Beyond DDT and Lead:
a review of toxins affecting wildlife

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Definitions

- ***Toxicant*** (or toxin, poison) – [n] any substance that can interfere with homeostasis of the organism, without acting mechanically and irrespective of temperature
- ***Toxic*** – [adj] describes the effect of the toxicant
- ***Toxicity*** – [n] the amount of a poison that will produce the toxic effect
- ***Toxicosis*** – [n] the state of being poisoned by a toxicant

Toxin Diagnosis Reality Check

- Little to no 'history'
- Limited funding for confirmatory testing
- Need to suspect specific toxin

LC/MS/MS

Toxin Diagnosis in Rehabilitation

- Clinical signs
- History
- Known or suspected exposure
- No obvious signs of disease or trauma

LC/MS/MS

When to consider toxins

- **More than one animal with similar signs**
- **No evidence of trauma or specific disease**

Locations: Pesticide use areas

- Urban / Suburban lawns
- Agricultural fields
- Golf Courses
- Road Sides
- Waterways….

Species Affected

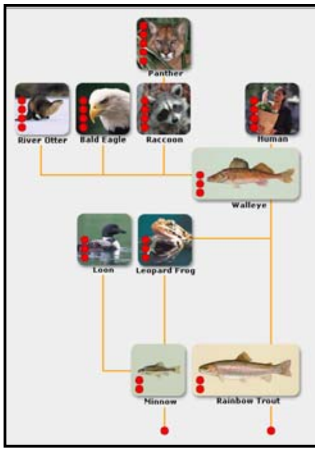
- All wildlife susceptible, but **Birds, Amphibians** and **Fish** are most sensitive
- Insectivores
- Predators
- Scavengers

http://www.jsmineset.com/2010/05/07/the-canary-is-dead/

QUIZ

- What is the difference between:

Bioaccumulation
and
Biomagnification?



Bioaccumulation = in individuals

Biomagnification = in food chain

Common Signs

1. Neurologic
   - Ataxia
   - Torticollis/Stargazing
   - Anisocoria
   - Tremors/Seizures
2. Diarrhea/Vomiting
3. Unusual odor
4. Unusual color or feel to feathers/fur
5. Sudden deaths

General Poison Treatment

1. Stabilize patient first
2. Eliminate further exposure to toxin

General Poison Treatment

3. Provide antidote if available & toxin known
4. Eliminate absorbed poison (chelation; ILE)
5. Provide supportive care

Sample Collection/Handling

Live Bird
- Whole blood, not frozen
  - Usually in EDTA
  - Zn results more reliable if non-rubber cap
  - Keep cool in shipping
- Crop/stomach content
  - In Whirl-paks™ or toxicolgically clean glass
- Contaminated fur/feathers

At Necropsy
- Often liver, kidney, brain, GI content
- Short-term storage—home freezer temps in cryotubes, wrap in Al foil placed within Whirl-paks™ or similar
- Long-term storage—freeze at -80º in toxicolgically clean glass (I-Chem® jars, royal blue top vacutainers)

Environmental Toxins

- Pesticides
- Heavy Metals
- Natural Poisons
- Endocrine Disruptors
- Oil and other Pollutants

http://www.birdfeeders.com/resources/wild-bird-articles/save-our-birds-prevent-harmful-pesticide-use

Pesticides

- Insecticides
- Acaricides
- Herbicides/Fungicides
- Rodenticides
- Avicides

- >21,000 registered
- >1,000,000,000lbs/yr
- <0.01% reach targets

Pesticide Impact on Wildlife

"It is estimated that as many as 67 million birds are killed by 'pesticides' in the United States each year, and millions more suffer from reduced breeding success as a result of poisonings."(1992)

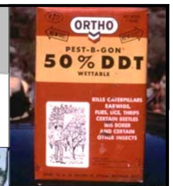
Most likely exaggerated for effect, but direct and secondary impacts do occur

