

● INSECTICIDE FACTSHEET

PYRETHRINS/PYRETHRUM

Pyrethrins and pyrethrum are the most frequently used home and garden insecticides in the U.S. They are often used in indoor sprays, pet shampoos, and aerosol bombs to kill flying and jumping insects.

Pyrethrins are a common cause of insecticide poisonings. According to a U.S. Environmental Protection Agency (EPA) survey of poison control centers, they cause more insecticide poisoning incidents than any other class of insecticides except the organophosphates. Symptoms include headaches, dizziness, and difficulty breathing.

Pyrethrins can trigger life-threatening allergic responses including heart failure and severe asthma.

In laboratory animals exposed through eating, by injection, or through breathing, pyrethrins have caused anemia.

Experiments with dairy cows suggest that nursing mothers exposed to pyrethrins can pass them on to their children.

Pyrethrins disrupt the normal functioning of sex hormones. They inhibit binding of sex hormones to human genital skin and proteins in human blood.

Pyrethrins are classified as "likely to be human carcinogens" by EPA because they cause thyroid tumors in laboratory tests. Farmers who use pyrethrins have an increased risk of developing leukemia.

Pyrethrins are extremely toxic to bees, fish, and other aquatic animals.

Following indoor treatments, pyrethrins have persisted up to 2 1/2 months in carpet dust.

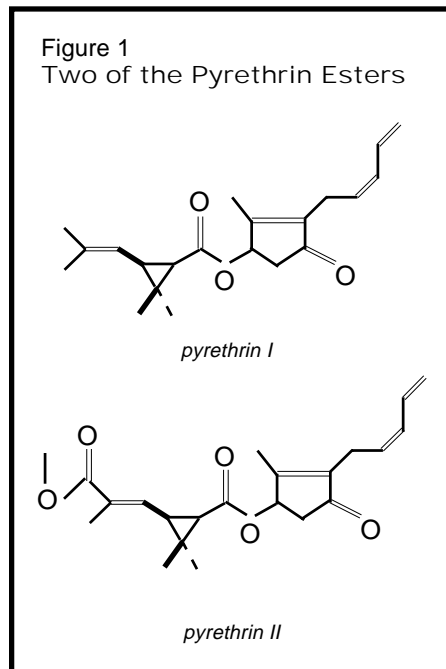
BY CAROLINE COX

Pyrethrum and pyrethrins have been used as insecticides since at least 1800¹ and for decades have been the most commonly used home and garden insecticides in the U.S.^{2,3} Pyrethrum is a natural insecticide, an extract made from two daisy-like flowers, *Chrysanthemum cinerariaefolium* and *Chrsanthemum cineum*. Pyrethrins are the six insecticidally active compounds in pyrethrum.¹ (See Figure 1 for two examples.) Pyrethrins are mainly used as indoor sprays, pet shampoos, and aerosol bombs to kill flying and jumping insects.¹ Although pyrethrins are natural insecticides, they do pose important hazards to human and environmental health. This article summarizes those hazards.

Pyrethrin insecticides often contain piperonyl butoxide, a chemical that increases the potency of pyrethrins.⁴



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The health and environmental hazards of piperonyl butoxide will be summarized in the summer 2002 issue of the *Journal of Pesticide Reform*.

A large family of insecticides, the synthetic pyrethroids, are structurally similar to pyrethrins but have been chemically modified to make them more toxic and more persistent.¹ For information about the hazards of three commonly used synthetic pyrethroids see JPR 14(2): 28-34 (cyfluthrin); JPR 16(2): 15-20 (cypermethrin); and JPR 18(2): 14-20 (permethrin).

Use

In the early part of the twentieth century pyrethrum was "the most commonly used household insecticide."² The most recent U.S. Environmental Protection Agency (EPA) home and garden pesticide survey estimated that over 240 million of these applications are made annually in the U.S., more than any other insecticide.³ There are more registered uses for pyrethrins than for any other insecticide.⁵ Worldwide, about 200,000 kilograms (440,000 pounds) of pyrethrins are used each year.⁶

Other than home and garden uses, pyrethrins are used on a variety of

agricultural crops and for structural and public health pest control. The amount used in agriculture is small relative to the other uses.⁷ (See Figure 2.)

