maine
BOARD OF PESTICIDES CONTROL
DEPARTMENT OF AGRICULTURE, CONSERVATION & FORESTRY

Rodenticides: modes of toxicity and their impact on non-target animals

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www.thinkfirstspraylast.org

Overview: Categories, active ingredients, and registered products

Anti-coagulants

Rodenticides (AR)

NON-AR

	Registr. #
1st Gen. Anti-Coag	
Chlorophacinone	
Diphacinone	
Warfarin	
2nd Gen. Anti-Coag	
Bromadiolone	
Difethialone	
difenacoum	fewest
brodifacoum	
Other	
Zinc phosphide	
Bromethalin	most
cholecalciferol	
strychnine	

Registered products range from about 1-190.

Toxicological overview

1st Gen. Anti-Coag	rat LD_{50}	Registr. #
Chlorophacinone		
Diphacinone		
Warfarin		
2nd Gen. Anti-Coag		
Bromadiolone		
Difethialone		
difenacoum		fewest
brodifacoum	Most toxic	
Other		
Zinc phosphide		
Bromethalin		most
cholecalciferol	least toxic	
strychnine		

LD50 values range from 0.2 – 40 mg/kg body weight

ACUTE TOXICITY CATEGORIES FOR PESTICIDE PRODUCTS

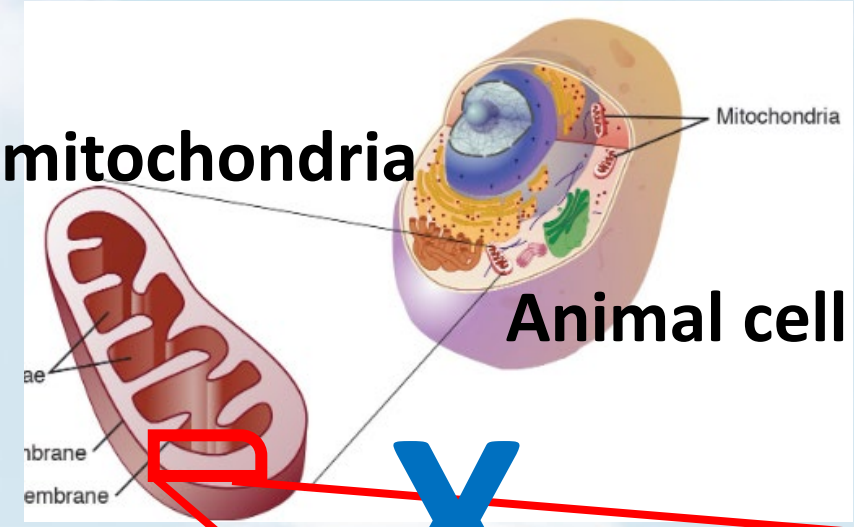
Hazard Indicators	I	II	III	IV
Oral LD_{50}	Up to and including 50 mg/kg	>50 thru 500 mg/kg	>500 thru 5,000 mg/kg	>5,000 mg/kg

