

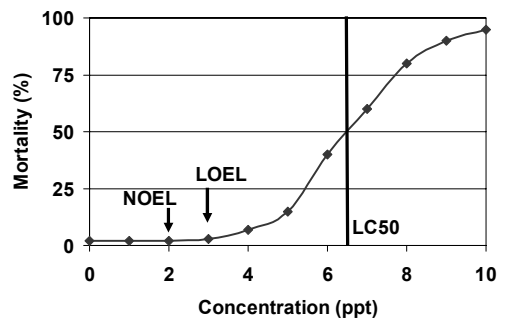
Wildlife Toxicology

Sources & Types of Toxins

- Natural
 - Minerals, salts, naturally occurring elements
 - Plant toxins (e.g., tannins, arsenates, glycosides)
 - Animal toxins (venoms)
 - Fungal toxins
 - Microbial/algal toxins ("red tide", *Pfiesteria*, *Botulinum*)
- Human Generated
 - Agrichemicals (pesticides, herbicides, fertilizers)
 - Industrial chemicals (e.g., PCBs)
 - Radioisotopes
 - Heavy metals (lead, mercury, etc.)
 - Hormonal mimics

Principles & Terms

- Effect levels
 - LD50 dose that kills 50% of animals (mg/kg)
 - LC50 concentration in food or water that kills 50% (ppt, ppm, ppb)
 - LOEL "lowest observed effect level"
 - Minimum dose or concentration causing statistically detectable effects.
 - NOEL "no observed effect level"
 - Maximum dose or concentration causing NO statistically detectable effects.
- Risk assessment
 - Is expected dose/concentration likely to cause adverse effects?



Principles & Terms

- Bioavailability
 - Availability of toxins to enter animal bodies and cause harm
 - Chemical reactions in the environment can make compounds more or less available at a given concentration
 - E.g., microbes can convert inorganic mercury (uptake is difficult) to methyl mercury (uptake is easy)
- Bioaccumulation
 - Some toxins are stored and accumulated in the body
- Biomagnification
 - Fat-soluble toxins tend to become more concentrated up the food chain

Salt

- High plasma Na → cells shrink (incl. brain cells)
- Effects:
 - Weakness, paralysis
 - Brain is red & congested

Salt

- Stolley and Meteyer 2004 (JWD 40:571-4) observed black-bellied whistling ducklings that hatched on an island in a hypersaline lake (La Sal Vieja, Texas)
 - 71% mortality of within 5 hrs after entering the water (some in minutes)
 - Carcasses had >2,000 ppm Na in brain

Selenium

- A necessary nutrient, but toxic at high concentrations
- Sources: soil (esp. in western U.S.), plants, & invertebrates; smelters, sewage sludge, irrigation runoff
- Effects:
 - Developmental abnormalities, hydroencephaly, emaciation, blindness

Selenium

- Kesterson Reservoir National Wildlife Refuge
- est. 1970 in San Joaquin Valley, CA
- Irrigation runoff → highly elevated Se levels (30X federal guidelines)
- Dieoffs, reproductive failure, and deformities in water birds observed beginning in early 1980s

Lead

- Sources:
 - Ingestion of shot pellets, fishing sinkers, mine wastes, paint, bullet fragments
- Effects:
 - Uncoordination, inability to fly (birds), weakness, paralysis (wing droop in birds) emaciation, digestive impaction
- Species most affected: ducks & geese, loons, eagles, California condors

From: NWHC Field Manual of Wildlife Diseases (Ch 43)

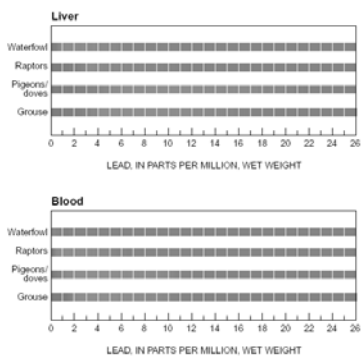


Figure 43.19 Lead residues in the liver and blood associated with subclinical, toxic, and mortality findings in several groups of birds. Variability within groups occurs because of differences in species and a variety of factors affecting toxicity within species.