Mode of Action

Pyrethrins, like all members of the pyrethroid insecticide family, kill insects by disrupting their nervous systems. Pyrethrins are toxic to the “sodium channel,” the cellular structure that allows sodium ions to enter a cell as part of the process of transmitting a nerve impulse. This leads to repetitive discharges by the nerve cell which causes paralysis and death.⁸ DDT and related insecticides have the same mode of action.⁹

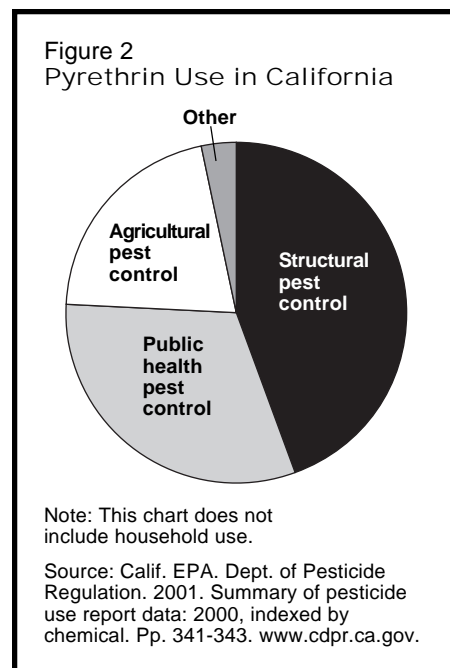
Nerves in humans and other mammals are also susceptible to pyrethrin poisoning. However, mammals have enzymes that more rapidly detoxify pyrethrins into compounds that don't disrupt the nervous system.¹⁰

Inert Ingredients

Like most pesticides, commercial pyrethrin-containing insecticides contain ingredients other than pyrethrins which, according to U.S. pesticide law, are called “inert.”¹¹ Except for acute toxicity testing, all toxicology tests required for registration of pyrethrin products were conducted with pyrethrins, not with the combination of ingredients found in commercial products.¹² Most inert ingredients are not identified on product labels, and little information about them is publicly available. For more information about the hazards of some of the inert ingredients in pyrethrin products see “Hazards of Inert Ingredients,” below.

Acute poisoning

Frequency: Pyrethrins are a common cause of insecticide poisonings. When EPA summarized calls to poison control centers in 1991, the agency found that pyrethrins, and pyrethrins



California data suggest that agricultural uses of pyrethrin are small relative to other uses.

HAZARDS OF INERT INGREDIENTS

Propane is used as an inert propellant in pyrethrin products. (See footnote 1 for some examples.) It can cause dizziness when inhaled. It is also “extremely flammable”² and easily ignited by heat, sparks, or flame.²

Isobutane is also used as an inert propellant in pyrethrin products. (See footnote 3 for some examples.) It depresses the central nervous system and can cause dizziness when inhaled. Like propane, it is “extremely flammable”⁴ and easily ignited.⁴

Hydrotreated light petroleum distillates (hydrotreated kerosene) are used as an inert solvent in pyrethrin products. (See footnote 5 for some examples.) The Chemical Abstract Services number for this solvent is 64742-47-8. This solvent has caused skin tumors when applied to the skin of laboratory mice.⁶

Hydrotreated heavy naphtha (white spirits) is also used as an inert solvent in pyrethrin products. (See footnote 7 for some examples.) The Chemical Abstract Services number for this solvent is 64742-48-9. It is damaging to kidneys and the nervous system.⁸ In a recent laboratory study, the offspring of animals exposed to white spirits developed “long-lasting and possibly irreversible changes” in brain cells. This damage to the brain was caused by an inability to maintain normal calcium concentrations.⁹

