Relative Hazards of Turf and Ornamental Pesticides to Non-target Species

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One of the more publicly visible issues involving pesticide use on turfgrass and in landscape plant protection involves harm to desirable non-target species, such as birds, fish, earthworms, and other wildlife. Inadvertent wildlife kills draw scrutiny to pesticide application. Federal laws protecting wildlife have caused further regulation of this issue. At the same time, landscape practices such as gardening to attract wildlife to yards and the expanding popularity of fish ponds are increasingly bringing fish and birds in close contact with landscape plantings which may need protection from pests.

Potential hazards to fish and birds are sometimes not well communicated on the label. However, it is in the interest of turf care and landscape professionals to become aware of potential hazards associated with products, so that problems can be minimized.

Methods used in determining toxicity of pesticides

The relative toxicity of various chemicals, including pesticides, is often expressed in terms of their $_{50}$. This is the dose of the chemical which kills 50 percent of the test animals. The figure is adjusted for body weight of the animal and expressed as a number based on milligrams (mg) of pesticide required per kilogram (kg) of body weight. This is equivalent to parts per million of body weight. In this scheme, the lower $_{50}$ the higher the toxicity.

$_{50}$ values can be developed for various measures of pesticide exposure. The most easily developed and most widely available are values based on a single exposure applied either orally (ingestion) or to the skin (dermal). These are often called acute exposure values.

Effects of pesticides to fish and other aquatic organisms are measured somewhat differently. Instead, an $_{50}$ value is given, based on the lethal concentration of the pesticide diluted in water. Studies on fish are usually run over a 4 day period (96 hour), and $_{50}$ expressed in parts per million (or parts per billion) of the pesticide in water. For both $_{50}$ and $_{50}$ values, the technical (i.e., unformulated) pesticide is almost always tested. The values given in Tables 1 and 2 reflect this. Formulated pesticides may have different values, since the other ingredients added during formulation can affect uptake by fish or birds.

Turf and ornamental insecticides and miticides are sometimes toxic to birds. The insecticides most toxic to birds (Table 1) are primarily organophosphates, such as diazinon, Dursban, and Mocap. Bendiocarb (Dycarb, Turcam) is the lone carbamate among the higher risk insecticides. Most of these insecticides are considerably more toxic to birds than to mammals. Diazinon, for instance is 100 times more toxic to birds ($_{50}$ value 3.5 mg/kg) than for mammals (about 350 mg/kg), a few granules of the 14G formulation being a lethal dose to many birds. This insecticide typically carries a label indicating only moderate toxicity (Warning), whereas it would be in the highest risk category if risk to birds was the basis for label direction warnings. Concerns about toxicity have recently resulted in more restrictive diazinon-product labels.

Table 1. Acute avian (bird) toxicity of insecticides and miticides used in tree and turf care. $_{50}$ values for single feed acute toxicity of mallard ducks are given unless otherwise indicated.

Pesticide (Trade name)	$_{50}$ value	Pesticide Class
Highly toxic to birds (equivalent to Category I-Danger/Poison label-pesticides for human exposure, oral $_{50}$ 0-50)		
bendiocarb (Turcam, Dycarb, Ficam)	3.1 mg/kg	Carbamate
diazinon	3.5 mg/kg	Organophosphate
ethoprop (Mocap)	4.2-61 mg/kg	Organophosphate
dimethoate (Cygon)	7-22 mg/kg	Organophosphate
Moderately toxic to birds (equivalent to Category II-Warning label-pesticides for human exposure, oral $_{50}$ 51-500)		
isazophos (Triumph)	61 mg/kg	Organophosphate
chlorpyrifos (Pageant, Dursban)	76.6 mg/kg	Organophosphate
avermectin (Avid)	84.6 mg/kg	Avermectins
fonofos (Crusade)	128 mg/kg	Organophosphate
imidacloprid (Merit, Marathon)	152 mg/kg (quail)	Chloronicotinyl
acephate (Orthene)	350 mg/kg	Organophosphate

