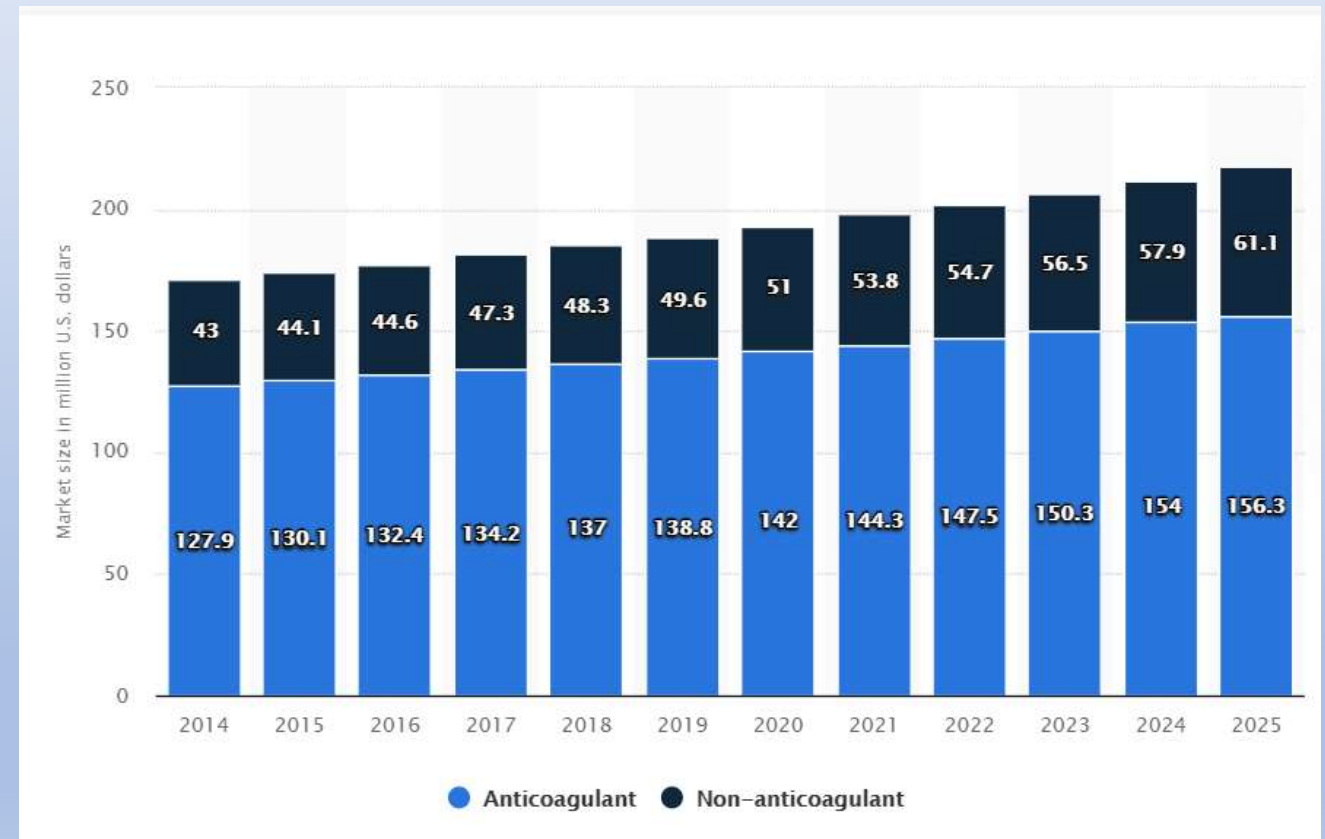


# Anticoagulant Rodenticides



Thanks to Gretchen Fowles and Kathy Clark

# Rodenticide Market

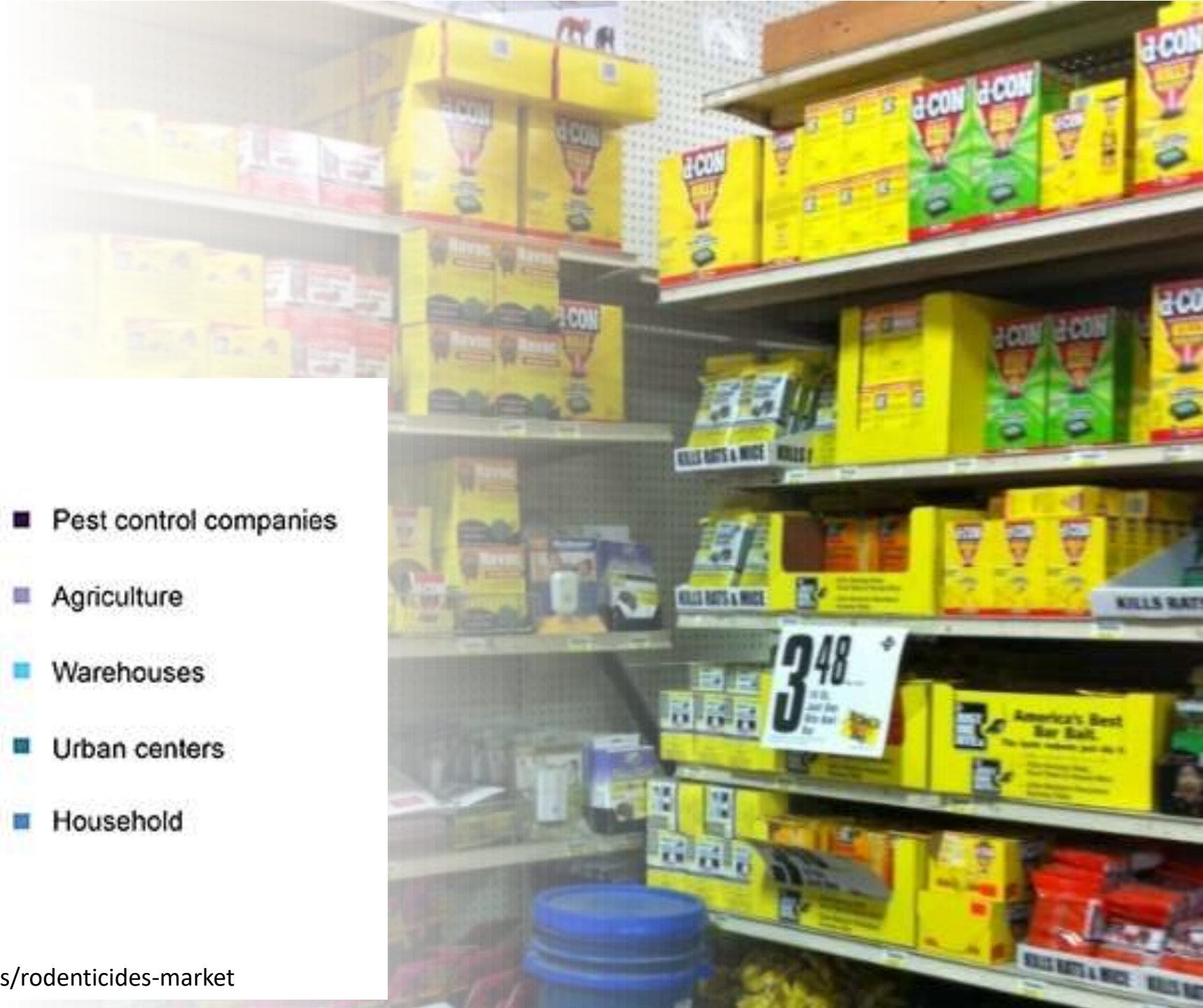


<https://www.grandviewresearch.com/industry-analysis/rodenticides-market>

# Rodenticides



- Pest control companies
- Agriculture
- Warehouses
- Urban centers
- Household





# Anticoagulant Rodenticides

## 1<sup>st</sup> generation

Warfarin, Pindone, Diphacinone

- Multiple feedings
- Less toxic



## 2<sup>nd</sup> generation

Brodifacoum, Bromadiolone, Difethialone, Difenacoum

- “One feeding”
- Persists in tissues