- Whitmire Micro-Gen. 1998. MSDS: P.I. Contact Insecticide. www.wmmg.com/pest/products/pdf/MSDS/pi.pdf.; Value Garden Supply. Undated. MSDS: Black Leaf Home Insect Fogger. www.valuegardens.com/msds/Home%20Insect%20Fogger.pdf; Amrep, Inc. 1997. MSDS: Misty Fog Plus Fogger. www.amrep.com/ii/products/msds/aerosols/476.pdf.
- Hazardous Substance Data Bank. 2001. Propane. http://toxnet.nlm.nih.gov.
- Value Garden Supply. Undated. MSDS: Black Leaf Home Insect Fogger. www.valuegardens.com/msds/Home%20Insect%20Fogger.pdf; Amrep, Inc. 1997. MSDS: Misty Fog Plus Fogger. www.amrep.com/ii/products/msds/aerosols/476.pdf.
- Hazardous Substance Data Bank. 2001. Isobutane. http://toxnet.nlm.nih.gov/.
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- Whitmire Micro-Gen. 1998. MSDS: P.I. Contact Insecticide. www.wmmg.com/pest/products/pdf/MSDS/pi.pdf;
- United Nations Environment Prog. et al. 1996. White spirit (Stoddard Solvent). Environmental Health Criteria 187. Geneva, Switzerland: World Health Organization. Pp.73-75, 77-78, 90-128.
- Edelfors, S., U. Hass, and A. Ravn-Jonsen. 1999. The effect of in vitro exposure to white spirit on [Ca²⁺] in synaptosomes from rats exposed prenatally to white spirit. *Pharmacol. Toxicol.* 84: 197-200.

with the synergist piperonyl butoxide, caused over 9,000 incidents. Only the organophosphate insecticides caused more insecticide poisoning incidents.¹³ (See Figure 3.)

Symptoms: Some symptoms of pyrethrin poisoning in people, headaches and dizziness, are related to disruptions of the nervous system. For example, the Centers for Disease Control compiled reports of pyrethrin exposure incidents including one in which a cook developed these symptoms following installation of pyrethrin insecticide dispensers in the restaurant where he worked. A customer in the same restaurant developed similar symptoms.¹⁴

The patients also developed other symptoms that may not be related directly to pyrethrins' effect on the nervous system: sore throat and difficulty breathing.¹⁴

Physiological mechanisms: Laboratory tests have demonstrated that pyrethrins cause several neurological disruptions in mammals. These may be the cause of the sodium channel

disruption that results in their toxic effects in insects, or an additional effect. (See "Mode of Action," p. 15.) For example, researchers from the University of Maryland School of Medicine and the University of Alexandria (Egypt) showed that pyrethrins inhibited calcium uptake in rat brain cells. Calcium plays a "vital role"¹⁵ in the nervous system, promoting the normal release of transmitter chemicals from junctions between nerves and stabilizing the membrane surrounding nerve cells.¹⁵ Two groups of researchers, from the University of Mississippi Medical Center¹⁶ and the University of Tampere Medical School (Finland)¹⁷ showed that pyrethrins disrupt energy production in brain cells.

Pyrethrins also affect physiological processes that are not related to the nervous system. For example, researchers at the Osaka City Institute of Public Health and Environmental Sciences (Japan) showed that in rat livers pyrethrins inhibit mitochondria, the cellular bodies that convert food to usable energy.¹⁸

Allergic Responses to Pyrethrins

Pyrethrins can trigger allergic responses that range from unpleasant to life-threatening. Skin rashes, asthma, and hives caused by exposure to pyrethrins or pyrethrum have been reported in medical literature since the 1920s and 1930s.¹⁹

More serious reports were published in 1994 and 2000. Physicians in New York reported that a woman developed shortness of breath five minutes after beginning to wash her family dog with a pyrethrin shampoo. Almost immediately she suffered heart failure and died after paramedics transported her to a hospital.²⁰ An Oregon physician reported that an 11-year-old girl developed a severe asthmatic attack when washing the family dog with a pyrethrin shampoo. She died a few hours later, despite medical treatment.²¹

The refined pyrethrins in the products that caused these incidents are less allergenic than unrefined pyrethrum²² but still have caused these serious reactions.