Pesticide Toxicities Occur via

- Direct impact or ingestion
- Run-off into waterways
- Ingestion of treated seed
- Ingestion of target species
- Intentional (mis)use as a toxin

Specific Pesticides & Wildlife

Organochlorines



- Chlorinated Hydrocarbons
- Bioaccumulate
  - Stored in fat
- Persists

Organochlorine Toxicity

Chronic toxicity
- Eggshell thinning
- Decreased hatchability
- Poor survival of young
- Deformities

Photo credit: http://www.allposters.com/

Organochlorines in the Environment

- First pesticide use in 1939
- Found in dying grebes in early 1950's
- *Silent Springs* 1962
- DDT banned in 1972
- Toxic Substances Control Act 1976
- Bioaccumulation, persistence
- Many (e.g., Dicofol) still used

Organochlorine Toxicity

Low acute toxicity

Prolongs opening of Na+ ion gate of nerve impulse transmission

Acute clinical signs:
- Twitching
- Convulsions
- Abnormal posture
- Unable to stand
- Respiratory failure

Organochlorines

Migratory birds
- Pick up DDT in other countries
- Lower return rates from migration
- Migration releases toxin and may affect reproduction

Northern Harrier

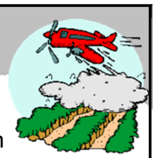
Case: Recent Organochlorine Tox.

- California condors currently have egg-shell thinning
  - Eating marine mammals that bioaccumulated DDT/DDE
- Robins in Michigan dying

Robin photo by Claude Nadeau

Photo credit: Ventana Wildlife Society

Cholinesterase Inhibitors



- Carbamates
- Organophosphates
- Est. 2 million songbirds killed annually

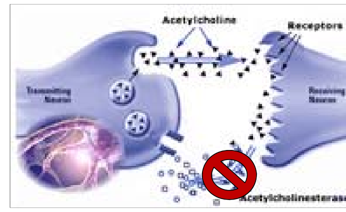
- Carbofuran
- Carbaryl (Sevin dust)
- Fenthion
- Diazinon
- Methomyl
- Coumaphos
- Phorate

Comes in many forms

Many banned or restricted in recent years

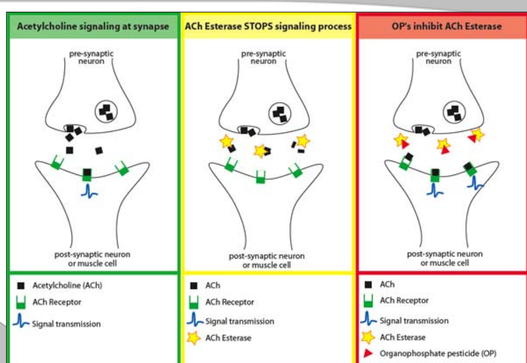
Cholinesterase Inhibitors

- Inhibits AChE by binding to its receptor site
- ACh continues to stimulate nerve transmission



http://www.youtube.com/watch?v=-glqZ8IxctE

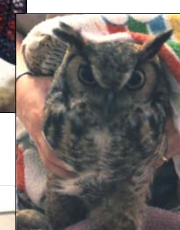
http://depts.washington.edu/opchild/images/ach.jpg



Cholinesterase Inhibitors

Clinical signs:

- Ataxia
- Salivation
- Muscular twitching
- Tachypnea
- Dilated pupils
- Convulsions
- Rigid paralysis



Diagnosis of OP/Carbamate Toxicity

- Live Bird:
  - Blood or Plasma ChE
  - Pesticide screen
    - crop/stomach contents
    - Feather wash
- Dead Bird:
  - Liver
  - Brain ChE

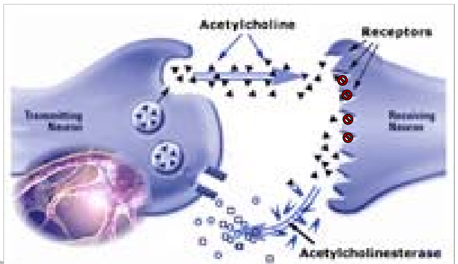
Cholinesterase Inhibitors

Treatment

- Atropine
  - to block ACh receptors
- Midazolam or Diazepam
  - to control seizures
- Activated charcoal
  - to prevent absorption
- Decontamination if external