For comparison

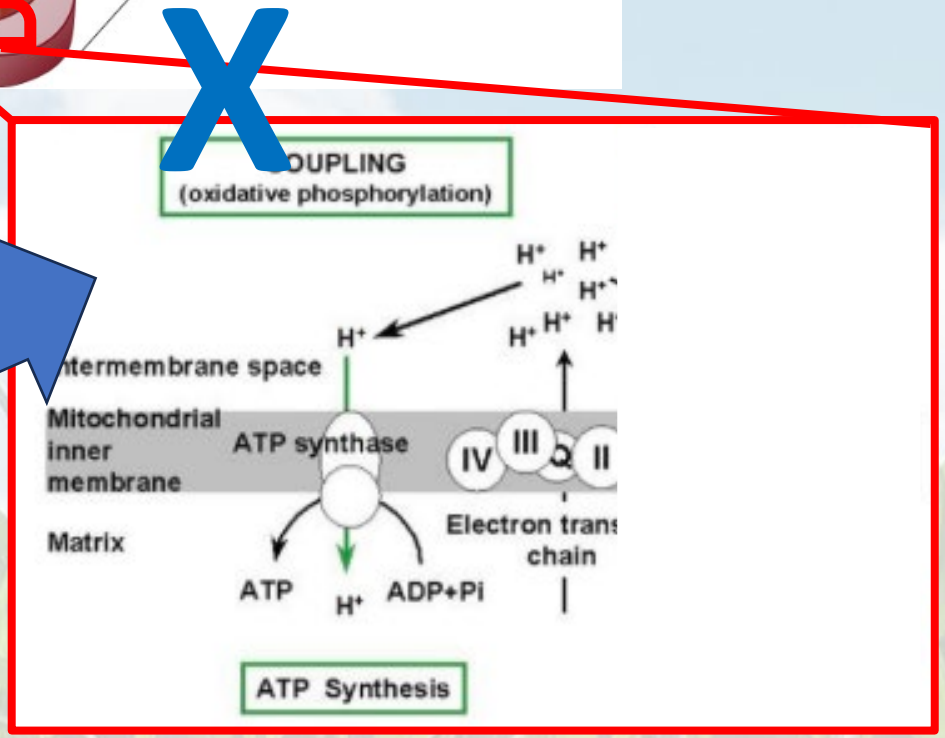
	rat (mg/kg)
cyanide	3.6
DDT	87
aspirin	250
table salt	3000

Non-AR: Zinc phosphide- mitochondrial inhibitor

1st Gen. Anti-Coag	rat
Chlorophacinone	
Diphacinone	
Warfarin	
2nd Gen. Anti-Coag	
Bromadiolone	
Difethialone	
difenacoum	
brodifacoum	
Other	
Zinc phosphide	
Bromethalin	
cholecalciferol	
strychnine	



Mitochondria make cellular energy (ATP) so cells can work, survive.



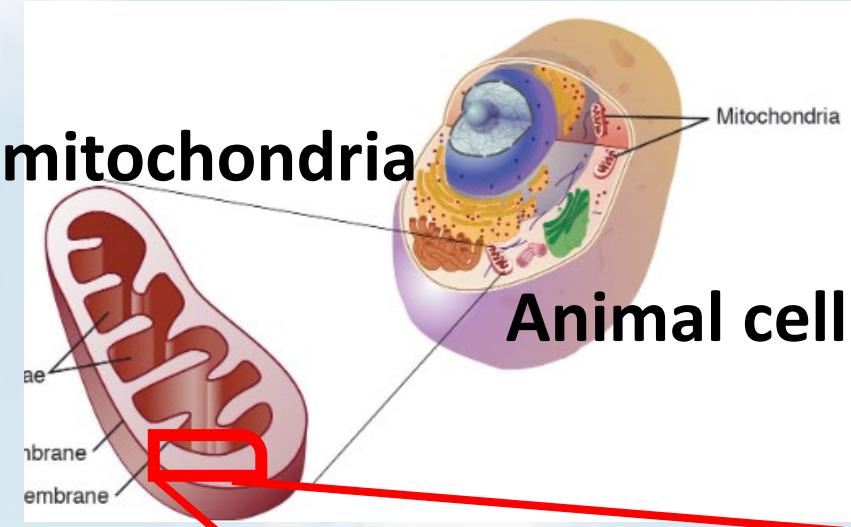
$$Zn_3P_2 + 6\ H_2O \rightarrow 2\ PH_3 + 3\ Zn(OH)_2$$