Lower toxicity to birds (equivalent to Category III-Caution label-pesticides for human exposure, oral $_{50}$ 501+)		
bifenazate (Floramite)	726 ppm	Miticide
fenpropathrin (Tame)	1089 mg/kg	Pyrethroid
malathion	1485 mg/kg	Organophosphate
spinosad (Conserve)	> 2000 mg/kg	Naturalyte
pymetrozine (Endeavor)	> 2000 mg/kg	Pyridine azomethine
pyridaben (Sanmite)	> 2000 mg/kg	Miticide
bifenthrin (Talstar)	> 2150 mg/kg	Pyrethroid
fipronil	> 2150 mg/kg	Phenyl pyrazole
carbaryl (Sevin, Chipco Sevimol)	> 2179 mg/kg	Carbamate
fenoxycarb (Precision)	> 3000 mg/kg	Carbamate (IGR)
lambda-cyhalothrin (Scimitar)	> 3950 mg/kg	Pyrethroid
fluvalinate (Mavrik)	> 2510 mg/kg	Pyrethroid
hexythiazox (Hexygon)	> 2510 mg/kg	Miticide, unclassified
propargite (Ornamite)	> 4640 mg/kg	Miticide, unclassified
cyfluthrin (Tempo)	> 5000 mg/kg	Pyrethroid
halofenozide (MACH-2)	> 5000 mg/kg	Growth regulator
permethrin (Perm-X, Astro, Intercept)	> 9,900 mg/kg	Pyrethroid
Pesticides of low toxicity to other birds but data for mallards unavailable. Data on $_{50}$ values, if given, is for bobwhite quail.		
dicofol (Kelthane)	3010 mg/kg	Chlorinated hydrocarbon
dienochlor (Pentac)	4319 mg/kg	Chlorinated hydrocarbon

Toxicity of turf and ornamental insecticides and miticides to fish. Fish show a very different pattern of susceptibility to insecticides and miticides. The newer insecticides, pyrethroids (Talstar, Mavrik, Tempo) and avermectins (Avid), dominate the high risk insecticides to fish (Table 2). For example, bifenthrin, the active ingredient in Talstar, has an $_{50}$ value equivalent to 1 teaspoon per 8,680,560 gallons of water.

It is regularly pointed out by manufacturers of pyrethroid insecticides that organic matter in natural ponds binds to most of the insecticide. This greatly reduces risk hazards of these products, although they remain inherently toxic to fish and need to be used with special caution in and around fish-bearing waters. Concerns about these compounds has greatly affected their registration progress in recent years, particularly where endangered aquatic species occur.

Many of the miticides (Pentac, Kelthane) also show considerable toxicity to fish, whereas they are of much lesser risk, to mammals and birds. Organophosphates are highly toxic to birds, but are much less toxic to fish.

Table 2. Acute toxicity of insecticides and miticides used in tree and turf care to rainbow trout. $_{50}$ (lethal concentration in water) values for 96 hour exposure.

Pesticide (Trade name)	$_{50}$ value	Pesticide class
bifenthrin (Talstar)	0.15 ppb	Pyrethroid*
cyfluthrin (Tempo)	0.68 ppb	Pyrethroid*
fluvalinate (Mavrik)	2.9 ppb	Pyrethroid*
avermectin (Avid)	3.6 ppb	Avermectins
isazophos (Triumph)	6.3 ppb	Organophosphate
fenpropathrin (Tame)	10.3 ppb	Pyrethroid*
permethrin (Perm-X, Astro, Intercept)	12.5 ppb	Pyrethroid*
dienochlor (Pentac)	50 ppb	Chlorinated hydrocarbon
fonofos (Crusade)	50 ppb	Organophosphate
dicofol (Kelthane)	53-86 ppb	Chlorinated hydrocarbon
lambda-cyhalothrin (Scimitar, Battle)	240 ppb	Pyrethoid*
fipronil	248 ppb	Phenyl pyrazole
diazinon	635 ppb	Organophosphate
propargite	118 ppb	Miticide, unspecified
fenoxycarb (Precision)	666 ppb	Carbamate (IGR)
binfenzate (Floramite)	760 ppm	Miticide, unspecified
ethoprop (Mocap)	1.02-1.85 ppm	Organophosphate
dimethoate (Cygon)	1-10 ppm	Organophosphate
bendiocarb (Turcam, Ficam, Dycarb)	1.55 ppm	Carbamate
carbaryl (Sevin, Chipco Sevimol)	1.95 ppm	Carbamate
malathion	2.00 ppm	Organophosphate
chlorpyrifos (Dursban, Pageant)	3.0 ppm	Organophosphate