Cholinesterase Inhibitors

- Atropine blocks the receptors, thereby blocking the signal



Case: Diazinon

- Diazinon G-14
- Applied to park
- 19 CAGO that day
  - 16 dead, 3 live
  - One died later
- 22 CAGO 2d later
  - 7 dead, 15 live

Case: Golden Malrin

- Methomyl (carbamate) & tricosene
- Intended to kill flies
- Mix w/soda to kill raccoons, skunks & opossums
- Fast acting
- Vomiting, seizures, death

Case: Furadan

- Dead fox, owl, & three dead eagles
- Two live but neurologic eagles
- Chicken carcass with Furadan

Case: International

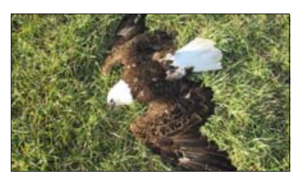
- 25 Andean condors poisoned w/OP pesticide in Chile
- 2 dead fox and 1 dead cow also found
- Run-off or intentional?

© AconcaguaNews

http://apnews.myway.com/article/20130813/DA84O2IG0.html

Case: Carbamate Incidents

- 13 dead BAEA on 20 Feb 2016 in MD
- 5 dead and 3 live BAEA on 19-20 Mar 2016 in DE
- Common source? or 'copycat' crime?



A mature bald eagle was one of 13 found dead on a farm near Federalsburg. (MD Natural Resources Police)

Case: Eagles in MD & DE

Maryland, January 2017
Dead and weakened eagles
Suspect toxicity
Under federal investigation


Photo: Courtesy of DNREC


Photo: Courtesy of Tri-State Bird Rescue & Research

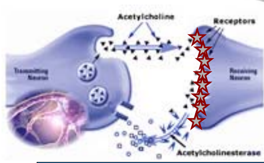
Neonicotinoids

- Synthetic nicotine
  - e.g., Imidacloprid, Nitenpyram
- Most widely used insecticides
- Persistent & water soluble


Photo credit: Janet Thomson/CBC

Neonicotinoids

- Bind to nicotinic receptors
- Toxic signs
  - Similar to Cholinesterase inhibitors
  - No good diagnostics
- Treatment
  - Oxygen & Fluids
  - Symptomatic
  - Atropine not effective



Case: Neonics in RWBB in NJ?

- Nov 2016, approx. 200 blackbirds
- Farm field
- Treated wheat seed
- Seeds in gizzards

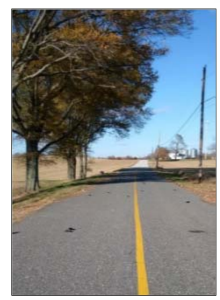


Photo courtesy of Sue Luchese, NJ DOA

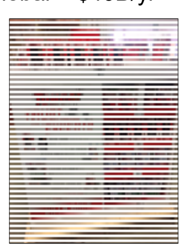
Colony Collapse Disorder

- Insecticides
  - aldicarb, carbaryl, chlorpyrifos and imidacloprid
- Fungicides
  - boscalid, captan and myclobutanil
- Herbicides
  - pendimethalin & chlorothalonil
- Pollen samples averaged 6 different pesticides

http://www.beeccdcap.uga.edu/documents/CAPArticle16.html

Rodenticides

- US = $1.4B/yr
- Global = $40B/yr



Anticoagulant Rodenticides

1[st] generation

Warfarin, Pindone

- Multiple feedings
- Less toxic

2[nd] generation

Brodifacoum, Diphacinone

- "One feeding"
- Persists in tissues

- Sometimes combined with antibiotics

Anticoagulant Rodenticides

Signs: bruising, internal hemorrhages, profuse bleeding

Dx: failure to clot; response to vit K1

Tx: vitamin K1, supportive care and minimal handling; prevent additional absorption

