Pesticides and Natural Enemies

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Naturally occurring biological control is still one of the cheapest forms of pest control, and as such is of great interest to pest managers. It has the additional benefit of carrying almost no negatives attributes where worker safety or environmental impact is concerned. An exceptions to the first generalization would be the use of predatory vespid wasps for biological control, which can produce a painful sting and an allergic reaction in humans. The exception to the second generalization, low environmental impact, usually revolves around the effect of purposely introduced and released natural enemies which can also attack some native, non-pest species in their new environment - the same type of non-target effect ascribed to pesticides.

While the pureest form of classical biological control has a few examples, most crop systems have some level of pesticide inputs, and thus we are more frequently concerned with **integrated control**; in this scenario, we must promote and conserve the natural enemies by protecting them in some manner from the pesticide inputs. Thus, we need to preferentially choose and use pesticides that are inherently selective, or use the pesticide in a selective manner. Selectivity generally falls into three classes:

Physiological selectivity: The natural enemy is inherently not susceptible to the pesticide, or the population has developed tolerance through repeated exposure to the pesticide. Example: predatory mites gain tolerance to organophosphates used for codling moth control, allowing integrated control of mites. Example: acaricides used against mites do not affect a hymenopterous aphid parasitoid, because the pesticides are only toxic to the Acari.

Behavioral selectivity: The natural enemy either has naturally occurring or developed behaviors which keep it from coming into contact with the pesticide. Example (hypothetical): a parasitoid gains tolerance by reducing grooming when exposed to a stomach poison, thus ingesting less of the toxicant.

Ecological selectivity: Pest control operations are manipulated in some way to minimize contact of the susceptible natural enemy with the pesticide, typically through timing, placement, or formulation of the pesticide. Example: 1) making applications of Penncap-M only when *Pnigalio flavipes* are in the pupal stage, or before they emerge in the spring. 2) Spraying the outer canopy with carbaryl to avoid contact with predatory mites. 3) alternate row middle spraying.

Of the three types of selectivity covered, ecological selectivity lends itself the most to integration into an IPM program. We can develop the appropriate knowledge of biology and stage-specific toxicity of pesticides, and these may give us the tools to alter timing or placement of the otherwise toxic pesticides. Physiological and behavioral selectivity (either inherent or developed through selection) are chance occurrences, over which we have little or no control. The exception would be the case where a natural enemy is either transgenically imbued with resistance, or is deliberately selected in greenhouse colonies by repeated exposure to promote resistance.

In general, parasitoids tend to be more susceptible to insecticides than predators, and the organophosphates as a group, tend to be broadly toxic to natural enemies. That said, generalizations are of very little use in constructing specific integrated management programs. Data that are specific to the region, natural enemy species and stage, and the specific array of pesticides that they are likely to be exposed to, are far more useful.

Types of Pesticide Effects: Studies of toxicity many be classed by type of test (laboratory vs. field) and by type of test (acute toxicity vs. sublethal effects). Laboratory tests are frequently called bioassays, short for biological assays. Researchers in Europe have developed a system of routinely screening pesticides for toxicity to natural enemies, and the results are used in developing IFP guidelines. They have a three-tiered system (laboratory, semi-field, and field test), but currently only test for acute toxicity.

<u>Acute Toxicity:</u> This is the effect produced by direct exposure to the pesticide, either topical (being hit by the spray) or residual (walking over the treated surface, and being exposed to the residues). Since the effects often occur together in the field (and are usually inseparable in field tests), they are frequently tested together in bioassay format. While bioassays in general measure a response, the purpose of acute toxicity tests to measure just one response: death. Depending on the material, the period for the response (death) to occur may be anywhere from a few hours to a few weeks, and bioassay procedures have to be developed specifically for each material. Other considerations involve the stage tested, and how to evaluate response. Evaluation death of adult or motile forms of insects is usually fairly straightforward; death in the egg stage is usually defined as inability to hatch in the normal time frame for the species at a given temperature regime.

<u>Sublethal effects:</u> as the term implies, this can any number of effects except death, but which result in a reduced capacity of the natural enemy to control the target pest. Effects fall into essentially two classes:

1) those that reduced the ability of the natural enemy to find, consume, or parasitize prey: reduced longevity, reduced prey consumption; repellency, host masking (thus reducing prey consumption)

2) those that reduce its ability to reproduce. Examples are reduced fecundity of females (lay fewer eggs over their lifetime); egg sterility (eggs don't hatch).

Routes of exposure: in general, bioassays try to mimic those that might occur in the field: contact (hit by spray, walk over residues), per os (ingestion, usually of intoxicated prey). With predators that consume large numbers of prey, and migrate into the orchard in response to an outbreak, the issue of intoxicated spray may be more to the point than with an orchard resident such as *Typhlodromus occidentalis*, which is likely to be hit directly by sprays and have prolonged exposure to residues.

