The Uncertain Risk of Pyrethrin Exposures

By Kelly A. Reynolds, MSPH, PhD

Although commonly distinguished as natural pesticides, pyrethrins (and their synthetic cousins, pyrethroids) have been associated with acute poisonings. Their use is common in the US and recent pesticide-related deaths at vacation resorts, along with new research on chronic exposure effects, indicates a need to revisit previous studies on the safety of these chemicals.

Varied and widespread pesticide use

Extracted from the African flower, *Chrysanthemum cineriaefolium*, pyrethrins are naturally occurring insecticides that have been in commercial use since the 1950s. The chemicals damage a wide range of adult insect populations (i.e., mosquitoes, fleas, flies, moths, ants and more) by interfering with their nervous-system functions. Their use has been essential for controlling adult mosquito populations and preventing dangerous infections from the West Nile virus and other vector-borne diseases.

Use of pyrethrins and pyrethroids (or pyrethrums collectively) is common and reportedly increasing. Currently there are more than 3,500 registered pesticide products that contain the compounds. Products have been marketed for applications in homes, gardens, commercial agriculture, dog shampoos, bug repellents and medical treatments (i.e., treatment of head lice or fleas).

Environmental applications of the pesticide usually involve dispersal of a fine mist, or fog, over large geographical areas (i.e., several acres to multiple square miles). The natural form of pyrethrins is not very stable in the environment where the chemical breaks down rapidly in the presence of sunlight. This is a benefit for protecting the environment and reducing persistence of the chemicals in soil or water but limits their intended efficacy for insect control.

Synthetic pesticides with similar chemical structures and abilities were created as a more effective alternative to pyrethrins. These chemicals, known as pyrethroids, are resistant to degradation when exposed to light and have a longer duration of activity against insects compared to pyrethrins. Pyrethroids include an array of chemicals including permethrin and other compounds that have variable toxicity.

Exposure potentials and risk assessment

Previously, pyrethrums have been tested for acute and chronic health effects in animals and humans. Adverse reactions following exposure to natural pyrethrins include skin, lung and allergic responses. Most studies have focused on the evaluation of high-dose exposures and usually in adult workers. Farming applications of synthetic pyrethroids in the 70s failed to demonstrate any serious health effects or neurological impairment in adults. Mild symptoms, such as numbness, itching, burning and tingling had been reported following heavy dermal contacts but the symptoms reportedly subsided within a day.[1]

Use of pyrethroid-treated clothing for military personnel prompted a thorough review of dermal exposures in the 90s. Results indicated a very high margin of safety between estimated daily exposure levels and concentrations where no observed adverse effects occurred in animal toxicity studies. At very high doses, higher than one would expect for humans or animals in practice, adverse effects to the liver and neurological systems were noted in various animal models. A review of toxicity studies three decades ago concluded that the class of pyrethrums were some of the safest available pesticides, particularly relative to other popular pesticides, such as organochlorides like DDT and organophosphates that have more severe toxicity profiles.

A review of several pyrethrum poisonings found that in large ingestion cases (i.e., 200-500 mL of concentrated formulations), coma and seizures occurred within 20 minutes.[2] In this same review, another report of 27 farm workers and four emergency responders was linked to pesticide drift of a synthetic pyrethroid. Headache, nausea, eye irritation, muscle weakness, anxiety and shortness of breath were reported in a majority of those exposed.

In 1999, the US EPA classified pyrethrins as likely carcinogens via the route of ingestion. This classification was supported by studies in rats and mice who developed thyroid tumors following high-dose ingestion over two years.[3] The agency re-evaluated pyrethrins in 2004 and determined the data was insufficient to classify the compounds as a human carcinogen. Limited data in exposed farmers suggests higher rates of leukemia, however, confounding effects of other carcinogenic exposures in this population were not well controlled.

New concerns

The majority of criticism related to pyrethrum toxicity studies is the limited focus on potential reproductive, genetic or carcinogenic effects. Little is known about persistence of these compounds in the environment, along with ecological effects and long-term, low-level exposures in more vulnerable groups such as developing fetuses or children. Also in question is the possibility of selective hypersensitivity in certain people or those with chronic conditions, such as asthma, that may exacerbate symptoms. Convulsions, dermatitis and death have been documented following inhalation and ingestion routes.[4]

In water exposed to sunlight, the half-lives of pyrethrums are less than 12 hours but in the absence of light, they break down much more slowly, requiring more than two weeks for half of the levels to break down. The chemicals do not dissolve well in water and readily bind to sediment where half-lives increase to up to 86 days.[5] Persistence in aquatic environments are a concern for fish and honey bees, which are extremely vulnerable to pyrethrum toxicants. Long-term exposures in fish caused reproductive effects; however, such outcomes have only been minimally explored.