Zinc phosphide

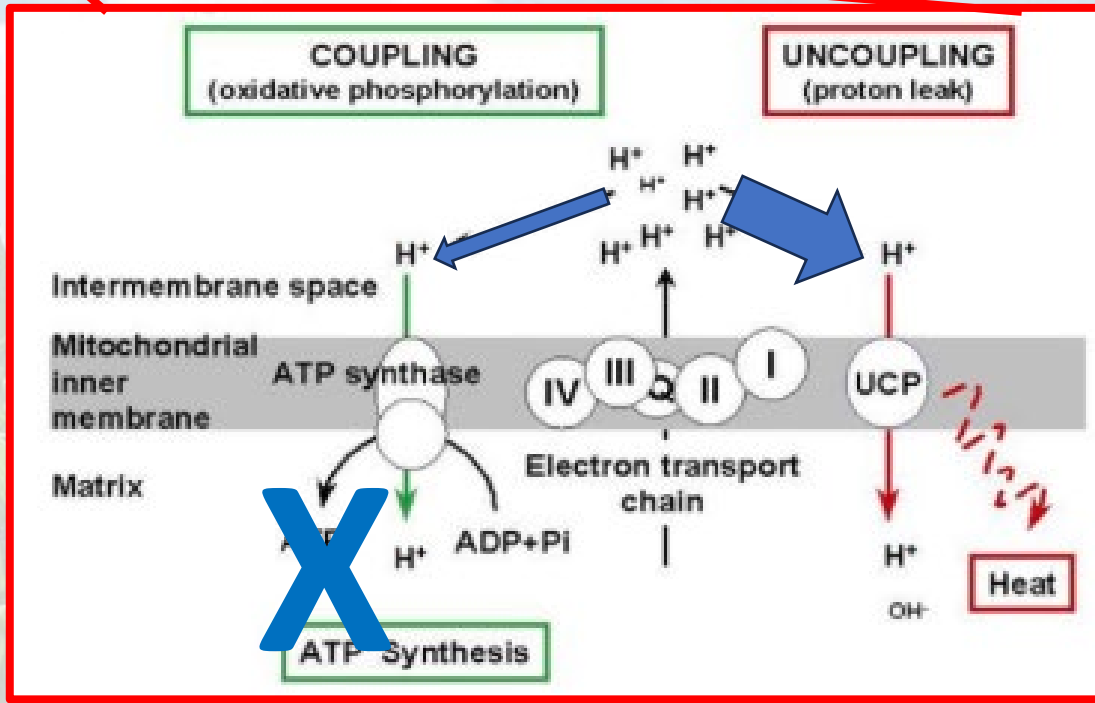
Phosphine gas

Non AR: Bromethalin- a mitochondrial uncoupler

1st Gen. Anti-Coag	rat
Chlorophacinone	
Diphacinone	
Warfarin	
2nd Gen. Anti-Coag	
Bromadiolone	
Difethialone	
difenacoum	
brodifacoum	
Other	
Zinc phosphide	
Bromethalin	
cholecalciferol	
strychnine	

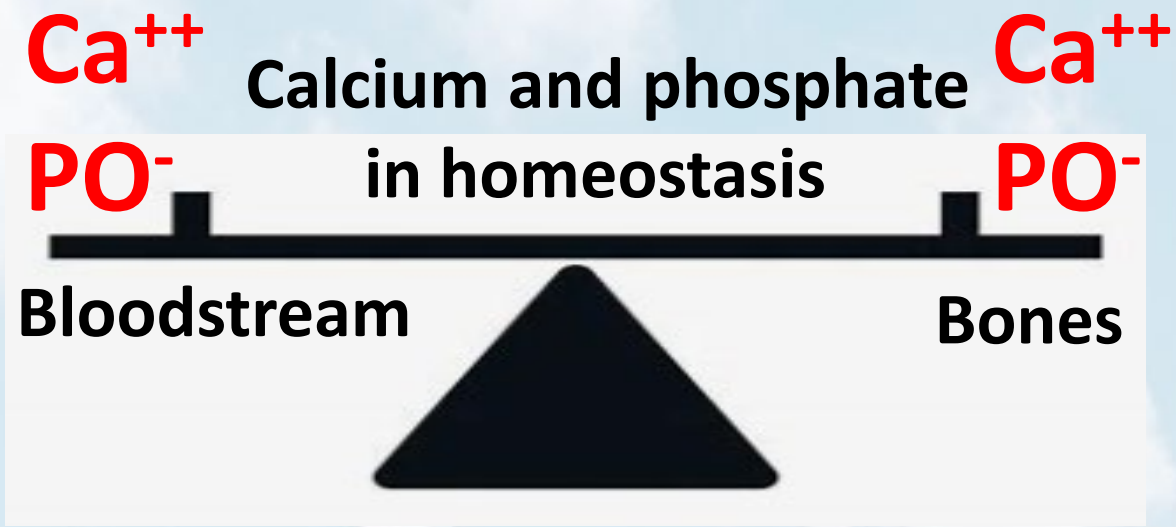


Mitochondria make cellular energy (ATP) so cells can work and survive.



