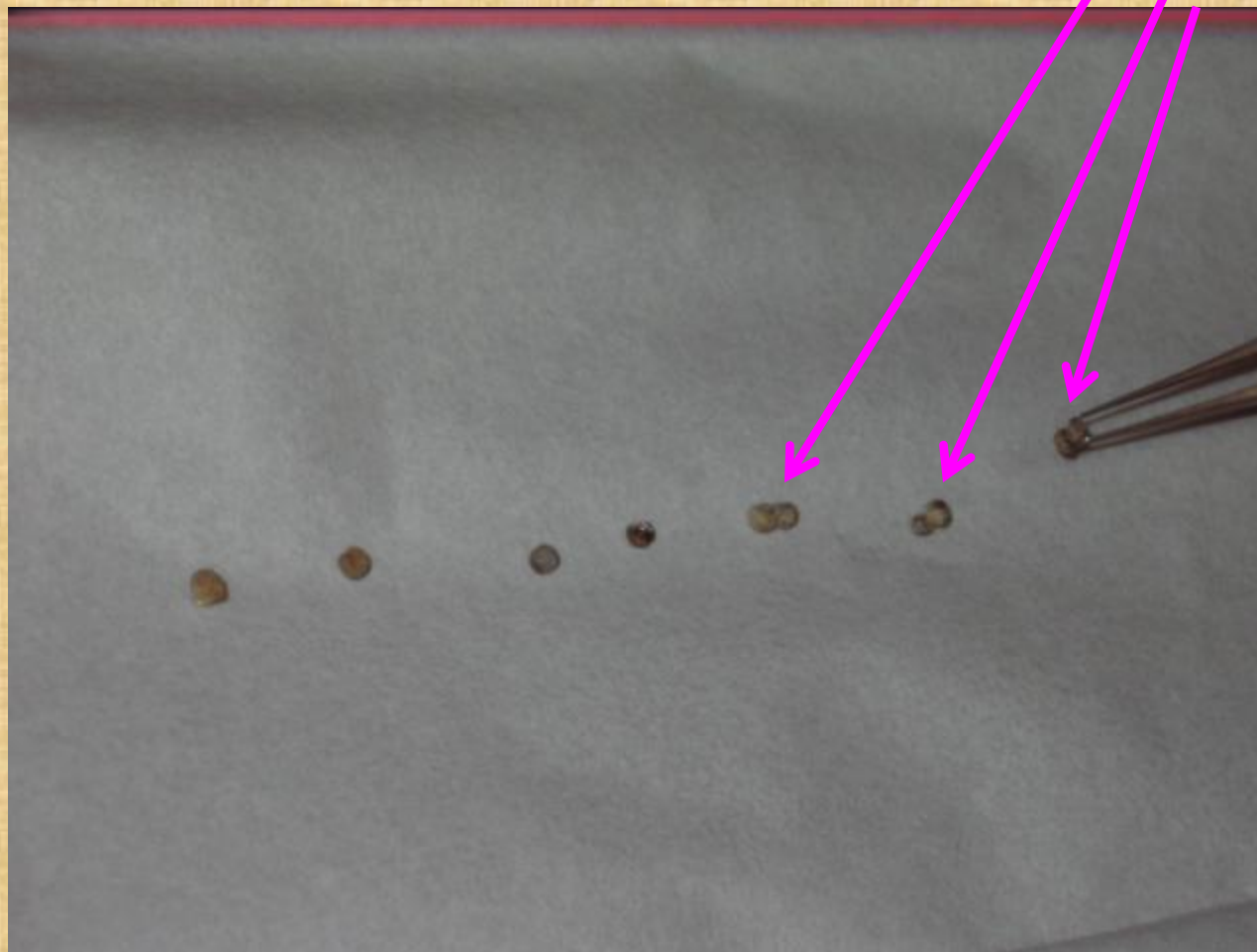
Investigators	Dosing approach/mechanism	Species	Notes
Rocke et al., 1997	random ingestion in 1.6 ha enclosures with counts as high as 2,000,000/ha	sentinel mallards	
Pattee et al., 2006	dosed with 0, 2 , or 6 pellets; re-dosed if regurgitated	Andean condors	
Buerger et al., 1986	dosed with 0, 2, 4 #8 pellets; delivered orally by dropping to back of mouth	captive mourning doves	
Carrington, et al., 1989	dosed with 0 and 1 pellet; force-fed; released to wild and tracked for 21 days	free-ranging mourning doves	similar mortality rates in controls and treated birds
Castrale and Oster, 1993	dosed with 0, 1, 2, 4 #8 Pb pellets	mourning doves	Mortality: 1 shotters - 1/10 2 shotters - 0/10 4 shotters - 4/10
Marn et al., 1988,	0 or 1 shot pellet	captive mourning doves	no mortality
McConnell et al., 1967	0 to 100 shot (new and some left on ground for 2-weeks); force fed	bobwhite quail and mourning doves	decreased egg production ; decreased hatchability
Kendall and Scanlon, 1982	0 or 1 shot pellet; looked only at decreased ALAD	mourning doves	decreased ALAD

