O.59 - Terrestrial bioaccumulation: experimental approaches on an arthropod prey-predatory mite system

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Abstract

Accurate risk assessment is the main element in identifying persistent organic pollutants. When developing toxicity and ecotoxicological tests, new problems arise due to new modes of action of certain pesticides. The ability of some pesticides to pass trough a gravid female into the embryo, known as 'transovarial transport', could lead to magnification processes by enhancing both residual activity and movement of the active ingredient. Shown by simple standardised tests, one out of five new acaricides registered for use in the United States provoked a total reduction of fertility on *Galendromus occidentalis* Nesbitt (Acari, Phytoseiidae) that consumed eggs laid by treated phytophagous mite females, *Tetranychus urticae* Koch (Acari, Tetranychidae). It did not affect parasitoid emergence on a host/parasitoid system; *Lobesia botrana* Dennis & Schiffermuller (Lepidoptera, Tortricidae) and *Trichogramma cacoeciae* Marchal (Hymenoptera, Trichogrammatidae). These results suggested a need for bioaccumulation in order for these dose-dependent active ingredients to take effect. At the population level, a negative relationship between proportion of treated females released and predator instantaneous rate of increase was obtained, suggesting dietary bioaccumulation by the predator. The behaviour of these pesticides should be tested before inclusion into plant protection programmes due to the potential risk of bioaccumulation.

New-generation active ingredients are being used to control important pests. These new substances include newer and not widely known modes of action that interfere with organisms' physiological processes that can have adverse effects on humans, wildlife and the ecosystem. Accurate ecotoxicological risk assessment is the main element in identifying pesticide threats to health, environment and ecological systems. The Stockholm Convention on Persistent Organic Pollutants highlighted the importance of identifying bioaccumulative substances: "Persistent organic pollutants possess toxic properties, resist degradation, bioaccumulate and are transported, through air, water and migratory species, across international boundaries and deposited far from their place of release, where they accumulate in terrestrial and aquatic ecosystems."

As a rule, bioaccumulative substances are hydrophobic, fat-soluble chemicals having high K_{OW} (octanol-water partition coefficient). Therefore to identify bioaccumulative substances, regulatory authorities rely on the chemical's K_{OW} or, when available, on bioconcentration factors (BCFs) or bioaccumulation factors (BAFs). As reported by Kelly et al., most research and regulatory efforts are concentrated on aquatic environments while mechanisms of pesticide assimilation into terrestrial food webs are generally lacking, and biocides are detected once they become part of the food chain. In the same report, they demonstrated that organic chemicals with moderate K_{OW} to water breathing organisms without bioaccumulative potential, are susceptible to biomagnification in air-breathing animals. Also, less hydrophobic substances below regulatory criterion were found to magnify in terrestrial food chains. Studies by Bentzen et al. (2008) and Barber (2008) demonstrated that dietary bioaccumulation can cause an increase in chemical concentration with increasing trophic levels in aquatic environments but more intensively on terrestrial food webs. Governments worldwide are trying to identify, potentially bioaccumulative substances, and efforts are being made to develop new tests for identifying these kinds of substances, indicating the need for further development of the existing protocols.

Transovarial transport is described as passage of parasites or infective agents from the maternal body to eggs within the ovaries. If an active ingredient has transovarial activity and reaches the egg at the necessary concentration, it can kill the embryo, jeopardising future generations, and frequently giving an end to the pesticide activity. But what happens to the system if the active ingredient is still active inside the embryo? For how long and how far can this hazard penetrate into the trophic chain?

Standard tests to evaluate dietary bioaccumulation through terrestrial systems can be developed. Using an arthropod prey-predator system, we documented potential relative risk of bioaccumulation in terrestrial trophic webs by one out of five newly registered acaricides available for use commercially in the United States and elsewhere. The active ingredient, etoxazole, showed transovarial activity by killing the embryo of topically treated spider mite females. Moreover, when eggs of treated females were given as food to its predatory mite, a total reduction on fertility was observed, that could only be explained by the ingestion of the active ingredient accumulated in the prey egg by the adult female. Sáenz de Cabezón and Zalom found same transovarial effects, when *G. occidentalis* adult females were sprayed by the same dose of etoxazole, without having an effect on female longevity. This was not observed in the prey-parasitoid system, suggesting the need of a dietary bioaccumulation process. Translated to the population level we observed a clear reduction on population growth as the proportion of treated females rises in the experimental arena, suggesting once more the bioaccumulation process, and the potential inclusion of the active ingredient into the trophic web.

The persistence of the activity inside the unfertile egg, as shown by our first experiment, could enhance both the residual activity of the active ingredient, and its movement depending on predator and prey dispersal capacity, increased by repellence effects of pesticide application. Bioaccumulation and enhanced persistence of the acaricide dicofol was observed by Mano et al. (1996) on the bacterium *Azospirillum lipoferum* by protecting this acaricide against hydrolysis. Due to the fact the active ingredient does not have observable effects on adult females, it can be transported from the sprayed area to non target areas out from the crop, not only affecting pest species but affecting potential endangered species as the active ingredient is introduced in the food chain, giving importance not only for how long the active ingredient can be active in an individual but also inside the food web, due to the fact that differences could exist on the metabolism of this substance by species or different trophic levels. Actual tests do not include the enhancement of residual activity by living organisms, and the significance of it when it reaches the food web, but detecting properties like the active ingredient etoxazole should trigger the incorporation of more detailed experimental designs.

The findings described in this paper support the hypothesis that substances with moderate K_{OW} to water breathing organisms without bioaccumulative potential, are susceptible to biomagnification in air-breathing organisms. Moreover, they can determine the fate of food webs, be transported to other non aquatic environments and their persistence could be enhanced inside living organisms. The authors believe that the inclusion of simple experimental designs to test for bioaccumulation potential, mainly on persistent active ingredients, would help in triggering further experiments to accurately evaluate the bioaccumulation potential, avoiding costly and time consuming experimental designs. New active ingredients with unclear modes of action having transovarial properties like etoxazole, BPUs or certain growth regulators, could pose a threat to the environment if not measured accurately, including behaviour inside food webs.

References

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