Mosquito spray increases toxicity of pyrethroids in creek, study finds

July 28 2006

A relatively benign compound contained in a widely used group of insecticides can mix with and increase the toxicity of existing pesticides in the environment, according to a new study led by biologists at the University of California, Berkeley.

While the increase in toxicity was relatively modest, the effects from the interaction of chemicals were unexpected, the researchers said.

The study's results, reported in the July 26 online edition of *Environmental Science & Technology*, send a message to environmental regulators to reassess how they evaluate a product's toxicity, said Donald Weston, UC Berkeley adjunct professor of integrative biology and lead author of the study. "This interaction of compounds is a whole new issue when doing pesticide risk assessments that has been largely ignored by regulators," said Weston.

The findings came from water and sediment samples collected from six creeks in Sacramento, Calif., after the county's mosquito control authorities took the rare step of applying an insecticide by air in August 2005. UC Berkeley researchers point out that aerial applications can cover far more acreage than ground spraying from trucks, and are used if the human health risk from mosquito-borne infections is perceived to be greater than the risk of exposure to the pesticide.

In this case, the decision to spray by air came after two dozen people in Sacramento County had become infected that summer by the West Nile

virus. An 85-square mile region north of the American River was treated on Aug. 8, 9 and 10, and a 104-square mile area south of the American River was treated Aug. 20, 21 and 22.

Sediment and water samples were taken from the northern creeks on Aug. 12, about 34 hours after the third night's application of the pesticide. In the southern creeks, samples were collected on Aug. 14, six days before the first application, and Aug. 22, about 10 hours after the second night's application.

The insecticide contained a mixture of pyrethrin, a natural pesticide found in a type of chrysanthemum, and piperonyl butoxide (PBO). On its own, PBO has a low level of toxicity, but it is a chemical synergist, which means it increases the toxicity of other chemicals such as pyrethrin and its synthetic counterpart, pyrethroid.

"PBO shuts down the enzyme that animals use to detoxify pyrethrin, so it gives pyrethrin more punch," said Weston. "Without PBO, you'd need a greater concentration of pyrethrin or pyrethroid to be effective as a pesticide."

To assess the toxicity of the water that was sampled in Sacramento after the aerial mosquito spray, the researchers compared the reproduction and survival rates of a species of water flea, Ceriodaphnia dubia. No detectable levels of pyrethrins were present in the water collected before and 10-34 hours after spraying, but researchers did find PBO. There was no significant increase in the water flea's mortality, although there was a decrease in the flea's reproduction in three of the 11 water samples.

Researchers also looked at the survival rates of a tiny, shrimp-like amphipod called Hyalella azteca, an indicator species for sediment toxicity. More significant effects were seen in the Sacramento creeks, where many of the sediments were toxic to H. azteca. That alone was not

surprising, for their earlier studies had shown that pyrethroids from general urban pesticide use were in a high enough concentration to be toxic. The unexpected finding was that PBO left in the water from the mosquito spray made the sediments even more toxic to H. azteca than they already were.

The research team found that the level of PBO from the mosquito spray was high enough to double the toxicity of pyrethroids already present - primarily bifenthrin, one of the more toxic chemicals of the group. PBO, when in a pesticide product, can increase pyrethroid toxicity tenfold or more, but to see even a doubling of toxicity due to PBO in creek waters was unexpected.

"In this instance, it appeared the biggest concern was not the aquatic toxicity of the pyrethrin insecticide in the mosquito spray, but the fact that the non-toxic synergist actually synergized the 'wrong' thing - pyrethroid pesticides that were already in the creek sediments," said Weston.

"This is the first field study to show an interaction of PBO with something in the environment, so even a two-fold increase is a pretty major finding," added study co-author Michael Lydy, associate professor of zoology at Southern Illinois University.

Other co-authors of the study are Erin Amweg, a UC Berkeley post-doctoral researcher in integrative biology; Abdou Mekebri, a chemist at the California Department of Fish and Game; and R. Scott Ogle, a toxicologist at Pacific EcoRisk.

Pyrethroids have risen to dominance as organophosphate pesticides, including diazinon and chlorpyrifos, are phased out due to concerns over their effects on the human nervous system. (Organophosphates have been largely eliminated from residential use, but are still widely used on

agricultural crops.) There are more than 1,200 pyrethroid-containing products on the market in California, ranging from cans of household bug killer to commercial pest control sprays.

Prior studies by Weston and colleagues have shown that pyrethroids exist in agricultural and urban streams at levels toxic to sensitive aquatic life. General urban pesticide use, such as applying insecticides on lawns, gardens and around the perimeter of homes, is likely responsible for the bulk of the pyrethroids found in the sediment of urban streams, the researchers said.

Based in part upon these prior findings, the California Department of Pesticide Regulation (DPR) announced earlier this month that it will begin re-evaluating some 600 pyrethroid-containing products. The re-evaluation process will likely help determine what urban pesticide use practices are leading to pyrethroids finding their way into creeks.

"We don't know yet if the source is a product a homeowner would use, such as lawn insecticides or other outdoor insecticides, or if they may be coming from applications by professional pest controllers. We just know they are somehow finding their way to urban creeks," Weston said.

Weston does not foresee a dramatic change in mosquito control strategies as a result of this study's findings, particularly when weighing the risks of mosquito-borne diseases. "Public health risk still trumps everything, and pyrethrin and PBO exposed to sunlight degrade easily into innocuous substances after a day or two," he said.

However, based upon these study results, Weston said regulators should not only consider the toxicity of individual active ingredients in a product, but also how ingredients may interact with other chemicals in the environment. While a decidedly challenging task, such interactions currently are not considered when risks of pesticides are evaluated by

regulators, he noted.

Changes to the instructions on how the pesticides are used may also help, the researchers said. Weston pointed out that authorities advised residents in Sacramento to hose down their outdoor furniture after the mosquito spray applications. That may have actually washed more PBO into the creeks, adding to the PBO coming from the spray that settled directly on the creek surface.

Considering this study's findings, said Weston, authorities may want to consider advising residents to leave their outdoor furniture unused in the sun for a day or two to let the pyrethrin and PBO residue degrade rather than send the runoff into the creeks.

Source: University of California - Berkeley