Natural Enemies of Importance and their susceptibility to Pesticides:

1. *Predatory mites.* We usually confine our studies to *T. occidentalis*, since this is the most common, widespread and abundant predatory mite, although Zetzellia mali may be contributory in some situations. Generally, we have learned that two classes of pesticides are toxic to predatory mites: Pyrethroids and Carbamates. Toxicity to predatory mites is what has prevented the pyrethroids from being recommended (or much used) on Washington apples, even though they have been registered for decades, and are effective on a number of important lepidopteran pests. Conversely, in pears, where pyrethroids were used against pear psylla, these predators could barely be found, and only widespread resistance in pear psylla has stopped their use. Originally, the carbamate carbaryl (Sevin) was highly toxic to predatory mites, and its use for thinning caused mite flareups. Although it is still acutely toxic, mite outbreaks from a single application are increasingly rare, so clearly there is some level of tolerance in our populations. Carzol, another carbamate, is also a miticide, and is acutely toxic to mites, but populations can, in general, recover from single applications. The organophosphates were never quite as toxic as the pyrethroids and carbamates, and predators became tolerant with a few years. This allowed the continued use of Guthion and other OPs for codling moth control, while still managing mites in an integrated program. This doesn't mean that other groups don't impact *T. occidentalis* populations. We normally test the effects of single sprays, but small impacts of multiple sprays can eventually depress *T. occidentalis* populations. This is most critical with codling moth sprays, which are more likely to be applied multiple times (2-6) throughout the season. Imidan appears to be fairly neutral toward integrate mite control, but the new chloronicotinyls as a group need careful scrutiny. There is already substantial evidence for either stimulation of mite populations or suppression of Typh populations with one or more of these compounds. Assail (not yet registered) is the best documented of these, and has caused consistent mite outbreaks in 4-spray codling moth programs in experimental work to date. Of the chloronicotinyls, Assail is the best codling moth material, and thus most likely be to used in a multiple spray program. The effect of Calpyso and Actara is less clear; the restrictions on the Actara label probably will prevent much damage to predator populations. Provado appeared not to affect predatory mites in a field trial, however, there has been a long-term, poorly defined, and largely observational association of Provado use and increases in mite populations, thus further testing is much needed. Kaolin (Surround) appear to interfere with predation by *T. occidentalis*, such that mite outbreaks occur following the use of this material, although sometimes not until the following year.

2. *Pnigalio flavipes*. This is the principal parasitoid of western tentiform leafminer, and is capable of inflicting a high degree of mortality on the prey population; thus, is very much worth conserving. Two organophosphates were discovered in both field and laboratory tests to be quite lethal: Penncap and Lorsban. The former has since removed from the market, and the latter restricted to the delayed dormant period. This timing. tends to minimize its impact on *P. flavipes* in that it is before the peak emergence in the spring; it is likely that the more damage was done with the summer leafroller sprays. This parasitoid is surprisingly tolerant of a number of other compounds, including Vydate, Thiodan and Guthion, and even Asana is only rated and moderate to high toxicity. Even more surprising, is that Success (spinosad), a relatively selective compound, has a fairly high level of acute toxicity to *P. flavipes,* although the overall impact is probably no more than moderate. Kaolin (Surround) appear to disrupt *P. flavipes* in some way,

such as host masking or repellency, and repeated applications of this material appear to cause higher leafminer populations than would otherwise occur.

3. *Colpoclypeus florus*. This is one of the important parasitoids of leafrollers, and can also inflict high rates of mortality. It is highly susceptible to organophosphates (Guthion, Lorsban, Diazinon, Dimethoate, Imidan) and the carbamates (Sevin, Vydate, Carzol). Thiodan, Provado, permethrin, Success and Asana are only moderately toxic.

4. *Lacewings*. These are generalist predators, and are attracted to orchards with plentiful prey, usually aphids, but their occurrence is not easily manipulable or predictable. This is unfortunate, since they are generally impervious to orchard insecticides, including Lorsban, Asana, and Vydate (among others), at least in the larval stage. Provado isn't toxic to them either, so it can be used as a selective material.

5. *Coccinellids*. There are several common species representing this group of generalist predators, including *Adalia bipunctata*, *Harmonia axyridis*, *Coccinella transversoguttata*, and *Hippodamia convergens*. Of the species tested, *C. transversoguttata* appeared to be the most tolerant to orchard pesticides. There was a clear trend for the coccinellids to be more susceptible to pesticides than lacewing larvae. In the case of carbaryl (*H. axyridis*), the rate of the pesticide made a substantial difference in mortality; 300 ppm caused high mortality, while 150 ppm had very moderate to low toxicity. In other cases (imidacloprid) rates from 7.5 to 30 ppm all caused low levels of mortality. As expected, the conventional broadspectrum insecticides (OPs and carbamates) caused the highest levels of mortality; the biorational materials (Success, oil, soap, Bt, neem, abamectin) and specific aphicides (Aphistar, Provado, Pirimor, Sterling) were low to moderate, and the IGRS (Confirm, Comply) and specific acaricides were low.

Note: summaries of tests done to date may be found, annually revised and updated, in the *Crop Protection Guide for Tree Fruits* in Washington (EB0419). In general, this summary deals with acute toxicity, although the rating is based on probable impact, which may take into account length of residues at a lethal level.