Lead

- Population Impacts:
 - Major mortality source of waterfowl (mainly due to ingestion of shot pellets and sinkers)
 - Lead-poisoned birds are very vulnerable to predators
 - Bellrose (1959 Ill. Nat. Hist. Surv. Bull.) estimated that
 - 25% of mallards in North America carried shot pellets in their gizzards
 - 4% of mallard population died of lead poisoning & complications / yr (700,000 birds)
 - Sidor et al. (2003, JWD 39:306-15)
 - Common loon populations in northeast have decreased since 1980's
 - almost 50% of deaths of adult common loons due to lead poisoning

Lead

- Management
 - Since 1991, lead pellets have been illegal for hunting waterfowl nationwide
 - Estimated to have reduced lead poisoning deaths in waterfowl by 64% (Anderson et al. 2000 JWM 64:848-57)
 - Lead pellets and bullets still legal for upland game hunting, except on many national wildlife refuges
 - Small lead sinkers have been banned in a few states (New Hampshire, Maine, New York, Vermont), Canada's national parks, and Yellowstone Park
 - Bans have been proposed in several other states

Agrichemicals

- Fertilizers: generally low acute toxicity, but can cause harmful algal blooms
- Herbicides: generally low acute toxicity, but some are endocrine disruptors (e.g., atrazine)
- Insecticides
 - Organophosphates
 - Organochlorines
 - Carbamates
 - Pyrethroids

Atrazine

- Most used herbicide in U.S. (Illegal in Europe)
 - 60 million pounds applied in 2001
 - Typically applied to crops, increases corn yield ~4%
 - Almost nowhere is atrazine-free
 - Found in groundwater, surface water, soil, and precipitation
- Endocrine disruptor
 - Interferes with hormone production, action, or degradation

Atrazine

- Reproductive anomalies in amphibians:
 - absent/atrophied testes, hermaphroditism, polygonadism, testicular oocytes, infertility, low testosterone
 - Effects detected at concentrations as low as **0.1 ppb**
 - Loss or diminishment of secondary sex characteristics (e.g. frog larynx)
 - Increased mortality

Organochlorines (OCs)

- DDT, Aldrin, Dieldrin, Mirex, etc.
- Became widely used after WWII
- DDT was banned in U.S. in 1972, use of other OC's strongly reduced
- Exposure
 - Sprayed on crops or trees, or used in seed coatings
 - Persist for many years in the environment
- Fat soluble
 - bioaccumulate: concentrations in tissue > food
 - biomagnify: concentrations increases up the food chain

Organochlorines (OCs)

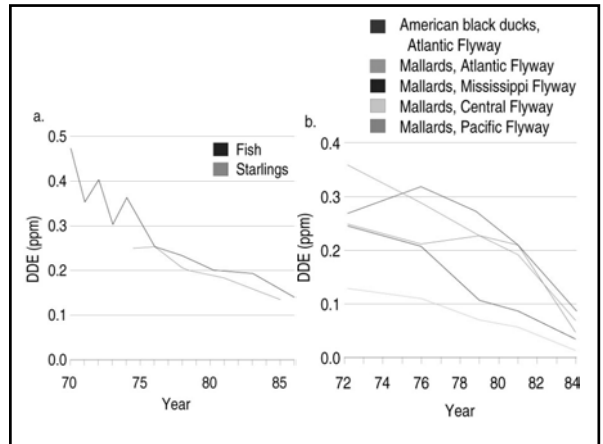
- Toxicity
 - Some (chlorodienes) have high acute toxicity
 - DDT & similar show generally low acute toxicity, but cause eggshell thinning in birds (especially raptors) and can be endocrine disruptors
 - Mobilizing fat reserves (as in migration) can release acutely toxic levels of OC's into bloodstream
- Effects:
 - Acute toxicity: neurological disfunction, paralysis, uncoordination, convulsions, lethargy
 - Chronic toxicity: eggshell thinning, emaciation, decreased embryo viability

Table 40.2 Toxicity for the mallard duck of some chlorinated hydrocarbon insecticides.