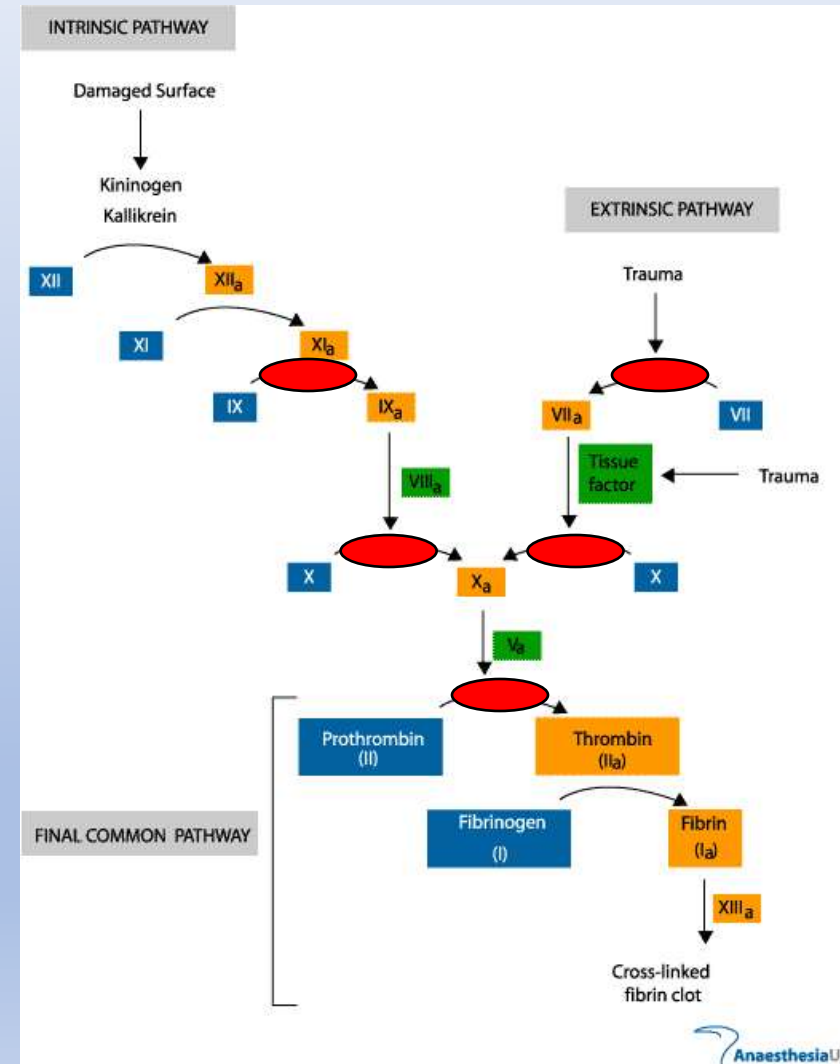
# Anticoagulant Rodenticides

## Mode of Action:

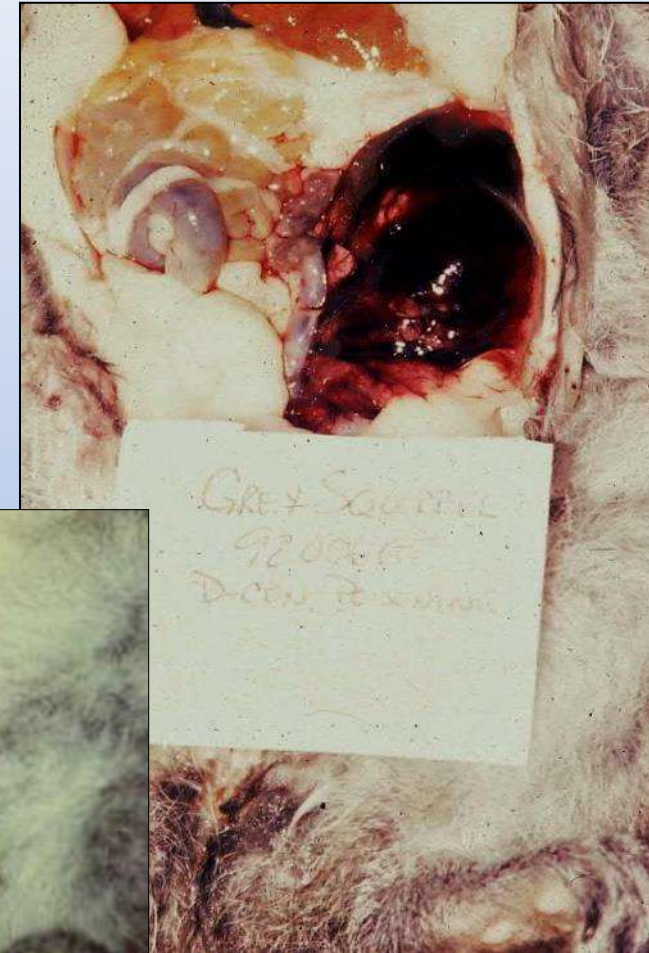
Prevents the conversion of vit K1 epoxide to active vit K1

## Signs:

- Bruising
- Internal hemorrhage
- Weakness
- Sudden death



# Anti-coagulants: Primary bait ingestion



# SGAC Rodenticides in Raptors

## Canadian Studies

70% owls found dead 1988-2003: *Arch Environ Contam Toxicol*, 58, 451-459

96% owls found dead 2005-2011: Hindmarch & Elliot, Raptor Research Fndn Mtg 2011

## Massachusetts (Tufts)

138/161 (86%) raptors that died/euth 2006-2010

RTHA, BDOW, EASO, GHOW

*Journal of Zoo and Wildlife Medicine*, 42, 88-97

## PennVet/NJDFW Study 2011:

5/23 (22%) BAEA, BDOW, GHOW, PEFA, RTHA blood

24/27 (89%) GHOW livers had exposure to SGACR

Project SNOWstorm (2013-19): 49/118 livers (41.5%) had exposure



Kristine Stellato, PV'14



# Repeated exposures

*Environmental Toxicology and Chemistry*—Volume 39, Number 2—pp. 468–481, 2020

Received: 5 August 2019 | Revised: 24 September 2019 | Accepted: 28 October 2019

468

## Hazard/Risk Assessment



# Brodifacoum Toxicity in American Kestrels (*Falco sparverius*) with Evidence of Increased Hazard on Subsequent Anticoagulant Rodenticide Exposure