Eye irritation

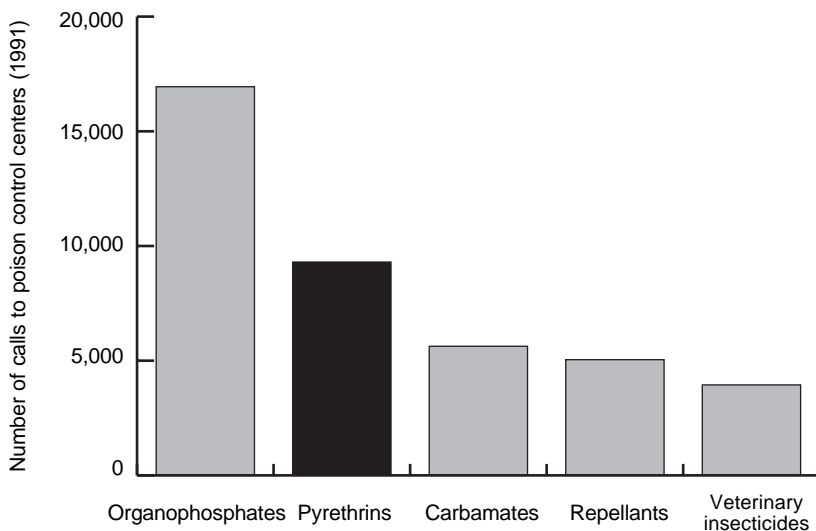
People exposed to commercial pyrethrin products have reported swelling, redness, and burning of the eyes following exposure.¹⁴

Effects on the Circulatory System

Pyrethrins affect both sugar levels and oxygen-carrying ability of blood. Researchers from the University in Rajasthan (India) showed that an injection of pyrethrins caused gerbil blood sugar levels to rise between 30 and 70 percent (depending on dose). Blood sugar peaked an hour after treatment, but the increase persisted for several days.²³ The same researchers showed that an injection of pyrethrins caused a decrease in the amount of hemoglobin (oxygen-carrying molecules) in the blood,²⁴ as well as a decrease in the number of red blood cells.²⁵ Hemoglobin concentration remained low for 2-3 weeks (see Figure 4);²⁴ the reduced number of red blood cells persisted for 2 days.²⁵

Other types of exposures with a

Figure 3
Frequency of Pyrethrin Poisonings



Sources: U.S. EPA. Office of Pesticides and Toxic Substances. Undated memo. Human insecticide exposures reported to Poison Control Centers in 1991. Prepared by J. Blondell, Health Effects Division.

Pyrethrin poisonings are more frequent than poisoning cause by any other class of insecticide except the organophosphates.

longer duration caused similar effects. A three-month feeding study with rats found pyrethrins caused a decrease in the amount of hemoglobin in females at doses at or above 170 milligrams of pyrethrins per kilogram of body weight (mg/kg) per day (the middle dose in this experiment). Similar effects were found in males at higher exposures. A three month inhalation study found that pyrethrins caused anemia at doses at or above 0.07 milligrams per liter of air in males (all but the lowest dose in this experiment). They also caused anemia in females, although at higher exposures.²⁶

Effects on the Kidney

A three-month feeding study with rats showed that pyrethrins caused degeneration of tubules (small tube-like structures) in the kidney at doses equal or greater than 170 mg/kg.²⁷