[Modified from Heinz and others, 1979. LC₅₀ is the insecticide concentration, in parts per million, in feed that is required to kill 50 percent of birds during a given period of time. LD₅₀ is the insecticide amount, in milligrams per kilogram of body weight, in a single dose that is required to kill 50 percent of birds. ppm, parts per million; mg/kg, milligrams per kilogram; >, greater than; ≥, greater than or equal to. — no data available]

Insecticide	Subacute exposure LC ₅₀ (ppm)	Acute exposure LD ₅₀ (mg/kg)
Aldrin	155	520
Chlordane	858	1,200
DDT	1,869	>2,240
Dieldrin	169	381
Endosulfan	1,053	33
Endrin	22	5.6
Heptachlor	480	≥2,000
Lindane	—	>2,000
Mirex	>5,000	>2,400
Toxaphene	538	71

From: NWHC Field Manual of Wildlife Diseases (Ch 40)



Organophosphates (OPs)

- Malathion, Parathion, Guthion, Diazinon, etc.
- Sprayed on crops & trees, applied as granules on ground, used in seed coatings, applied to livestock
- Exposure
 - Ingestion (including food, water, grooming), inhalation, transdermal
- Nerve toxins – acutely toxic!
 - inhibit acetylcholinesterase – prevent breakdown of neurotransmitter acetylcholine
 - break down quickly
 - unlikely to bioaccumulate, but may cause prey to be more vulnerable to predation
 - secondary poisoning (predators eating poisoned prey) is a major problem

Table 39.1 Toxicity for birds of organophosphorus pesticides and carbamate pesticides.

[Modified from Hoffman and others, 1995. LD₅₀ is the single oral dose of pesticide in milligrams per kilogram of body weight that is required to kill 50 percent of the experimental population]

Compound	Class	Species LD ₅₀		
		Mallard duck	Ring-necked pheasant	Red-winged blackbird
Aldicarb	Carbamate	3.4	5.3	1.9
Carbaryl	Carbamate	>2,000	707	56
Carbofuran	Carbamate	0.5	4.1	9.4
Metolcarb	Carbamate	13	279	4.6
Mexacarbate	Carbamate	3.0	4.6	10
Adaphos-methyl	OP	136	75	8.5
Diazinon	OP	42	29	6.6
Ethion	OP	>2,000	1,207	45
Phorate	OP	0.6	7.1	1.0
Terbufos	OP	79	35	42

From: NWHC Field Manual of Wildlife Diseases (Ch 39)

Clinical signs and bird behaviors that are commonly associated with acute exposure to cholinesterase-inhibiting pesticides
[Modified from Mosau, 1991]

- Convulsions
- Hyperexcitability
- Incoordination of muscular action (ataxia)
- Muscular weakness (myasthenia)
- Difficult breathing (dyspnea)
- Rapid breathing (tachypnea)
- Vomiting
- Defecation
- Diarrhea
- Spasmodic contraction of anal sphincter (tenesmus)
- Lethargy
- Induced tranquility
- Head and limbs arched back (opisthotonus)
- Slight paralysis (paresis)
- Blindness
 - Contraction of pupils (miosis)
 - Dilatation of pupils (mydriasis)
 - Drooping of eyelid (ptosis)
 - Protrusion of eyes (exophthalmia)
 - Excessive tear formation (lacrimation)
 - Excessive thirst (polydipsia)
 - Bleeding from nares (epistaxis)
 - Erection of contour feathers (piloerection)

Other Insecticides

- **Carbamates** (Sevin, Furadan, Fenoxycarb)
 - acute nerve toxins
 - less persistent than organochlorines
 - unlikely to bioaccumulate
 - secondary poisoning is a problem
- **Pyrethroids**
 - pyrethrums: derived from *Chrysanthemum* plants
 - pyrethroids: synthetic versions of pyrethrums
 - low toxicity to birds and mammals (high toxicity to fish)
 - low persistence in environment
 - unlikely to bioaccumulate

Things to Remember

- **Principles & Terms**
 - LD50, NOEL, Bioaccumulation, etc.
- **Types & sources of toxicants**
- **Types & characteristics of agrichemicals**
- **Case studies**