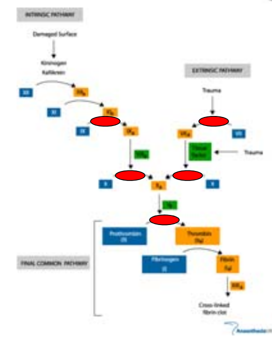


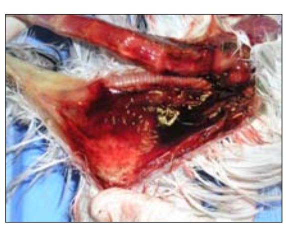
Image Source: www.frca.co.uk/

Case: Anti-coagulants (bait ingestion)

Case: Anti-coagulants
(secondary ingestion/relay toxicosis)

Case: Rodenticides

- August 2014
- Black-crowned Night Heron
- Brandywine Zoo
- Bromodialone



Case: Bobcats in NJ

- 2014 = 2/4 tested
- 2015 = 5/10 tested
- 2016 = 1/6 tested

- Rodenticides may have contributed to death

CA: those with mange had higher SGACR levels

SGAC Rodenticide Studies

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
86% raptors died/euth 2006-2010:
Journal of Zoo and Wildlife Medicine, 42, 88-97

Study at TSBRR:
82% GHOWs had exposure to SGACR;
89% of these were Bodifacoum or Bromadiolone

Misc. Rodenticides

Cholecalciferol
- Vitamin D3
- Causes calcification of tissues

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

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

Good News

SenesTech
- Sterilize rodents
- ½ life in blood is <15 min in rodents
- Breaks down in water
- Environmentally neutral

Barn Owls www.birdboxisrael.org

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

AVITROL—Avicide

BRINGING BALANCE TO AN UNBALANCED ENVIRONMENT

4-Aminopyridine
- Increases ACh release
- Clinical signs
  - Disorientation
  - Ataxia
  - Distress calls
  - Erratic flight
  - Torticollis
  - Tremors & Convulsions
  - Death

Avitrol®—Avicide

- Used to control large flocks of birds (starlings & pigeons)
  - in grain pellets
- Distress 15 minutes after ingestion
- May last 20 - 30 minutes
- Ingestion to death = 3-50 hours

Case: Avitrol® incident 2011

- Diagnose via clinical signs, history
- Prevent absorption
- Supportive care and diazepam

- Manufacturing stopped in Oct 2010; started again in 2011...

DRC-1339, Starlicide

- (3-chloro-4-methylbenzenamine hydrochloride)
- 3-24 hrs after ingestion:
  UA deposits in kidney and blood vessels→ necrosis / circulatory impairment
- Species sensitivity varies
- Metabolized quickly
- Supportive care fluids

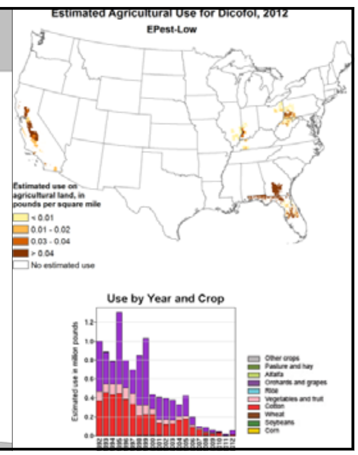
http://digitalcommons.unl.edu/icwdm_usdanwrc/585

Good News

https://water.usgs.gov/nawqa/pnsp/usage/maps/

Good News

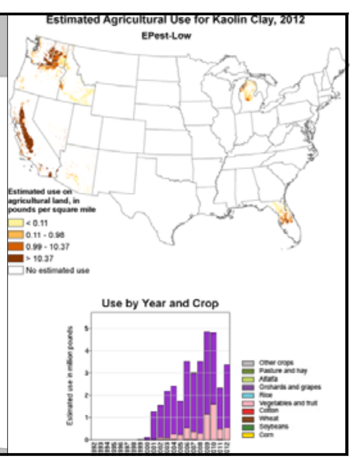
- Dicofol (& others)
  - Use is declining
  - Pressure from consumers & EPA