Barnett A. Rattner,<sup>a,\*</sup> Steven F. Volker,<sup>b</sup> Julia S. Lankton,<sup>c</sup> Thomas G. Bean,<sup>d</sup> Rebecca S. Lazarus,<sup>a</sup> and Katherine E. Horak<sup>b</sup>

<sup>a</sup>Patuxent Wildlife Research Center, US Geological Survey, Beltsville, Maryland, USA

<sup>b</sup>National Wildlife Research Center, Animal and Plant Health Inspection Service, US Department of Agriculture, Fort Collins, Colorado, USA

<sup>c</sup>National Wildlife Health Center, US Geological Survey, Madison, Wisconsin, USA

<sup>d</sup>Department of Environmental Science and Technology, University of Maryland, College Park, Maryland, USA



# AR Exposure in Eagles

## *Percent exposure and number of AR compounds detected in eagles*

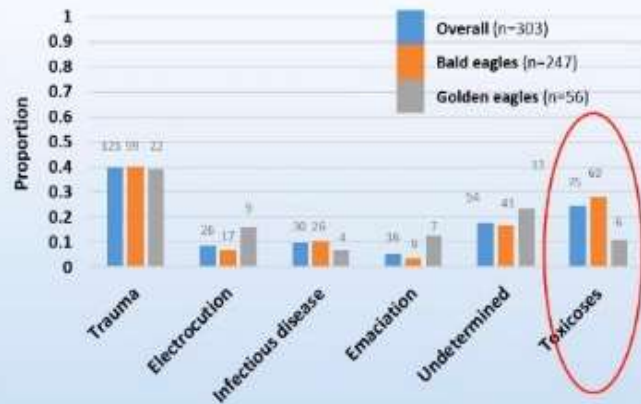
	<b>≥1 AR</b>		<b>1 AR</b>		<b>≥ 2 AR</b>	
	Exposed/ tested	% Exposed	Exposed/ tested	% Exposed	Exposed/ tested	% Exposed
BAEA	96/116	82.7%	56/116	48.3%	40/116	34.5%
GOEA	13/17	76.5%	4/17	23.5%	9/17	52.9%
Total	109/133	81.9%	60/133	45.1%	49/133	36.8%

## *Specific AR compounds detected in eagles*

		% AR Exposure (n)		
		BAEA (n=116)	GOEA (n=17)	Total (n=133)
First-generation AR	Chlorophacinone	0.9% (1)	5.9% (1)	1.5% (2)
	Coumachlor	0%	0%	0%
	Warfarin	0%	0	0%
	Diphacinone	0.9% (1)	11.8% (2)	2.3% (3)
Second-generation AR	Brodifacoum	84.5% (98)	64.7% (11)	80.5% (107)
	Bromadiolone	21.6% (25)	47.1% (8)	24.8% (33)
	Difethialone	18.1% (21)	5.9% (1)	16.5% (22)
	Difenacoum	9.6% (11)	11.8% (2)	9.8% (13)

Slide from a presentation by  
Bob Sargent of Georgia  
Wildlife Resources  
at the  
Atlantic Flyway's Nongame  
Technical Section, Raptor  
committee.

Data from Georgia bald  
eagles treated in  
rehabilitation centers.



## What's Killing Eagles? Toxicoses

Intoxication			
Compound	Total	Bald eagle	Golden eagle
Lead	15.8% (48)	17.9% (44)	7.1% (4)
Anticoagulant rodenticide	4.0% (12)	4.5% (11)	1.8% (1)
OP/Carbamate	≤1% (3)	≤1% (2)	1.8% (1)
Avian vacuolar myelinopathy	2.3% (7)	2.8% (7)	0
Pentobarbital	1.3% (4)	1.6% (4)	0
Zinc	≤1% (1)	≤1% (1)	0
Toxicant exposure			
Lead	15	13	2
Anticoagulant rodenticide	109	96	13

Slides from a presentation by Bob Sargent  
of Georgia Wildlife Resources  
at the  
Atlantic Flyway's Nongame Technical  
Section, Raptor committee.

