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

Whitney Cranshaw
Colorado State University

One of the more publicly visible issues involving pesticide use in turfgrass and landscape plant protection involves harm to desirable 'non-target' species, such as birds, fish, earthworms, and other wildlife. Pesticide applications do have the potential to harm these organisms - as well as the intended target pest species (grubs, webworms, billbugs, chinch bugs, etc.).

Inadvertent wildlife kills can draw intense scrutiny to the applicator of pesticides. Federal laws protecting wildlife have caused further regulation of pesticide use in the landscape. Landscape practices, such as gardening to attract wildlife and the expanding popularity of fish ponds, are increasingly bringing fish and birds into close contact with landscape plantings which may need pest protection.

Potential hazards of some turf pesticides to fish and birds are sometimes not well communicated on the pesticide label. A generic warning is used, but too often the warning doesn't reflect the seriousness of the potential hazard. It is in the interest of the turf care professional to be aware of these potential special hazards associated with pesticide products so that problems can be minimized.

Methods of Determining Pesticide Toxicity

The relative toxicity of various chemicals, including pesticides, is often evaluated in terms of their LD50 value. This is the lethal 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 kilograms (kg) of body weight (This is equivalent to parts per million of body weight). Using this approach, lower LD50 values indicate greater toxicity.

LD50 values can be developed for various types of pesticide exposure. The LD50 values most easily developed - and most widely available - are those based on a single exposure applied either orally (ingestion) or to the skin (dermal). These are often called acute exposure values.

Pesticide toxicity to fish and other aquatic organisms is measured somewhat differently. Instead of a lethal dose (LD) value, a lethal concentration (LC50) value is given, based on the concentration of the pesticide diluted in water that will kill 50 percent of an exposed fish population. Studies on fish are usually run over a four-day period (96 hours) and LC50 values are expressed in parts per million (or parts per billion) of the pesticide in water.

For both LD50 and LC50 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 because the other ingredients added during formulation can affect uptake by fish or birds. Inert ingredients found in the formulated product can also affect toxicity.

Toxicity of pesticides to earthworms, a group of animals important for lawn health, is not routinely determined in laboratory trials. Information on this subject is based on field trials conducted by turfgrass researchers, often entomologists.

Toxicity of turf and ornamental insecticides and miticides to birds. The insecticides most toxic to birds (Table 1) are primarily organophosphate insecticides such as diazinon, Cygon, 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 (LD50 value 3.5 mg/kg) than for mammals (about 350 mg/kg). A few granules of the 14G formulation of diazinon would be considered a lethal dose to many birds. This insecticide typically carries a label indicating only moderate toxicity (Warning) but would be in the highest risk category if risk to birds was the basis for assigning label warnings. Concerns about toxicity have recently resulted in more restrictive diazinon-product labels.

Toxicity of turf and ornamental insecticides and-miticides to fish. Fish show a very different spectrum of susceptibility to insecticides and miticides. The newer insecticides, pyrethroids (Talstar, Mavrik, Tempo) and avermectins (Avid), dominate the insecticides of high risk to fish. These are extremely toxic to fish, at least in the clear water tanks in which most studies have been conducted. For example, bifenthrin, the active ingredient in Talstar has an LC50 value equivalent to 1 teaspoon per 8,680,560 gallons of water.

Table 1. Acute avian (bird) toxicity of insecticides and miticides used in tree and turf care. *LD50 values for single feed acute toxicity of mallard ducks are given unless otherwise indicated.*

Pesticide (Trade name)	*LD50 value*	*Pesticide Class*
Highly toxic to birds (equivalent to Category I-Danger/Poison label-pesticides for human exposure, oral LD50 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 LD50 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 LD50 501+)		
fenpropathrin (Tame)	1089 mg/kg	Pyrethroid
malathion	1485 mg/kg	Organophosphate
spinosad (Conserve)	> 2000 mg/kg	Naturalyte
biphenthrin (Talstar)	> 2150 mg/kg	Pyrethroid
fipronil	> 2150 mg/kg	Phenyl pyrazole
carbaryl (Sevin, Chipco Sevimol)	> 2179 mg/kg	Carbamate
lambda-cyhalothrin (Scimitar)	> 3950 mg/kg	Pyrethroid
fluvalinate (Mavrik)	> 2510 mg/kg	Pyrethroid
hexythiazox (Hexygon)	> 2510 mg/kg	
cyfluthrin (Tempo)	> 5000 mg/kg	Pyrethroid
halofenozide (MACH-2)	> 5000 mg/kg	Growth regulator
permethrin (Perm-X, Astro)	> 9,900 mg/kg	Pyrethroid
Pesticides of low toxicity to other birds but data for mallards unavailable. Data on LD50 values, if given, is for bobwhite quail.		
dicofol (Kelthane)	3010 mg/kg	Chlorinated hydrocarbon
dienochlor (Pentac)	4319 mg/kg	Chlorinated hydrocarbon

It is regularly emphasized by manufacturers of pyrethroid insecticides that organic matter in natural ponds binds to and inactivates most of the insecticide. Even though this greatly reduces the risk hazards of these products, they still 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 progress of registration in recent years, particularly where endangered aquatic species occur.