“Environmental” shot vs. new shot

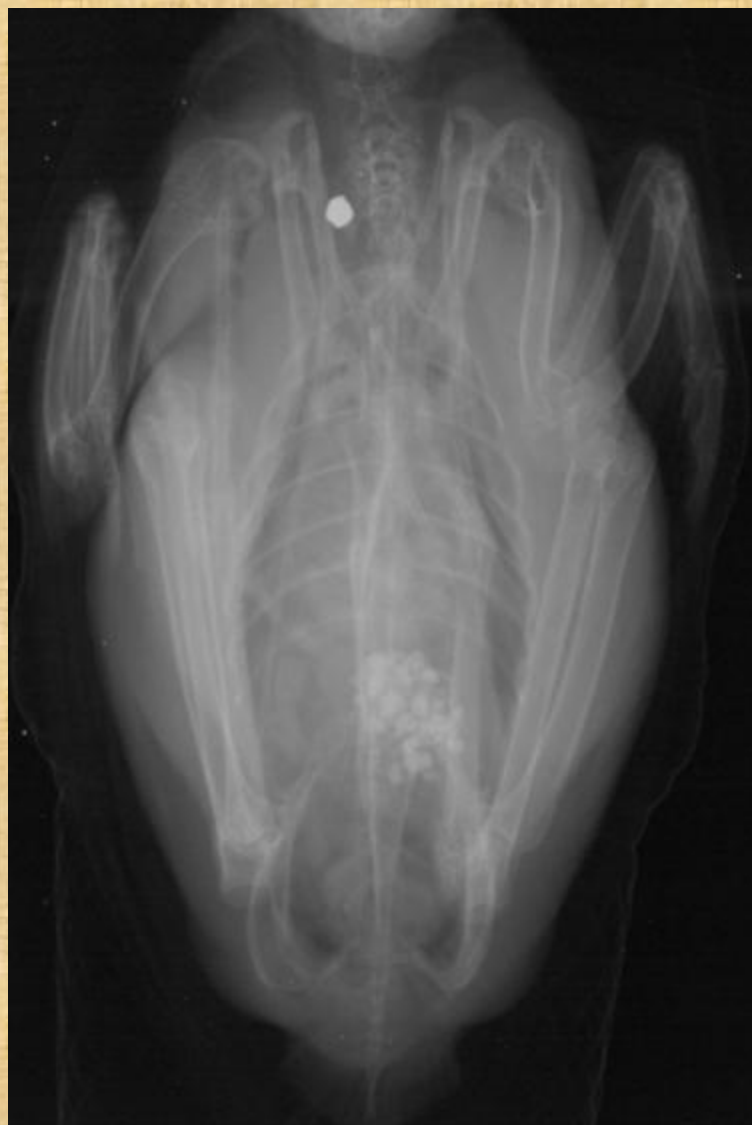




Look closely . . .
Make sure you're not seeing 'double'