Non AR: Cholecalciferol- an electrolyte perturber

1st Gen. Anti-Coag	rat
Chlorophacinone	
Diphacinone	
Warfarin	
2nd Gen. Anti-Coag	
Bromadiolone	
Difethialone	
difenacoum	
brodifacoum	
Other	
Zinc phosphide	
Bromethalin	
cholecalciferol	
strychnine	



Increased concentration of these ions in blood causes renal failure.

Anti-coagulants: An overview

1st Gen. Anti-Coag	LD50 rat	metabolism	depuration	persistence	bioaccumulation	Secondary poisoning
Chlorophacinone		faster	faster	lower	lower	less risky
Diphacinone						
Warfarin						
2nd Gen. Anti-Coag						
Bromadiolone		slower	slower	greater	greater	more risky
Difethialone						
difenacoum						
brodifacoum						

Anti-coagulants: mode of action

	LD50 rat
1st Gen. Anti-Coag	
Chlorophacinone	
Diphacinone	
Warfarin	
2nd Gen. Anti-Coag	
Bromadiolone	
Difethialone	
difenacoum	
brodifacoum	

- These toxins disrupt blood clotting by targeting the function on Vitamin K.
- Nonfunctional Vitamin K thins the blood and results in hemorrhaging
- Mortality is a result of cardiovascular dysfunction and other associated comorbidities (*e.g.* renal, liver, and other organ failure).

Wildlife exposure: Secondary poisoning

Occurs when predatory animals consume prey that have ingested rodenticides, *e.g.* secondary anti-coagulants.

- **The New England Wildlife Center reports ~100-200 cases of secondary poisoning annually.**
- **A 2012-2016 study in Massachusetts autopsied 94 hawks:**
  - **96% of hawks contained at least 1 rodenticide**
  - **50% contained 3 or more rodenticides**
  - **18% of hawks had rodenticide concentrations associated with toxicosis.**
- **The same authors performed a follow-up study in 43 hawks; 100% of hawks contained rodenticides; more than 90% had at least two rodenticides.**

- **The Maine Department of IFW performed a limited sampling of rodenticides in 2024. This study detected rodenticides in bears (4 out of 4 individuals) and hawks (4 out of 6).**

- **A study examining 303 eagles from across the country identified rodenticides in 82% of individuals, which attributed to 4% of the mortalities (n=12).**

- **In California, more than 80% of all bears, bobcats, mountain lions, and fishers contained at least one rodenticide. In contrast, rodenticides were detected in only 8% of wild pigs (n=137) and were not detected in any deer (n=37).**

Drivers of anticoagulant rodenticide exposure in fishers (*Pekania pennanti*) across the northeastern United States

