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Long-term effects of low-dose pesticide exposure in the environment

Non-target aquatic wildlife species may be more vulnerable to pesticides' effects, with repeated exposure to low doses over the long-term, if they compete with other species for food, according to a recent study. Understanding how this process occurs can help those undertaking risk assessments and managing pesticides in the natural environment.

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Pesticides used in agriculture can affect non-target organisms if they are also susceptible to the toxicants. As low doses of pesticides can repeatedly end up in surface waters, the researchers wanted to see if an additional stressor, such as the presence of competitors that are less susceptible to the pesticide, can affect the impact of pesticides on more susceptible aquatic organisms.

The researchers, who received some funding for the study through the EU CREAM project[1], exposed populations of mosquito larvae (*Culex pipiens*) to repeated low doses of the pesticide thiacloprid (an insecticide used in, e.g. fruit and vegetable production that targets sucking and chewing insects, such as aphids and whiteflies). The mosquito larvae populations (representing non-target organisms for thiacloprid) were established in 5.5 litre glass nanocosms (small-scale laboratory systems representing larger natural systems). Twelve of the nanocosms contained only mosquito larvae and 24 nanocosms also contained water-flea larvae (*Daphnia magna*) (also representing non-target organisms for thiacloprid), which compete with mosquito larvae in natural freshwater systems, such as wetlands. All nanocosms were regularly supplied with food and both species in the two-species nanocosms competed for the same food resources.

Over a period of 277 days, nanocosms containing only mosquito larvae populations and nanocosms containing both mosquito and water flea larvae populations were exposed to five successive treatments of thiacloprid, at either 3.3 µg/L (micrograms per litre), 10 µg/L or 33 µg/L concentrations for 24 hours. The researchers photographed the nanocosms at intervals so that they could estimate the number of mosquito and water-flea larvae present from the images. The water-flea larvae were not affected by the pesticide, but the mosquito larvae were affected by all pesticide concentrations.

However, in nanocosms containing only mosquito larvae, populations were able to recover before the next dose of pesticide, except at the highest dose (33 µg/L). In nanocosms containing both mosquito and water-flea larvae, mosquito populations were unable to recover to pre-treatment levels and mosquito populations declined over the duration of the study. This suggests that when the water-flea larvae competed with the mosquito larvae for food, the ability of the mosquito populations to recover quickly from the pesticide was reduced. At the highest concentration of thiacloprid, competition from water-flea larvae was not relevant because the toxicity of the pesticide was the overriding factor affecting the mosquito larvae.

The researchers also reconstructed the process in a model of the two species competing for the same resource and the impact that a stressor has when one species is more susceptible to the stressor than the other. The pattern of population changes predicted was similar to that observed in the experiments: with competition, the water-flea larvae populations increased, whilst the mosquito larvae populations declined as they were unable to recover between exposure episodes.
From these results, the researchers suggest that a three-step process is responsible for the effects on susceptible species culminating from repeated exposure to low doses of pesticides:

1. Low doses of pesticides hinder the recovery of susceptible organisms, leaving more resources (e.g. food) available for competitors.
2. Competitor populations are able to increase, using those resources.
3. The susceptible population then has insufficient resources, which affects its ability to recover before the next pesticide exposure.

Although a pesticide itself does not become more toxic to a susceptible non-target organism when a less-susceptible non-target organism is present, competition for resources following repeated exposure events can result in long-term damaging effects of the pesticide on the more susceptible non-target organism.

1.CREAM (Mechanistic Effect Models for Ecological Risk Assessment of Chemicals) is supported by the European Commission through the Seventh Framework Programme. See: http://cream-itn.eu/