Effects on Reproduction

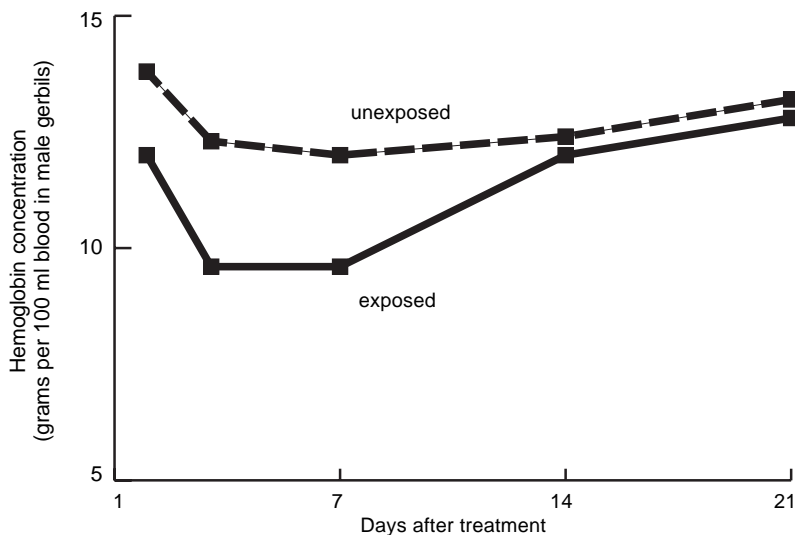
Pyrethrins can disrupt successful reproduction in both males and females. In a two-month feeding study with dogs, the weight of the testes in animals exposed to pyrethrins at doses at or above 30 mg/kg (all but the lowest dose tested) was less than that of unexposed animals.²⁸ In a two-generation feeding study with rats, the weight of offspring at birth and during nursing was less for rats fed pyrethrins at doses at or above 65 mg/kg (all but the lowest dose tested) than for unexposed animals.²⁹

Concerns about pyrethrins' effects on reproduction are heightened by studies of dairy cows. Following treatment of the cows with pyrethrins, pyrethrins were detected in the cows' milk.³⁰ This study provides support for the concern that exposed nursing mothers could pass pyrethrins on to their children.

Disruption of Hormone Systems

The impact that environmental pollutants can have on the normal function of human and animal hormone systems has been a significant concern in the last decade.³¹ Hormones are biologically active molecules that control all responses and functions of

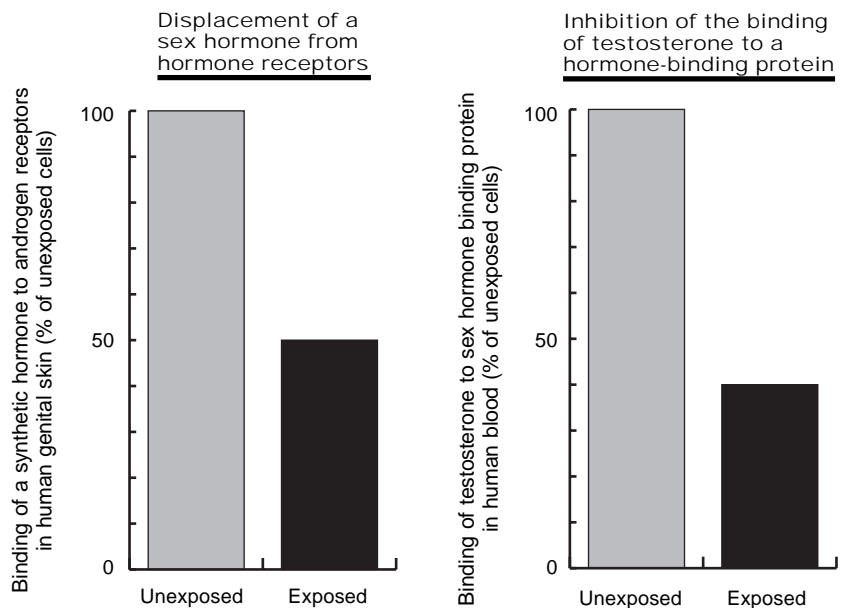
Figure 4
Exposure to Pyrethrins Causes Anemia



Source: Saxena, S.C. and A.K. Karel. 1974. A note on the effect of pyrethrum on haemoglobin concentration of Indian desert gerbils, *Meriones hurrianae*. *Pyreth. Post* 12:161-162.