## SCWDS Study Summary

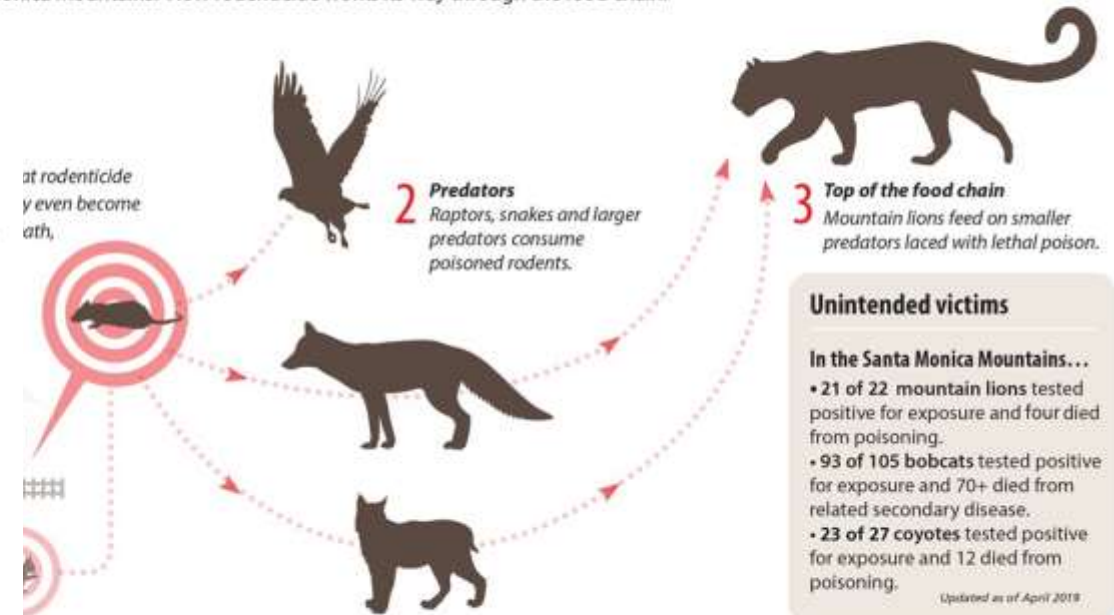
- SGAR exposure among bald and golden eagles is common and widespread despite use restrictions
  - Primary, secondary, and tertiary poisoning reported
  - Brodifacoum detected in 80% of eagles tested and 100% of intoxicated eagles
  - Although intoxication appears uncommon, the high prevalence of exposure is concerning
  - The impacts of subclinical SGAR exposure to eagle population health remain unclear

SCWDS = Southeast Cooperative Wildlife Disease Study



# Lethal Dose: Rat Poison & Local Wildlife

Local residents may inadvertently be poisoning wildlife. National Park Service researchers have found a direct link between exposure to anticoagulant rodenticides, commonly known as rat poison, and the deaths of wildlife in and around the Santa Monica Mountains. How rodenticide works its way through the food chain:



## Anticoagulant Exposure and Notoedric Mange in Bobcats and Mountain Lions in Urban Southern California

Author(s): SETH P. D. RILEY, CASSITY BROMLEY, ROBERT H. POPPENG, FRANCISCO A. UZAL, LYNN WHITED, and RAYMOND M. SAUVAJOT

Source: Journal of Wildlife Management, 71(6):1874-1884. 2007.

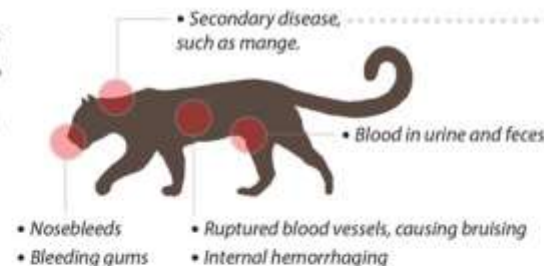
Published By: The Wildlife Society

DOI: <http://dx.doi.org/10.2193/2005-615>

URL: <http://www.bioone.org/doi/full/10.2193/2005-615>

### How anticoagulant rodenticide kills

These compounds interrupt blood-clotting, which leads to uncontrolled bleeding and death. They may also suppress the animal's immune system, making it susceptible to other diseases. **Symptoms include:**



### What is mange?

A microscopic mite that burrows into the skin and causes...

1. Extreme itchiness and skin lesions.
2. Fluid and nutrient loss through the skin.
3. Infection, starvation, hypothermia or other complications, eventually leading to death.