Pesticide (Trade name)	$_{50}$ value	Pesticide class
halofenozide (MACH-2)	> 8.6 ppm	Growth regulator
spinosad (Conserve)	30 ppm	Naturalyte
pymetrozine (Endeavor)	> 117 ppm	Pyridine azomethine
imidacloprid (Merit, Marathon)	> 128 ppm	Chloronicotinyl
hexythiazox (Hexygon)	> 300 ppm	unclassified
acephate (Orthene)	> 1000 ppm	Organophosphate

ppb = parts per billion; ppm = parts per million.

* Note: These values indicate hazard under laboratory conditions. Hazard under field conditions may differ greatly. For example, most pyrethroid insecticides appear to have greatly reduced hazard in field situations because they have a high affinity to organic matter particles in water.

Toxicity of turf and ornamental insecticides and miticides to earthworms. Earthworms are essential to lawn health, as macrodecomposers that help recycle organic matter and naturally aerate soils. Destruction of earthworms can disrupt a healthy soil ecosystem, contributing to other problems, notably build-up of thatch. Older insecticides in the chlorinated hydrocarbon group, such as chlordane, devastated earthworms creating unhealthy lawn environments. Currently used pesticides have lesser effects on lawn decomposers. However, even among current products some have potentially great impact on earthworms.

The most recent data on lawn care pesticide impact on earthworms was produced by Dr. Dan Potter at the University of Kentucky. In field trials (Table 3), only a few of the tested products significantly impacted populations two weeks after treatment. These primarily included the carbamate insecticides, such as carbaryl and bendiocarb and the fungicides benomyl along the organophosphate insecticide ethoprop (Mocap). Most other commonly used insecticides and fungicides had little, if any, impact on earthworm populations.

Table 3. Effects of pesticides on earthworm populations. (Based on data from Dr. Dan Potter, University of Kentucky.)

Pesticides that affected earthworm populations two-three weeks after treatment (% population reduction)
Dursban 4E (-32.3)
Diazinon 14G (-58.4)
Triumph 4E (-59.4%)
Benomyl (Tersan 1991) (-60.0)*
Sevin SL (-89.8)*
Mocap 10G (-96.8)*
Turcam 2.5G (-99.0)*
Fonofos (Crusade) (-96)**
Thiophanate-methyl (Cleary's 3336) (-88)**
Pesticides that did not have significant effects on earthworm populations
2,4D
Triclopyr
Dicamba
Senariol (Rubigan)
Triademephon (Bayleton)
Isofenphos (Oftanol)
Pendimethalin (Pre-M, etc.)
Trichlorfon (Proxol)
Chlorothalonil (Daconil 2787)
Propaconazol (Banner)
Iprodione (Chipco 26019)
Isoxaben (Gallery)
Prodiamine (Barricade)
Dithiopyr (Dimension)
Mycobutanil (Eagle/RH3866)
Bifenthrin (Talstar)
Cyfluthrin (Tempo)
Fluvalinate (Mavrik)
Flurprimidol (Cutless)
Mefluidide (Embark)
Metalaxyl/Mancozeb (Pace)
Fosetyl-al (Alliete)
Cyprocanazole (Sentinel)
Tebuconazole (Lynx)
Azadirachtin (Margosan-O)
Steinernema carpocapsae (Savior)
Halofenozide (MACH-2)

* Pesticides that had significant effects on earthworm populations 20 weeks after application. Reduction of earthworm populations at 20 weeks ranged from 79%-40%.

** 20 week evaluations not made.

These data indicate the variable effects that pesticides can have on different types of organisms. Becoming aware of these differences can allow the applicator to use them with great care and avoid harming susceptible species. This can allow avoidance of hazardous materials in areas where highly sensitive species occur. However, the most important factor in determining hazard of a pesticide use is how the pesticide is applied. Applicators should always attempt to make applications in a manner that best avoids exposure to non-target species. Time of application, limiting the area treated, control of drift, rates and formulation are all important factors which can greatly affect the severity of unintended effects of a pesticide application.