Good News

- Kaolin Clay
- Non-toxic
- Natural

photo: Michael Glenn, USDA Appalachian Fruit Research Station



Heavy Metals

Lead Poisoning

Plumbism

- Ingestion of lead; absorbed from GIT and stored in tissues
- CNS, ataxia, wing droop, diarrhea, crop impaction, “voice change”


QUIZ

- What are some sources of lead poisoning in wildlife?

Lead Sources


Lead Shot Fragmentation

>550 lead fragments in a muledeer neck

Source: nps.gov

Lead—Diagnosis

Clinical signs

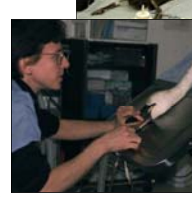
Radiographs

Blood lead level



Lead—Treatment

- Physical removal
  - Lavage
  - Endoscopy/surgery
- Psylium
- Chelation
  - DMSA (Succimer)
  - CaEDTA
  - Ca Versonate

Lead—Prevention

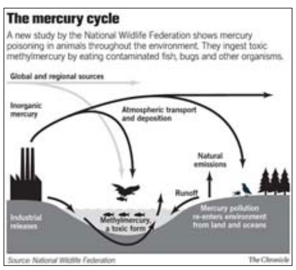
Alternative Sinkers **Alternative Ammo**

Zinc

Similar to lead toxicity
- Ataxic
- Neurologic
- Emaciated
- Dehydrated
- "Voice" change

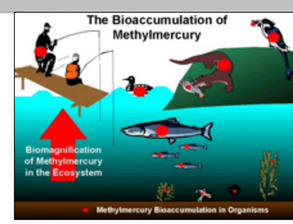
Mercury

- Naturally present
- Air pollution
  - Coal-fired power
  - Cement plants
  - Mining industries
- Winds carry it
- Returns in rain, snow and fog as methyl-mercury



Mercury

- Toxic at low levels
- Bioaccumulates
- Found Hg in loons
  - Males > females
  - high risk of behavioral and reproductive impacts based on these levels
- Adults with high Hg lack good parenting skills
  - Don't incubate consistently enough for chicks to hatch
  - Results in reduced hatching rate of eggs



Mercury

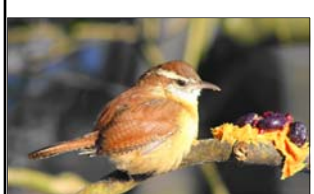
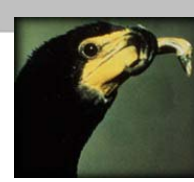


Photo: Elaine Smith

Photo: audubon.org

PCBs

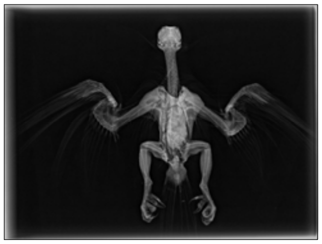
- 1st produced in 1929
- EPA banned use in 1979
- U.S. was responsible for ~half of the world's production of PCBs and imported 50% of the remainder



PCB exposure causes bird deformities like the crossed bill in this cormorant. Courtesy of EPA.

Case: PCBs

- Several Mississippi kites
- More than one nest
- Deformed ulnae
- Polydactyly



Natural Toxins

Botulism

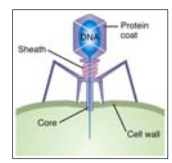
- A disease caused by *__the pre-formed toxin__* of the anaerobic, Gram +, spore-forming, bacterium *Clostridium botulinum*

Magnified x 1,040

http://www.ppdictionary.com/bacteria/gpbac/botulinum.jpg

Toxin formation

- Spores ubiquitous in aquatic environ
- Vegetative or reproductive stage
  - Mechanism to produce toxin but lack the genetic material
- 'infection' by a bacteriophage
- Viral gene encodes for toxin in vegetative stage