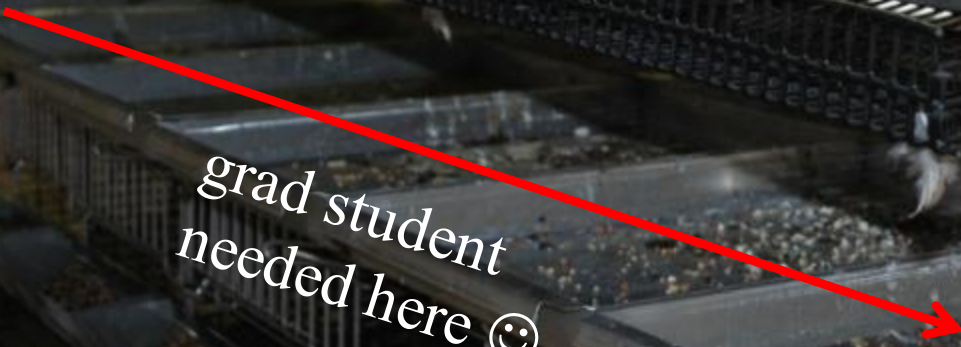






the alternative to radiography

grad student
needed here 😊

A red arrow originates from the text 'grad student needed here 😊' and points towards a tray of soil in a wire rack. The tray is filled with a dark, granular material, likely soil or a substrate for a biological experiment. The rack is part of a larger metal structure with multiple levels and compartments.



Ecologically-relevant

Pb shot pellet testing . . .

- use weathered or what we might term 'environmental' shot
- gavage a reasonable # of particles at one time; on their own, birds do not ingest and retain 5 or 10 shot particles or bullet fragments in a day.
- track the location of gavaged particles





1st dosing study: bobwhite quail, 28-day (acute) exposure to 0, 1, 5, and 10 spent shot (aka “environmental shot”)



US PHC (Provisional) approved











US PHC (Provisional) approved

Relevant findings: pellet retention



1. pellet retention after 1 week: 21%
2. pellet retention after 2 weeks: 7%
3. pellet retention at 3 weeks: 0%
4. Between 1 and 14 days: about 93% of ingested shot was either cleared or absorbed.
5. The transit rate of weathered shot through the GI tract was independent of number of gavaged shot.
6. There appeared to be no correlation between # of shot gavaged and # shot retained.





Relevant findings: Blood lead concs., etc.

1. related to # of shot gavaged
2. dropped over time in all groups (by as much as 60% from week to week).
3. PCV statistically reduced only in the 5- and 10-shot birds
4. Total RBC numbers and MCV not significantly different across groups or time
5. microscopic observations of RBCs with severe lytic changes were not significantly different among groups.
6. In the 5- and 10-pellet birds within 7 days - decreased activity, decreased feed intake, and weight loss





Relevant findings: somatic effects

1. necrotic lesions: none in the 1-shotters; statistically significant in 10-shotters
2. Morphology and % of leukocytes: no significant differences across # of shot or exposure length
3. δ -ALAD activity:
 - significantly reduced in all birds
 - by week 3, activity began to increase
 - by week 4 , s had regained $\approx 25\%$ of control activity
4. For the 5- and 10-pellet birds (within 7 days) . . . decreased activity, decreased feed intake, weight loss





Relevant findings: mortality

# of gavaged pellets	male	female
0	0/4	0/5
1	0/5	0/5
5	1/4 terminated at day 11	0/5 terminated at day 11
10	2/5 terminated at day 11	1/5 terminated at day 11





Relevant findings: mortality

# of gavaged pellets	male	female
0	0/4	0/5
1	☺/5	☺/5
5	1/4 terminated at day 11	0/5 terminated at day 11
10	2/5 terminated at day 11	1/5 terminated at day 11



**2nd dosing study: bobwhite quail,
56-day (acute/(sub-chronic?)) exposure to
0, 1, 2, 3 spent shot (aka “environmental shot”)**



US PHC (Provisional) approved





Relevant findings: mortality

# of gavaged pellets	male	female
0	1/6* *I kid you not; death by snake attack	0/4
1	1/6	😊/5
2	😊/5	2/5
3	😊/5	😊/6





3rd dosing study: bobwhite quail, 14-day (acute) exposure to 0, 1, 5 bullet fragments