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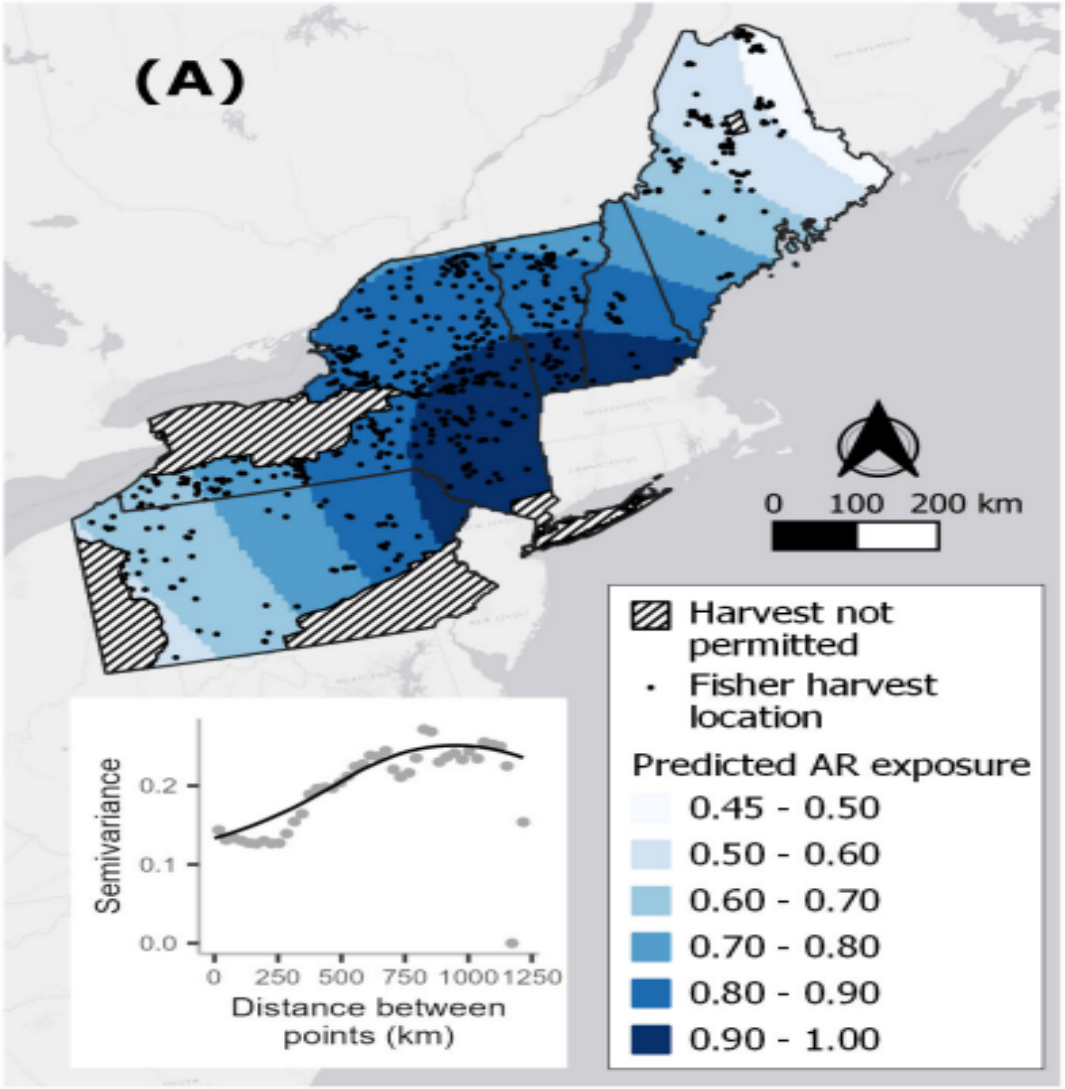
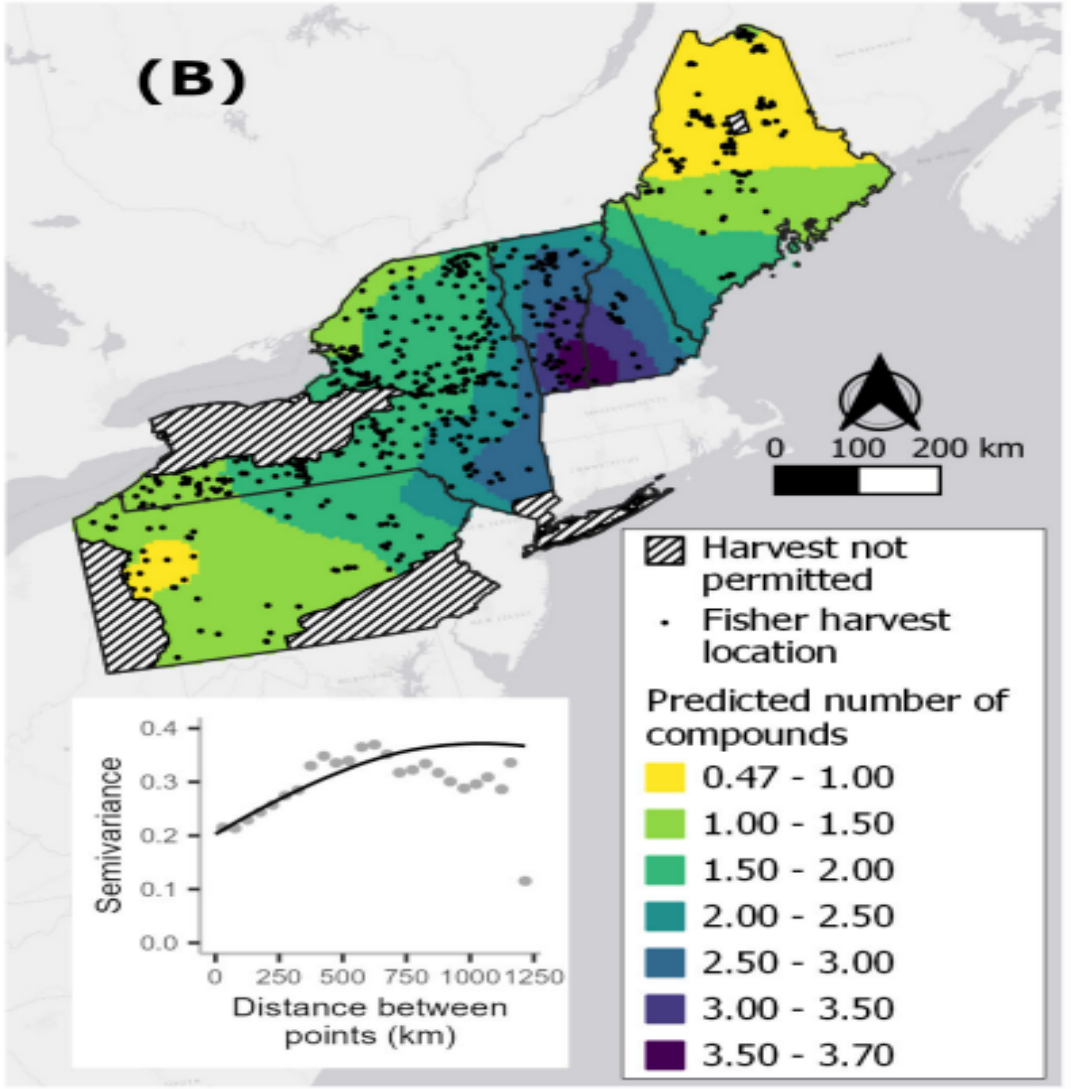