A single dose of pyrethrins (by injection) caused anemia which persisted for two weeks.

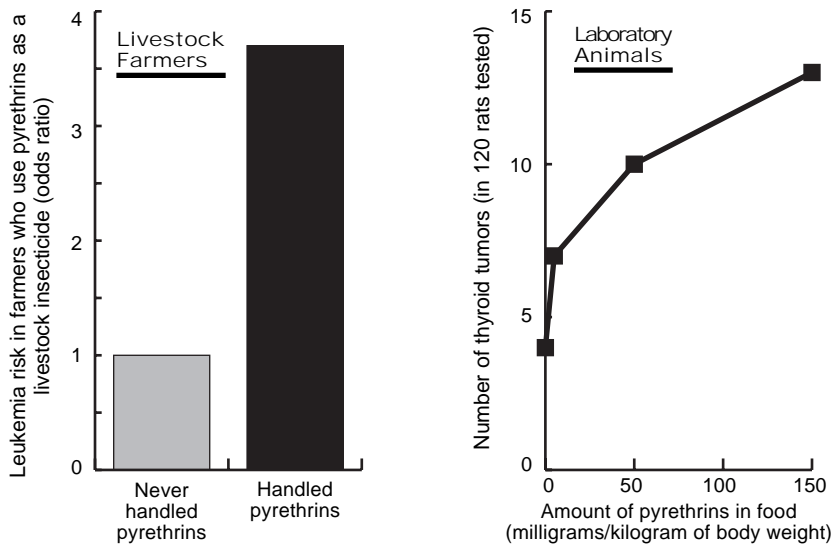
Figure 5
Exposure to Pyrethrins Disrupts Normal Hormone Functions



Source: Eil, C. and B.C. Nisula, 1990. The binding properties of pyrethroids to human skin fibroblast androgen receptors and to sex hormone binding globulin. *J. Steroid Biochem.* 35: 409-414.

In experiments with human cells, pyrethrins inhibited the normal binding of sex hormones.

Figure 6
Exposure to Pyrethrins is Associated with Increased Cancer Risks in Farmers and Laboratory Animals



Sources:
Brown, L.M. et al. 1990. Pesticide exposures and other agricultural risk factors for leukemia among men in Iowa and Minnesota. *Cancer Res.* 50: 6585-6591.
World Health Organization and Food and Agricultural Organization. 2000. Pesticide residues in food — 1999. [Part II] Toxicological evaluations. Geneva, Switzerland: World Health Organization. p. 281.

Pyrethrins are associated with an increased leukemia risk in farmers who use them to control livestock pests. They also cause an increased frequency of thyroid tumors in laboratory studies.

the body. Dramatic changes in the activity of cells in humans and other animals “are caused by extremely small amounts” of hormones or other chemicals that disrupt this system.³²

Pyrethrins appear to disrupt the normal functioning of sex hormones. Researchers from Brown University and the National Institutes of Health showed that pyrethrins displace hormones from androgen receptors in cell cultures of human genital skin. Androgens are sex hormones that promote development of male sex characteristics; testosterone is a familiar example. The same researchers also showed that pyrethrins block the binding of testosterone to the a sex hormone binding protein in human blood. In both experiments pyrethrins were more potent than the synthetic pyrethroids tested.³³ (See Figure 5.)

Pyrethrins also inhibit binding to peripheral benzodiazepine receptors, found in high concentration in the testes and thought to be involved in “ste-

roid metabolism or hormonal responsiveness.” As in the study summarized in the previous paragraph, in this experiment pyrethrins were more potent than the synthetic pyrethroids tested.³⁴

Carcinogenicity

Pyrethrins are associated with increased cancer risks among farmers and have also caused cancer in laboratory tests. (See Figure 6.)