Many of the miticides (Pentac, Kelthane) also show considerable toxicity to fish, but they are of much lesser risk to mammals and birds. Organophosphates, which are highly toxic to birds, are generally at the bottom among insecticides that are ranked for their toxicity to fish.

Toxicity of turf and ornamental insecticides and miticides to earthworms. Earthworms are essential to lawn health, in that they are macrodecomposers that help recycle organic matter such as thatch and they naturally aerate soils. Destruction of earthworms can disrupt a healthy soil ecosystem, contributing to other problems, notably build-up of thatch layers. Older insecticides in the chlorinated hydrocarbon group, such as chlordane, devastated earthworms and created unhealthy lawn environments. Pesticides currently in use apparently have considerably less effects on decomposers inhabiting turf. However, even among current products some can have a potentially serious impact on earthworms.

The most recent data on the impact of lawn care pesticides on earthworms was produced by Dr.

Table 2. Acute toxicity of insecticides and miticides used in tree & turf care to rainbow trout. *LC50 (lethal concentration in water) values for 96 hour exposure.*

Pesticide (Trade name)	*LC50 value*	*Pesticide class*
biphenthrin (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)	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
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
halofenozide (MACH-2)	> 8.6 ppm	Growth regulator
spinosad (Conserve)	30 ppm	Naturalyte
imidacloprid (Merit, Marathon)	> 128 ppm	Chloronicotinyl
hexythiazox (Hexygon)	> 300 ppm	
acephate (Orthene)	> 1000 ppm	Organophosphate

ppb = parts per billion; ppm = parts per million.
** Note: These values indicate hazards under laboratory conditions. Hazards under field conditions might differ greatly. For example, most pyrethroid insecticides appear to have greatly reduced hazard in field situations because they have a high attraction to organic matter particles in water.*

Dan Potter at the University of Kentucky. In field trials (Table 3), out of all the products tested, only a few significantly reduced earthworm populations two weeks after treatment. These primarily included the carbamate insecticides (carbaryl, bendiocarb) and fungicides (benomyl), along with the organophosphate insecticide ethoprop (Mocap). Most other commonly used insecticides and fungicides had little, if any, impact on earthworm populations.

This data indicates 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 greater care and avoid harming susceptible species. This will help in the avoidance of hazardous pesticides in areas where highly sensitive species occur.

However, how the pesticide is applied will be the most important factor in determining the hazard of a pesticide. Turf managers should always attempt to make applications in a manner that best avoids exposure to any non-target species. Time of application, limiting the area treated, control of drift, rates applied and formulation are all important factors which can greatly affect the severity of unintended impacts of a pesticide on valuable, non-target organisms.

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
(percent population reduction)

Dursban 4E (-32.3)
Triumph 4E (-59.4%)
Thiophanate-methyl (Cleary's 3336) (-88)**
Fonofos (Crusade) (-96)**
Turcam 2.5G (-99.0)*
Diazinon 14G (-58.4)
Benomyl (Tersan 1991) (-60.0)*
Sevin SL (-89.8)*
Mocap 10G (-96.8)*

Pesticides that did not have significant effects on earthworm populations

2,4D
Dicamba
Triademephon (Bayleton)
Pendimethalin (Pre-M, etc.)
Chlorothalonil (Daconil 2787)
Iprodione (Chipco 26019)
Prodiamine (Barricade)
Mycobutanil (Eagle/RH3866)
Cyfluthrin (Tempo)
Flurprimidol (Cutless)
Metalaxyl/Mancozeb (Pace)
Cyprocanazole (Sentinel)
Azadirachtin (Margosan-O)
Halofenozide (MACH-2)
Triclopyr
Senariol (Rubigan)
Isofenphos (Oftanol)
Trichlorfon (Proxol)
Propaconazol (Banner)
Isoxaben (Gallery)
Dithiopyr (Dimension)
Bifenthrin (Talstar)
Fluvalinate (Mavrik)
Mefluidide (Embark)
Fosetyl-al (Alliete)
Tebuconazole (Lynx)
Steinernema carpocapsae (Savior)

** 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.*