Unanswered Question: are rodenticide detections in wildlife caused by secondary poisonings lethal, and driving factors in local population decline?

If they are not always lethal, do they impact their physiology and survival rates?

And if so, to what extent?

Red fox with mange

SCIENTIFIC REPORTS

OPEN

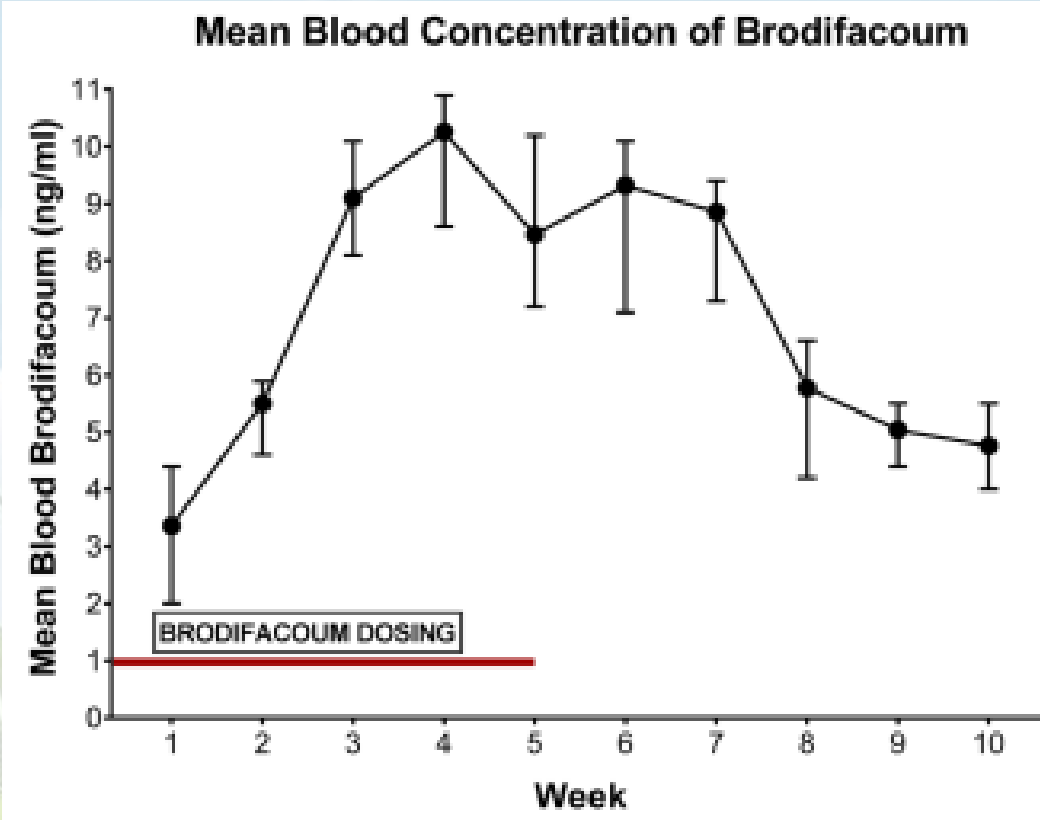
Effects of Low-level Brodifacoum Exposure on the Feline Immune Response