### Check the label

Here are the most common anticoagulant compounds:

- Bromadiolone
- Brodifacoum

- Diphacinone
- Difethialone



SOURCES: Santa Monica Mountains National Recreation Area research, L.E.K. Serieses, UrbanCarnivores.com

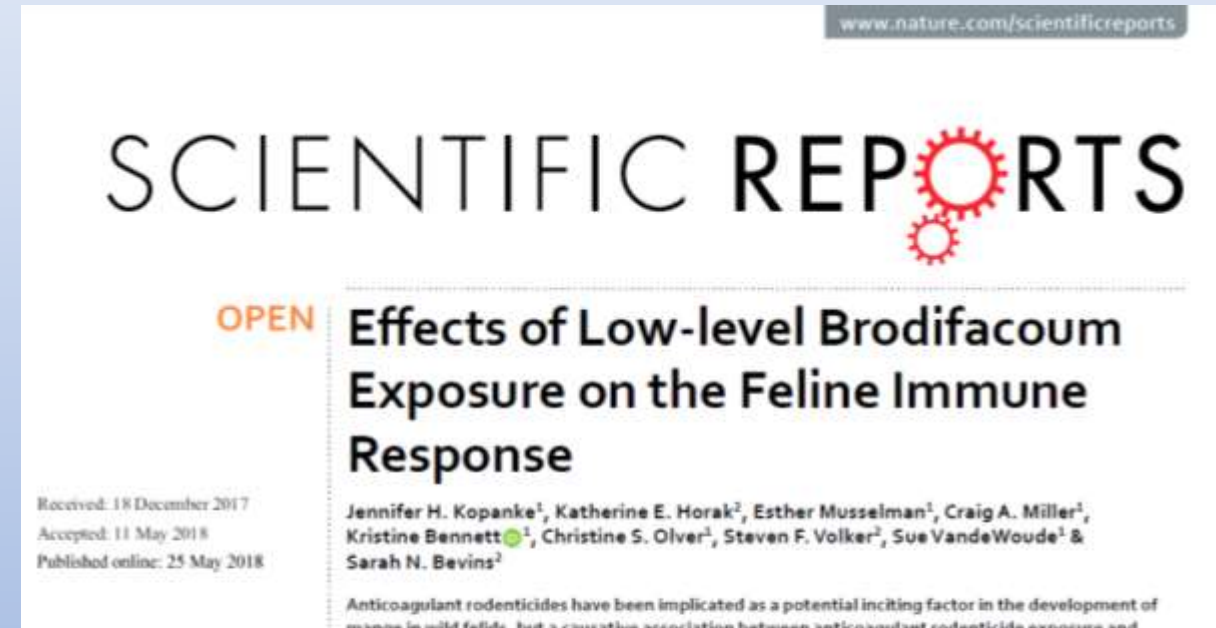
CREDIT: National Park Service  
<http://1.usa.gov/1SuhsXv>



# ACR Effects on Immune Function?



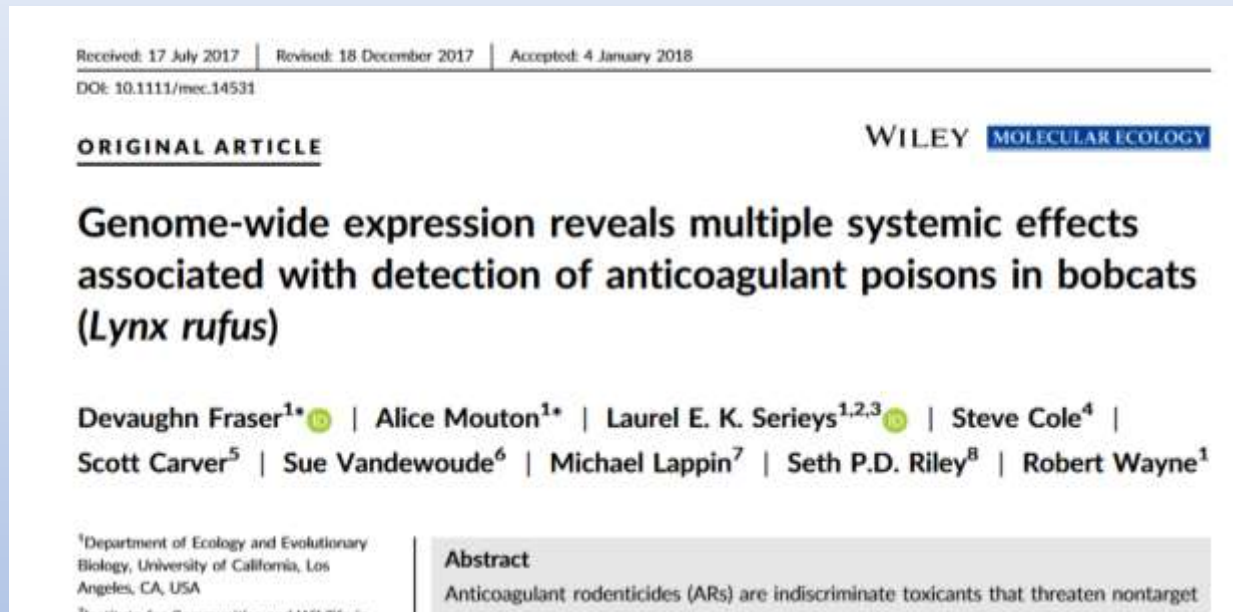
We find evidence of both inflammatory response and immune suppression associated with urban land use and rat poison exposure that could influence susceptibility to opportunistic infections.