Images: www.blog.labplanet.com & www.giantmicrobes.com

Cycle of Avian Botulism Type C

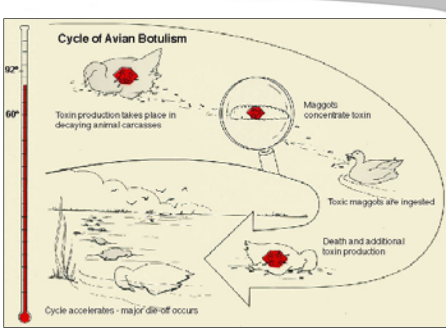


Image: USGS Field Manual of Wildlife Diseases

Botulism

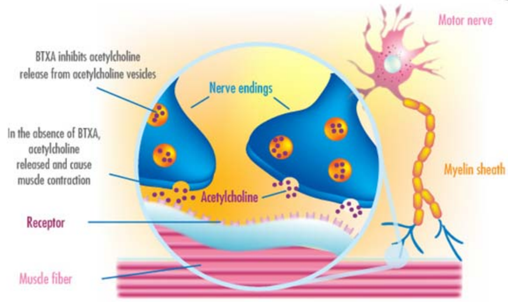
- Toxin crosses the intestinal wall and enters the blood and lymph

  -- toxin is carried to the PNS

  -- toxin binds with the neuromuscular junction

  -- blocks the release of acetylcholine

Botulism Toxin Mechanism



Botulism

- Toxin affects peripheral nerves and causes paralysis of voluntary muscles

  -- legs or wings

  -- neck

  -- 3rd eyelid

  -- tongue

  -- respiratory muscles

Botulism progression

Images: USGS Field Manual of Wildlife Diseases

Diagnosis

- Clinical signs
- Time of year
- Location found
- Verify w/serum
  - Mouse inoculation
- No specific signs on necropsy

http://clostridium-botulinum.wikispaces.com/

Botulism--Clinical Signs

Botulism — Field Treatment

- Removal of carcasses
- Protection from predators/exposure
- Access to clean water (avoid drowning)
- Good sanitation
- Nutritional support
- Botulism anti-toxin (best with Type E)

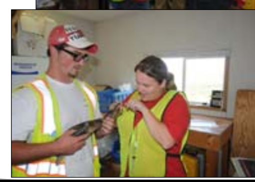
Image: USGS Field Manual of Wildlife Diseases

Botulism

- Treatment
  - Check vent for maggots / soiling
  - Flush eyes, lubricate with ophthalmic ointment
  - Gavage with oral fluids every 2 hours
  - Minimize handling & noise


Case: Botulism Incidents

- Poplar Island, MD
- Mostly Shorebirds & Ducks
- Every fall since ~2011

Harmful Algal Blooms (HAB)

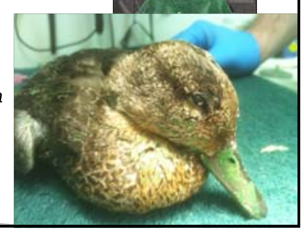
- Microalgae harbor and amplify potent phytotoxins
- Affects respiratory, GI, and/or neurologic systems
- Outbreaks often due to heavy rains increasing runoff of farm wastes and warm temperatures
- Increase w/ global warming??

Variety of Harmful Algal Blooms

•*Gymnodinium breve* - marine mammal die-offs and epidemics in cormorants and seabirds

•*Ciguatera* - Hawaiian Monk Seal die-off early 1990's

•Blue-green algae (*Cyanobacteria* and *Microcystins*) - acute die-offs in mallards and other waterfowl

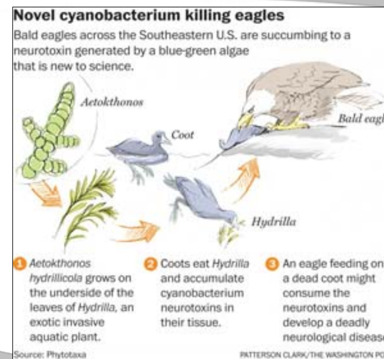
Harmful Algal Blooms

Microcystin bloom may initiate botulism and steatitis in piscivorous birds


Case: HAB Incidents

- *Microcystin* bloom on Poplar Island
- Sept-Oct 2012 &13
- Neurologic signs
- High mortality
- Concurrent botulism

HABs—AVM



Over-ripe Berries!