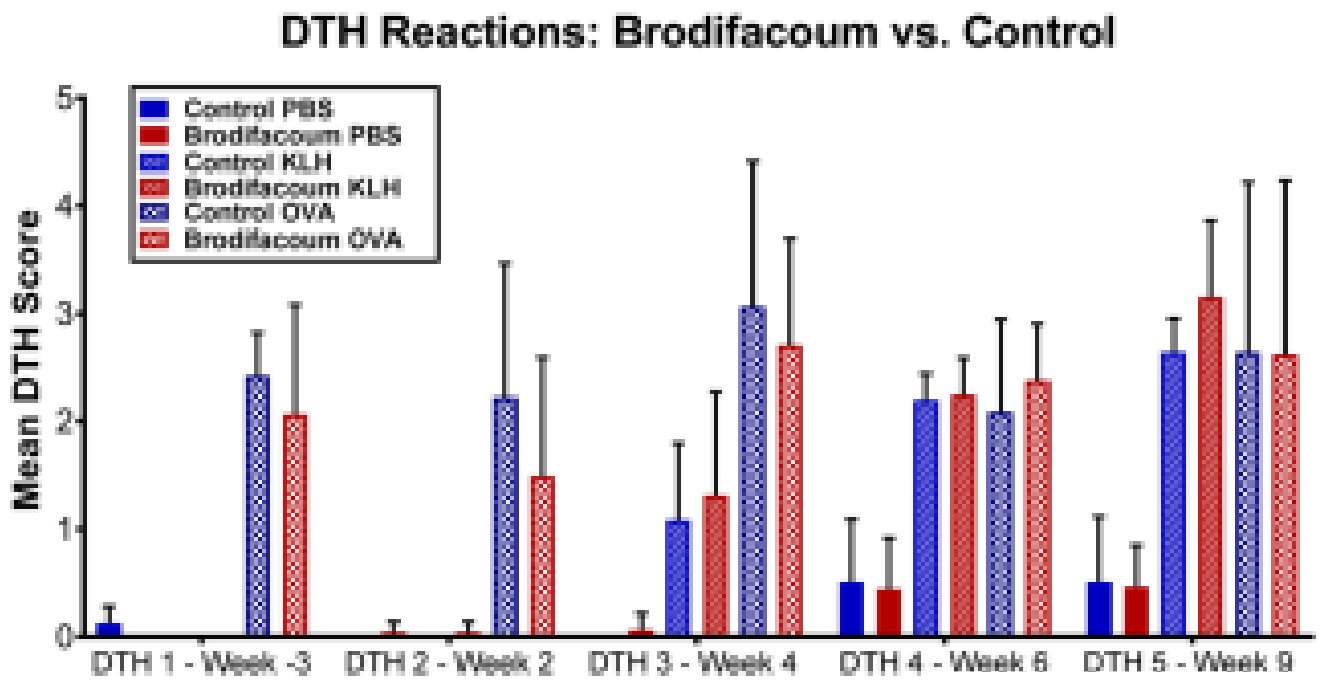
Received: 18 December 2017
Accepted: 11 May 2018
Published online: 25 May 2018