Researchers from the National Cancer Institute studying risk factors for leukemia found that farmers exposed to pyrethrins used for pest control on livestock had an increased risk of developing leukemia. Exposure to pyrethrins was associated with a 3.7-fold increase in risk.³⁵

In 1999, EPA evaluated the ability of pyrethrins to cause cancer. The agency concluded that pyrethrins should be classified as “likely to be a human carcinogen by the oral route.” This EPA evaluation was based on tests which demonstrated increases in the

frequency of several cancers in rats. The incidence of liver tumors was higher in exposed female rats than in unexposed ones. Also, in both sexes, the incidence of thyroid tumors was greater in exposed rats than in unexposed ones.³⁶

Other carcinogenicity studies showed that the incidence of lung cancers in exposed male mice was greater than in unexposed ones³⁷ and that the incidence of parathyroid tumors was greater in exposed rats than in unexposed ones.³⁸

Effect of Gender

Several laboratory studies suggest that females may be more susceptible to pyrethrins than males. The distribution of pyrethrins in rats after exposure is highest in body fat. However, the concentration in female fat was approximately double that found in male fat. Also, the median oral lethal dose for male rats was over twice the dose required to kill females.³⁹

Human Exposure

Pyrethrins are absorbed slowly through the stomach, intestines, and skin. However, pyrethrins can be absorbed “more quickly through the lungs.”⁴⁰ This suggests that exposure through breathing droplets or airborne particles deserves particular attention.

Synergy

Carboxyesterases, enzymes that detoxify pyrethrins, are inhibited by organophosphate insecticides, thus organophosphate insecticides increase pyrethrins’ toxicity.¹⁰

Effects on Cats

Cats are particularly susceptible to pyrethrin poisoning because their livers inefficiently detoxify this insecticide.⁴¹ As a consequence, there are a large number of poisoning incidents. Veterinarians summarizing calls made to an animal poison control center in 1986 found that pyrethrin-related incidents were more numerous than incidents involving any other insecticide.⁴²

Symptoms of pyrethrin poisoning in cats include excessive salivation, altered behavior, depression, anorexia, and high body temperature.⁴²

Young cats (less than four years old, but especially if less than one year old) are more susceptible to pyrethrins than older cats.⁴¹

Effects on Birds

In general, relatively large amounts of pyrethrins are required to kill birds.⁴³ However effects other than death have been found at lower exposures. Scientists from the University of Rajasthan (India) found that doses between 10 and 50 mg/kg of pyrethrum caused excitability and decreased appetites in pigeons.⁴⁴ In sparrows, doses of 400 mg/kg caused excitability and an increase in flying, as well as a decrease in food consumption and weight. The weight of the liver, intestine, pancreas, kidney, and testes also decreased.⁴⁵

Effects on Fish

Pyrethrins are “extremely toxic to fish,” according to the Agency for Toxic Substances and Disease Registry.⁴⁶ Median lethal concentrations (the concentration that kills half of a test population) range from 9 to 58 parts per billion. A summary by the U.S. Fish and Wildlife Service found that channel catfish and coho salmon were the most susceptible species.⁴⁷

Pyrethrins are more toxic to fish in warm water than in cold water.⁴⁷

Effects on Other Aquatic Animals

Aquatic animals other than fish are also killed by low concentrations of pyrethrins. The most susceptible larval stage of the American lobster is killed by concentrations of 1 part per billion.⁴⁸ The scud (a fresh water crustacean) is killed by concentrations of 12 parts per billion.⁴⁹

Effects on Honey Bees

Pyrethrins are “highly toxic” to bees; 0.02 micrograms is sufficient to kill a bee.⁵⁰ Toxicity of commercial pyrethrin products to bees was demonstrated by an entomologist at Auburn University who showed that a commercial pyrethrin insecticide caused 100 percent “knockdown,” the inability of the bee to walk or fly. Some of the inert ingredients used in pyrethrin products

appear to increase knockdown potency.⁵¹

Effects on Other Beneficial Insects and Spiders

It is not surprising that pyrethrins, because they are insecticides, are toxic to agriculturally useful insects and spiders. The International Organization for Biological Control found that a commercial pyrethrin product killed over 99 percent of two parasitoid wasps and a predatory fly. (Parasitoids are insects which develop in and kill the eggs or larvae of another species.) This study also found pyrethrins caused 80 percent mortality of two other parasitoid species, a fly and a wasp.⁵² Cornell University Agricultural Experiment Station researchers found that pyrethrins killed four common species of wasp that are parasitoids of house and stable flies in dairies.⁵³ The web-building spider *Argiope argentata* is also susceptible to pyrethrins; two commercial pyrethrin products caused more than 50 percent mortality of this spider in a test conducted at the University of Regensburg (Germany).⁵⁴