- Brazilian Pepper Tree (Schinus terebinthifolius)
  - Ethanol = 260–1,000 ppm
- Juniper berries
- Ampelopsis brevipedunculata in the Vitaceae (Grape Family)
- *Nandina domestica*
  - cyanide

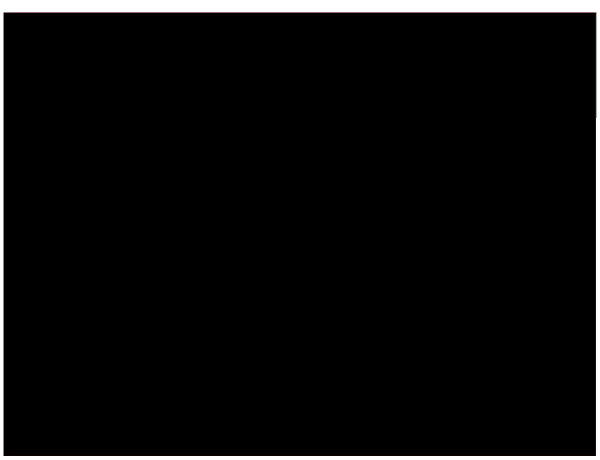
CEDW photo
Birds.Cornell.edu

http://www.hindawi.com/journals/vmi/2010/818159/

Toxic Mining Pits

- Est. 10,000 SNGO
- Montana, 2016-17

http://strangesounds.org



Pentobarbital Toxicity

- Euthanasia solution in discarded carcasses = Barbiturate overdose
- 29 BAEAs on one cow in Canada
- May 2014—Bald Eagle in Mt Pocono, PA
- Oct 2014—6 Turkey vultures in Marin, CA

Bald eagle perched on carcass bags at dump. Photo courtesy of Dr. Dick Stroud, USFWS (photographer unknown).

Salt Toxicity

- Potential problem for wildlife in winter
- Dehydration, intra-cellular & cerebral edema
- Thirst, CNS signs, respiratory distress, paralysis, discharge from nares

Other Garbage Toxicities

- Heavy metals
- Oils, ethylene glycol, etc.
- Foreign body impactions
- Death by chocolate

Vultures and gulls scavenge an active landfill. Photo courtesy of SA John Rawls, USFWS-LE.

Other Drug Toxicities

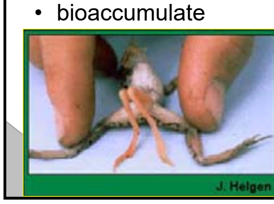
- Vultures in India
- mysterious deaths for 4 years…
- 3 *Gyps* species
- Diclofenac

Photo: source unknown; somewhere on the www…

Endocrine Disruptors

PCB's & PBB's
Organochlorines (dicofol)
Pesticides + Fertilizers

- Stable
- lipophilic
- bioaccumulate



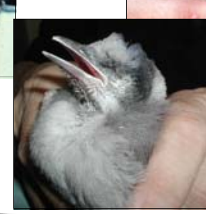
Endocrine Disruptors

- Altered growth rates
- Reproductive problems
- Alterations in sex ratios
- Physical deformities
- Cancers
- Immunosuppression

http://www.pmac.net/endodisr.htm

Environmental Toxins??

Beak deformities



Anoptic birds

Environmental Toxins??

Hawk photo courtesy Diane Nickerson

Supernumerary limbs & deformities

Thank You!