This study indicates that cats may be more resistant to clinical effects of brodifacoum exposure than other species and suggests that the gross impacts of environmentally realistic brodifacoum exposure on humoral and cell-mediated immunity against foreign antigen exposures in domestic cats are minimal.



# ACRs lead to poor fitness



Overall, our results show that the focus on the lethal effects of toxicants developed for pest control which cause a failure of blood to clot in target species may be misplaced. Individual fitness and population persistence may be critically impacted without signs of the target effects of ARs



<http://www.urbancarnivores.com>

# Reduced Escape Response; Transplacental Exposure

Ecotoxicology (2015) 24:844–862  
DOI 10.1007/s10646-015-1429-5

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## Anticoagulant rodenticides in urban bobcats: exposure, risk factors and potential effects based on a 16-year study

L. E. K. Serieys · T. C. Armenta · J. G. Moriarty ·  
E. E. Boydston · L. M. Lyren · R. H. Poppenga ·  
K. R. Crooks · R. K. Wayne · S. P. D. Riley

Accepted: 6 February 2015 / Published online: 25 February 2015  
© Springer Science+Business Media New York 2015

**Abstract** Anticoagulant rodenticides (ARs) are increas- bobcats sampled over a 16-year period (1997–2012) and a

- A reduced escape response has been observed in rats dosed with ARs (Cox and Smith 1992), and if carnivores secondarily exposed to ARs have a similarly reduced response to threats, they may be more vulnerable to vehicle collisions or predation
- Reproductive consequences associated with AR exposure in other species have included increased miscarriage, fetal toxicosis, fetal congenital deformities, and decreased sperm counts

# 85 Bobcats in NJ

- 2013 = 0+/3 tested
- 2014 = 2+/4 tested
- 2015 = 5+/9 tested
- 2016 = 3+/12 tested
- 2017 = 3+/15 tested
- 2018 = 5+/13 tested
- 2019 = 9+/20 tested
- 2020 = 4+/9 tested



[All animals were accidental takes or roadkill]



# Regulation change

- Restricted use of products since 2014-15:
  - Commercial use only
  - Tamper-resistant packaging