Humans can reduce their exposure to pesticides by wearing masks and gloves during applications and making sure indoor environments are well ventilated following use. Drinking water is not considered a major source of exposure to pyrethrums but the scarcity of data related to low-dose, long-term exposures still has many people concerned. A recent study showed that use of pyrethrums has dramatically increased and two-thirds of families tested in California were positive for the pesticide's metabolites.[6] Another recent study found that a 10-fold increase in pyrethroid metabolites in urine doubled the odds of behavioral problems.[7] These cognitive effects have been previously reported in animal studies but not studied extensively in humans.

In 2017, the Environmental Working Group called for an expanded assessment of pyrethrums, commenting that the US EPA's health assessments failed to consider recent studies of risks to cognitive effects on children or prenatal exposure outcomes.[8] EWG challenged the agency to consider new evidence of developmental neurotoxicity and cumulative exposures, especially in children, where links to autism spectrum disorders and other development delays were strongly associated with pyrethrums and other pesticide use.[9,10]

References

1. National Research Council. Health Effects of Permethrin-Impregnated Army Battle-Dress Uniforms. *National Academies Press*, 1994. doi:10.17226/9274.

2. US EPA. *Recognition and Management of Pesticide Poisonings: Sixth Edition: Chapter 4 pyrethrins pyrethroids.* (2013).

3. California Department of Public Health. *Safety of Pyrethrin and Pyrethroid Pesticides Used to Control Adult Mosquitoes*. (2014). Available at: https://www.cdph.ca.gov/Programs/CID/DCDC/CDPH Document Library/SafetyofPyrethrinandPyrethroidPesticidesUsedtoControlAdultMosquitoes.pdf. (Accessed: 10th November 2019)

4. Proudfoot, A.T. Poisoning due to pyrethrins. *Toxicological Reviews* 24, 107–113 (2005).

5. Bond, C.; Buhl, K.; Stone, D. *Pyrethrins General Fact Sheet*. Natl. Pestic. Inf. Center, Oregon State Univ. Ext. Serv. (2014).

6. Trunnelle, K.J. *et al.* Urinary pyrethroid and chlorpyrifos metabolite concentrations in northern California families and their relationship to indoor residential insecticide levels, part of the Study of Use of Products and Exposure Related Behavior (SUPERB). *Environ. Sci. Technol.* 48, 1931–1939 (2014).

7. Oulhote, Y. and Bouchard, M.F. Urinary metabolites of organophosphate and pyrethroid pesticides and behavioral problems in Canadian children. *Environ. Health Perspect.* 121, 1378–1384 (2013).

8. Environmental Working Group. *EWG Comments on Pyrethroid: Pyrethrin Insecticide Risk Assessments*. (2017). Available at: https://cdn3.ewg.org/sites/default/files/testimony/EWG Comments on Pyrethroid%3APyrethrin Insecticide Risk Assessments .pdf?_ga=2.149184118.1794145845.1570740341-255468089.1570041597. (Accessed: 10th November 2019)

9. Viel, J.F. *et al.* Behavioural disorders in 6-year-old children and pyrethroid insecticide exposure: The PELAGIE mother-child cohort. *Occup. Environ. Med.* 74, 275–281 (2017).

10. Shelton, J.F. *et al.* Neurodevelopmental disorders and prenatal residential proximity to agricultural pesticides: The CHARGE study in Everyday Environmental Toxins: Childrens Exposure Risks. 183–200 (*Apple Academic Press*, 2015). doi:10.1201/b18221.

About the author

Dr. Kelly A. Reynolds is a University of Arizona Professor at the College of Public Health; Chair of Community, Environment and Policy; Program Director of Environmental Health Sciences and Director of Environment, Exposure Science and Risk Assessment Center (ESRAC). She holds a Master of Science Degree in public health (MSPH) from the University of South Florida and a doctorate in microbiology from the University of Arizona. Reynolds is WC&P's Public Health Editor and a former member of the Technical Review Committee. She can be reached via email at reynolds@u.arizona.edu