Development of Resistance in Pest Insects

At least fifteen species of insects, including lice, cockroaches, weevils, bedbugs, house flies, mosquitos, meal moths, and aphids have developed pyrethrin resistance, the ability to survive treatment. Resistance ratios (the ratio between the amount needed to kill a resistant individual and the amount needed to kill a susceptible individual) are often relatively low, but in four species resistance ratios are above 100. The four species are the German cockroach, the granary weevil, and two house flies.⁵⁵

Repeated exposure to synthetic pyrethroids can cause the development of resistance to pyrethrins.⁵⁵

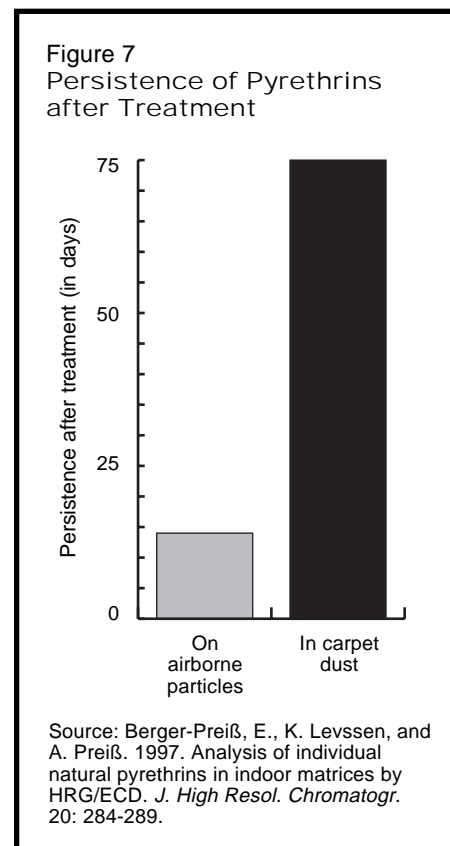
Persistence

Outdoors, pyrethrins persist only for a short time. For example, after application of pyrethrins to bare soil, the half life (the time required for half of the applied pyrethrin to break down or move away from the application site) was two hours or less.⁵⁶

Pyrethrins persist much longer indoors than they do outdoors. Studies conducted at the University of Ulm and the Fraunhofer Institute of Toxicology and Aerosol Research (Germany) found that pyrethrins persisted 60 hours after treatment on horizontal surfaces,⁵⁷ two weeks after treatment on airborne particles, and over two months in carpet dust.⁵⁸ (See Figure 7.)

Effects on Soil Fertility

Insecticides are generally not expected to have impacts on plants. However, they can indirectly affect plant growth if they change the growth or abundance of soil microorganisms that are important in the maintenance of soil fertility. Scientists at the University of Ibadan (Nigeria) showed that treatment of agricultural soils with pyrethrin caused an increase in the abundance of soil bacteria and a decrease in the abundance of soil fungi. In addition, the number of these species was less in treated soil than in



Pyrethrins persisted in carpet dust for over two months after treatment.

untreated soil. The end result was a reduction in the amount of the important soil nutrient nitrogen.⁵⁹ Another study, from the Central Rice Institute (India), showed that pyrethrin treatment of rice fields reduced the nitrogen-fixing ability of the soils as much as 80 percent.⁶⁰ Nitrogen fixation is the conversion (mostly by bacteria) of atmospheric nitrogen into a form that is usable by plants.⁶¹ ✦

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