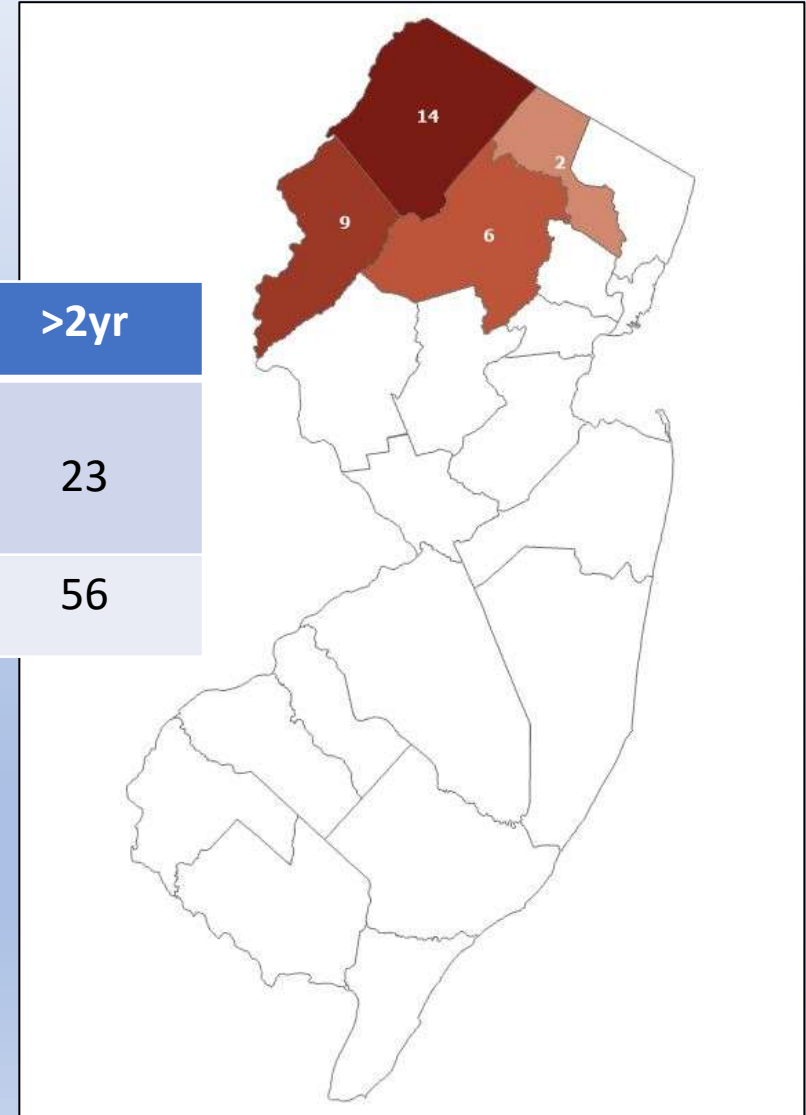


Bromethalin



Year	# bobcats tested	No ACR	Diphacinone ppm	Brodifacoum ppm	Bromadiolone ppm	Difethialone ppm	Rodenticides found	Frequency (any)	Frequency (>trace)
2013	3	3						0%	0%
2014	4	2	1	1			None (2) Brodifacoum (1) Diphacinone (1)	50% (2)	50% (2)
2015	9	4		5	4	1	None (4) Brodifacoum (1) Bromadiolone +Brodifacoum (3) Brodifacoum + Bromadiolone + Difethialone (1)	56% (5)	56% (5)
2016	12	9	3				None (9) Diphacinone (3)	25% (3)	17% (2)
2017	15	12	1	1	2		None (12) Brodifacoum (1) Bromadiolone (1) Diphacinone + Bromadiolone (1)	20% (3)	7% (1)
2018	13	8	2	3	3		None (8) Brodifacoum (1) Bromadiolone (1) Bromadiolone +Brodifacoum (1) Diphacinone + Bromadiolone (1) Diphacinone + Brodifacoum (1)	38% (5)	31% (4)
2019	20	11	7	1	2	1	None (11) Diphacinone (6) Bromadiolone (1) Difethialone (1) Diphacinone + Brodifacoum + Bromadiolone (1)	45% (9)	10% (2)
2020	9	5	3		3		None (5) Diphacinone (1) Bromadiolone (1) Diphacinone + Bromadiolone (2)	44% (4)	33% (3)
Total	85	54	17	11	14	2	None (54); one compound (20); two compounds (9); three compounds (2)	36% (31)	22% (19)

# NJ Bobcats with Rodenticide Exposure



	Male	Female	RK	Snare	<1yr	~1-1.5yr	>2yr
ACR Exposure	17	14	16	15	3	5	23
Total (85)	47	38	51	33	18	11	56

# Other Rodenticides

## Cholecalciferol

- Vitamin D3
- Causes calcification of tissues

## Strychnine

- Blocks glycine, an inhibitory neurotransmitter
- Causes neurotransmission in spinal cord → seizures



Photo courtesy: Diane Nickerson

## Bromethalin

- uncouples oxidative phosphorylation in mitochondria in CNS and liver
- Cerebral edema in 2-24hrs
- Main metabolite is bromethalin....

# Barn Owls [www.birdboxisrael.org](http://www.birdboxisrael.org)

- >3000 boxes in Israel
- Barn Owls & Kestrels
- Owls: up to 11/yr







# RAPTORS ARE THE SOLUTION

## Scientific Studies on Rodenticides, Wildlife, and Pets

On this regularly-updated page we provide links to articles, presentations, and scientific and regulatory studies about the impacts of rodenticides on wildlife and pets.

Anticoagulant rodenticides (ARs) continue to be widely used, affecting raptors and other non-target animals. These products can cause both the prey and the animal that eats it to bleed to death internally. They can also cause minor injuries to be much more severe than they would be normally—for example, a poisoned animal might hemorrhage from a wound that would not ordinarily cause death. These terrible poisons also cause “sublethal” impacts, including suppression of an animal’s immune system, and affect overall health, behavior, and survivability.

♦ = Recently added

### Wildlife:

- ♦ Sensitivity of turtles to anticoagulant rodenticides: Risk assessment in the Ogasawara Islands (Japan, 2021)
- ♦ Temporal Persistence of Bromadiolone in Decomposing Bodies of Common Kestrel (*Falco tinnunculus*) (Spain, 2020)

Accumulation of anticoagulant rodenticides in suburban wild boar: implications for human consumers (Spain, 2020)

Heavy rainfall releases anticoagulant rodenticides from baited sewer systems and outdoor surfaces into streams (Germany, 2020)

Toxic time bombs: Frequent detection of anticoagulant rodenticides in urban reptiles (Australia, 2020)

Frequent detection of anticoagulant rodenticides in raptors reflects government rodent control policy (Taiwan, 2019)

Survival and competing mortality risks: rodenticides are second-leading cause of death of mountain lions in greater Los Angeles area (2019)

<https://www.raptorsarethesolution.org/science-on-ars/>

# Thank you

**I like my meals poison free.**

---

**Rat poison kills more than rats.**

[www.raptorsarethesolution.org](http://www.raptorsarethesolution.org) | A Project of Earth Island Institute



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