Jennifer H. Kopanke[1], Katherine E. Horak[2], Esther Musselman[1], Craig A. Miller[1], Kristine Bennett[1], Christine S. Olver[1], Steven F. Volker[2], Sue VandeWoude[1] & Sarah N. Bevins[2]

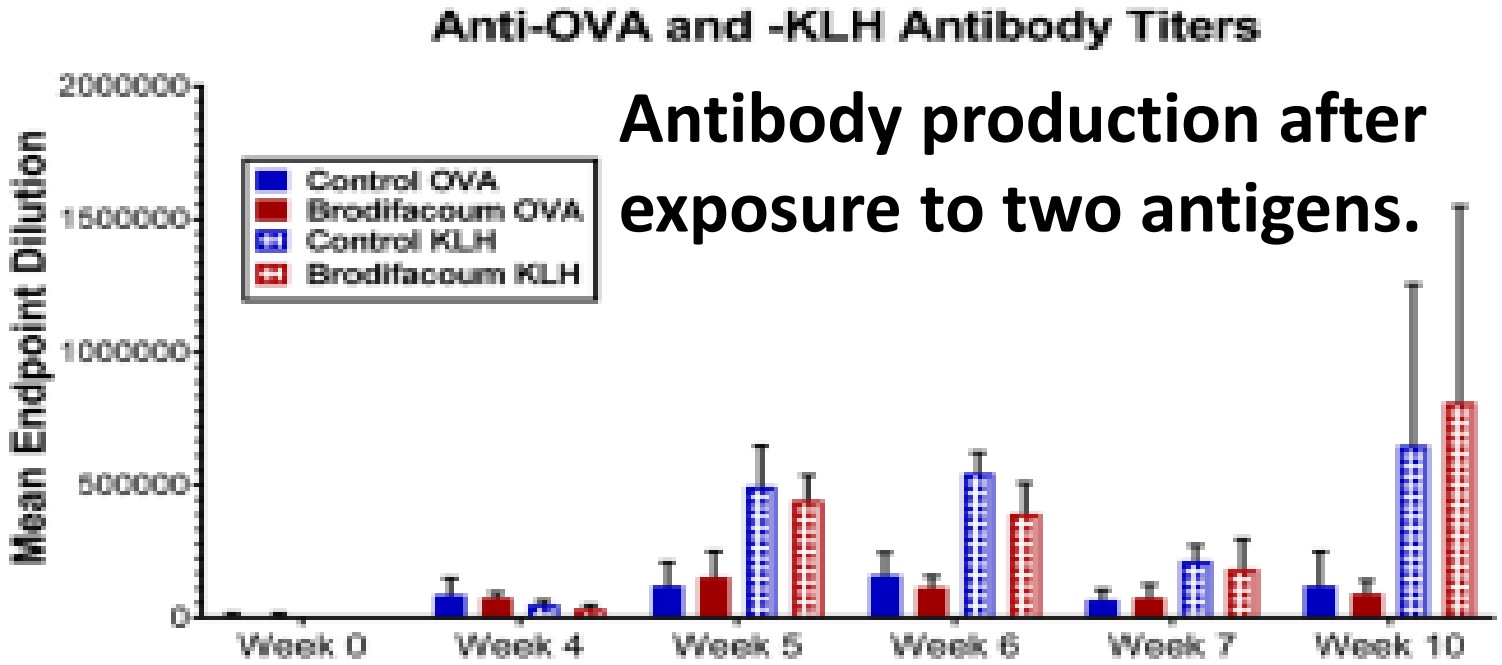
Research Question: does brodifacoum impair the immune response in felines

Methods: Cats ate one-brodifacoum contaminated rodent a week for 6 weeks. This dosage is~ 1/50th of a lethal dose in cats. The dosage is ecologically and physiologically relevant.





Conclusion: brodifacoum does not impair the immune system in cats, and is not likely to increase the incidence of mange in wild felines.



Antibody production after exposure to two antigens.

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Questions and Comments?

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