US PHC (Provisional) approved





Bullet fragments

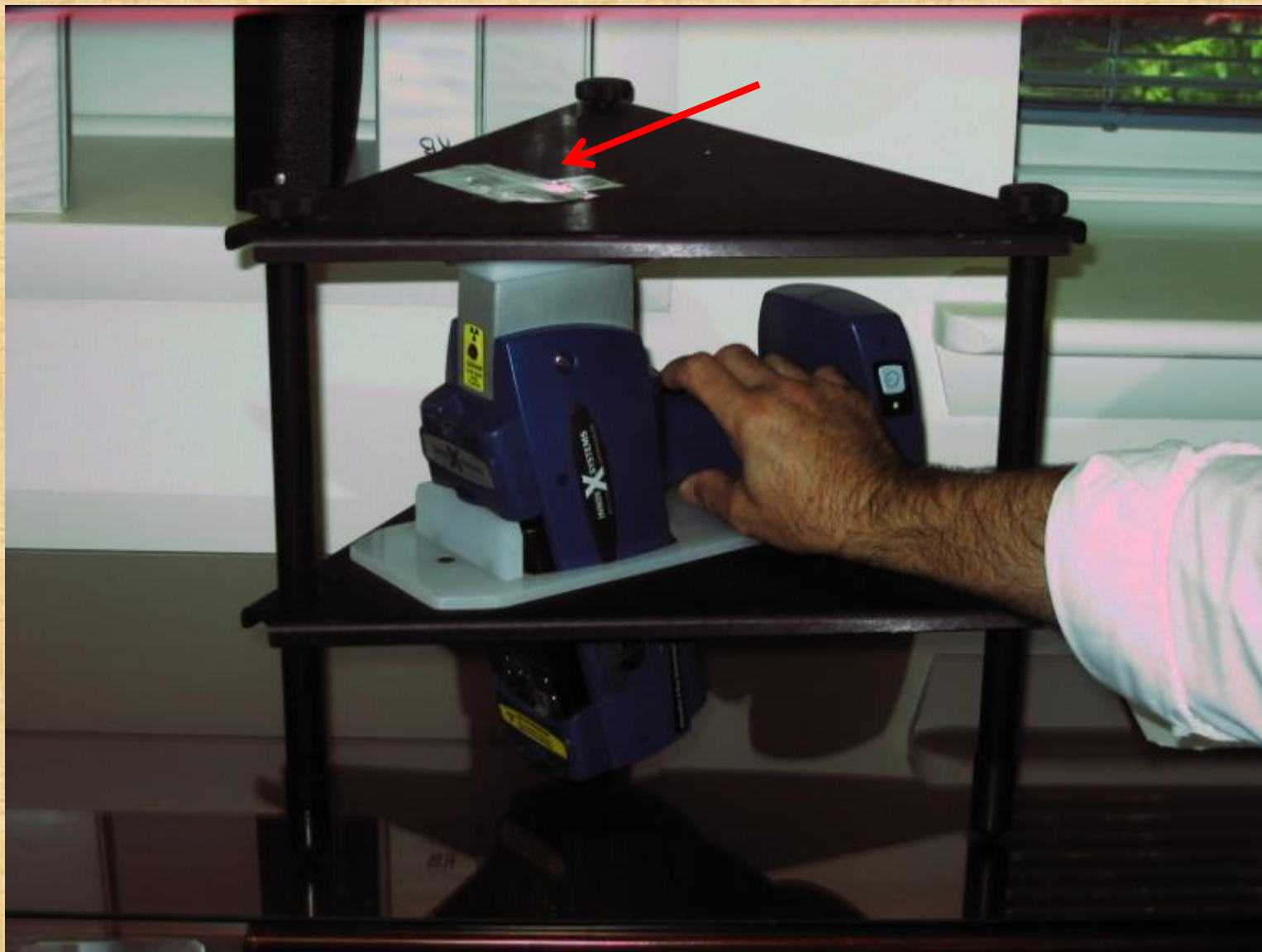
from a small arms range berm

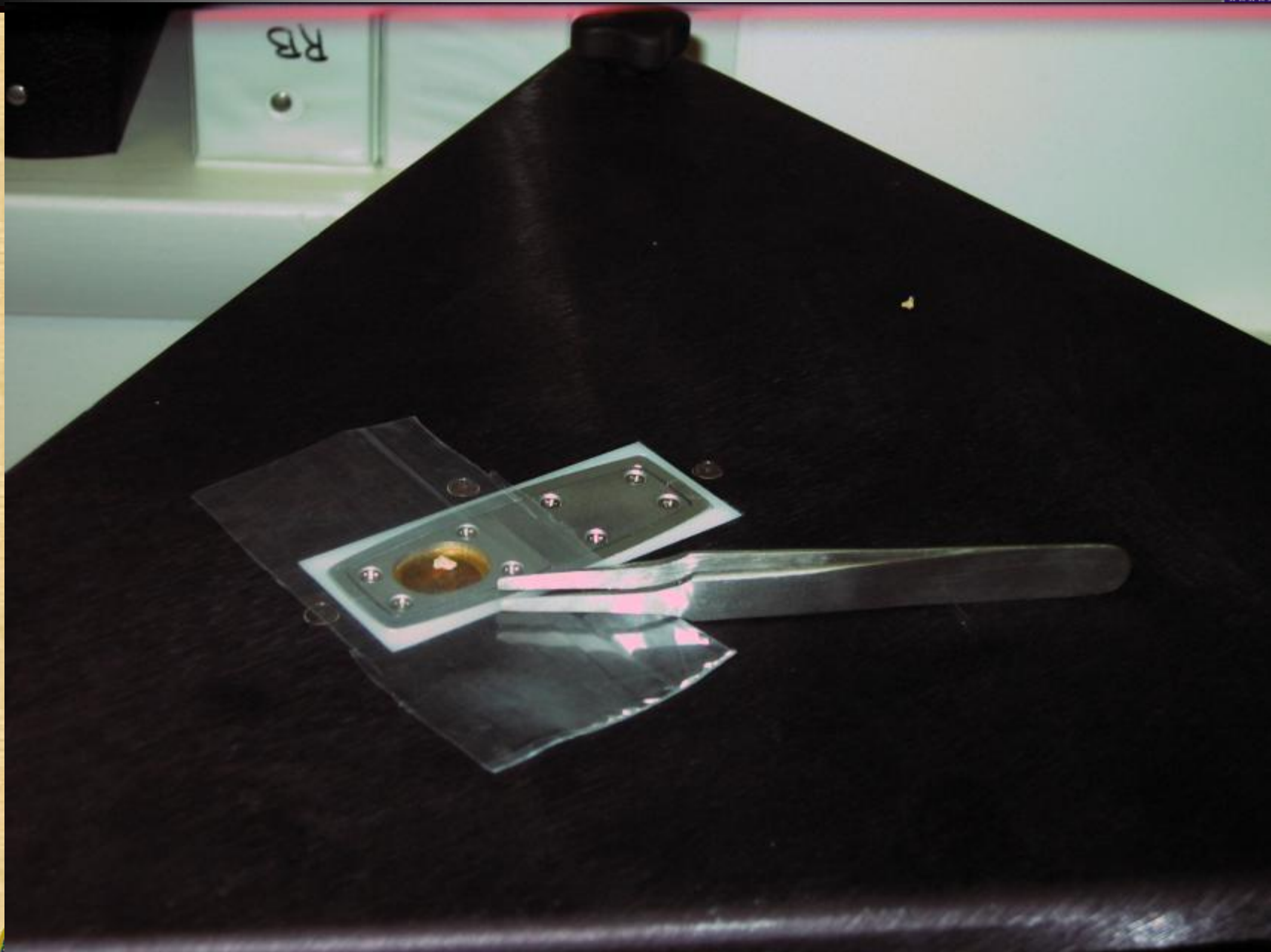


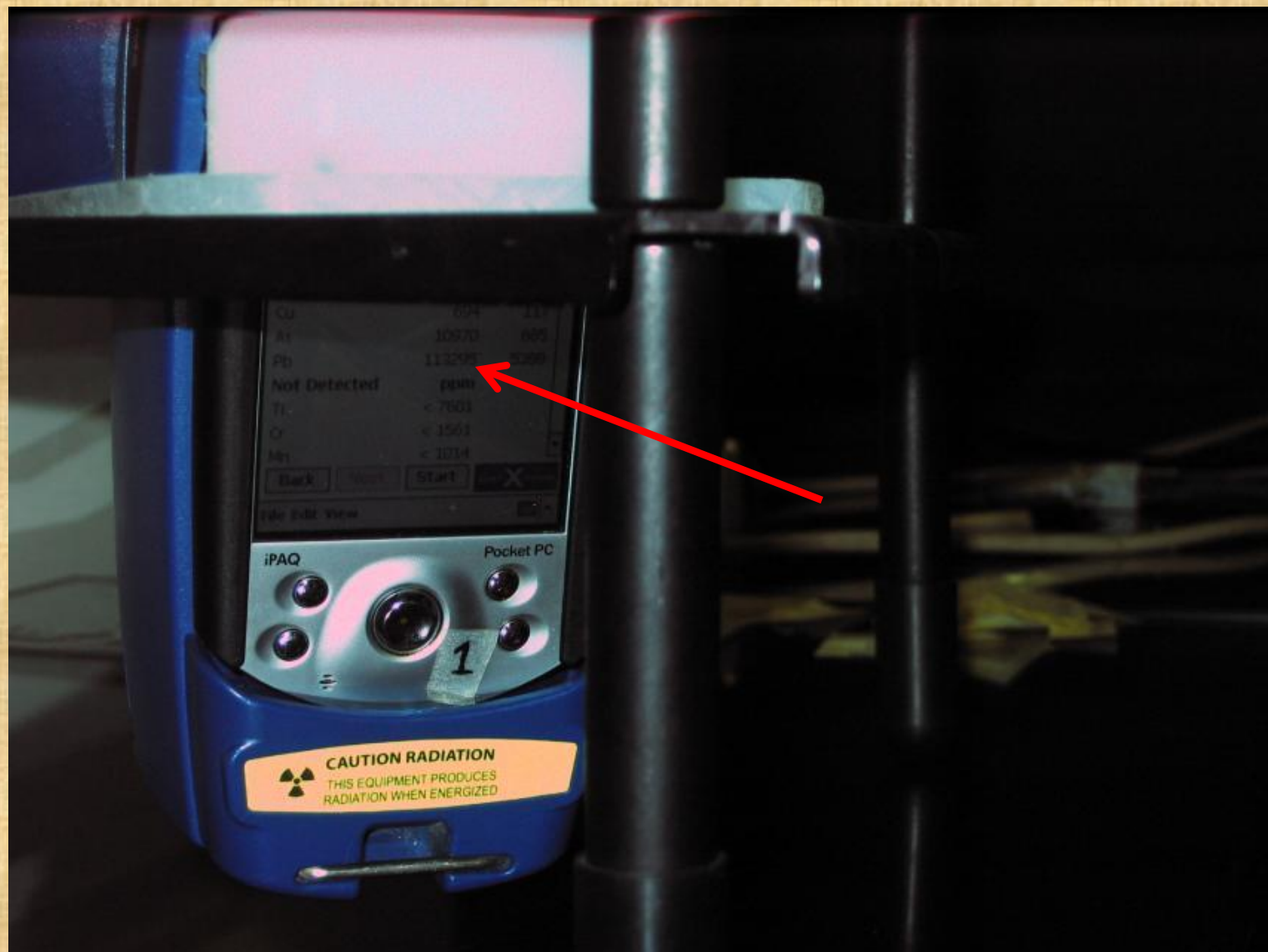






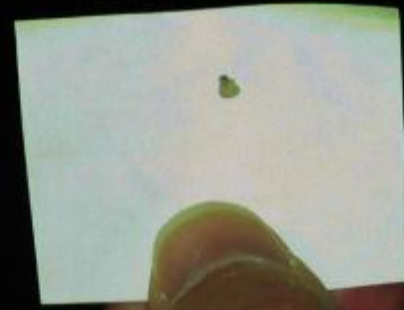








203,497 ppm





UGA Sample Name	VT Sample ID	weight (g)	% Pb conc.
113,295 ppm	1	0.0416	90%
113,707 ppm	2	0.0229	97%
138,564 ppm	3	0.0315	90%
168,712 ppm	4	0.0793	100%
191,472 ppm	5	0.074	98%
197,544 ppm	6	0.0265	95%
203,398 ppm	7	0.0384	92%
266,053 ppm	8	0.0482	97%
306,095 ppm	9	0.0702	95%
316,483 ppm	10	0.0815	98%



Relevant findings: fragment retention



- All fragments excreted by day 7!



Relevant findings: blood concs.



PbB ($\mu\text{g}/\text{dl}$)		Saline Mean \pm SEM	1 fragment Mean \pm SEM	5 fragment Mean \pm SEM
Baseline	Male	1.25 \pm 0.00	1.25 \pm 0.00	1.25 \pm 0.00
	Female	1.25 \pm 0.00	1.25 \pm 0.00	1.25 \pm 0.00
Week 1	Male	1.25 \pm 0.00	694.78 \pm 505.85	3202.20 \pm 729.57*
	Female	1.56 \pm 0.31	12.03 \pm 10.78	219.83 \pm 54.28*
Week 2	Male	1.25 \pm 0.00	87.85 \pm 41.19	897.50 \pm 784.30
	Female	1.25 \pm 0.00	20.89 \pm 13.95	126.27 \pm 46.52*

Nominal $n=5$, $n \geq 2$ birds/ treatment/ sex (* = $p \leq 0.05$, Dunnet's test)





Relevant findings: mortality

# of gavaged <u>bullet fragments</u>	male	female
0	0/6	0/6
1	☺/6	☺/5
5	2/6	2/5





Conclusions

- Ecologically-relevant doses of Pb particles (either shot or bullet fragments) at trap & skeet ranges and small arms ranges are not harmful to bobwhite quail.
 - “**ecologically-relevant**” means:
 - a most minimal number administered at one time;
 - in the case of shot, “weathered” or “environmental” shot is used;
 - gavage is to the gizzard, as confirmed by radiography





Conclusions

- Testing with both spent shot and bullet fragments, reveals highly individualistic response (for weight loss, retention time, Pb blood conc.).
- Retention times for shot are considerably shorter than previously thought, with most shot excreted by the first week. Retention times for fragments never exceeded 1 week.





Conclusions

- Grit ingestion models, as applied, appear to be fundamentally flawed. There is no need to know the likelihood of a bird ingesting a singular shot pellet (and seemingly retaining it in the gizzard for some period of time). Quail, and seemingly larger upland birds, do not die from singular pellet ingestion/gavage.

(Note: We plan to next test with pigeons!)





Observations / Common sense

- The fall zone of a trap & skeet range is about 3 acres in size. It is unreasonable/unrealistic to think that a bird would elect to have all of its (perhaps 5 or 10) grit ingestion events in a year only at the fall zone of a trap & skeet range.
 - birds are migratory
 - home range can significantly exceed the size of the fall zone
 - there's significant human disturbance at a trap & skeet range





Observations / Common sense

- At small arms ranges, there are really no opportunities for birds to get at grit-sized bullet fragments.
 - vastly larger fragments from the bullet jackets far outnumber the grit-sized fragments.
 - small upland bird species could not possibly push aside vast quantities of large jacket pieces to get at grit-sized ones.





Acknowledgements

- US Army Environmental Command
Fort Eustis, VA
- Fort Eustis - soils with spent shot
- Fort McClellan, AL - soils with bullet fragments
- University of Georgia, Dept. of Anatomy and Radiology, College of Veterinary Medicine

} funding



Thank you



Got any questions?

