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Fear as a Biological Control? How Scaring Farm and Garden Pests Could Lessen Plant Damage

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Introduction

For many of us the threats of predators — lions and bears, say — are long gone. Yet most animals face these pressures on a daily basis. The common pests in your garden or farm are no exception. Simply the threat of predation can greatly shape an organism's behavior, internal function, and even what it looks like. For example, pea aphids that are exposed to predators are more likely to produce offspring that have wings (Weisser et al 1999).

Nor do changes like these come cheap. As a pest shifts its energy from feeding and reproduction to hiding or dropping off of plants, it becomes less able to function or even survive.

Now convincing evidence suggests that the apparent risk of predation alone can reduce damage to plants by pests. Understanding the total effect of predators — including the risk perceived by their prey — will improve biocontrol treatments and could lead to new methods where *simply the cues of predators are used to protect plants.*

Integrated Pest Management and Biocontrols:

A pillar of integrated pest management is the use of biocontrols: the organisms enlisted to suppress pests. Leveraging natural enemies such as parasites, pathogens, and predators to regulate insect pest populations is a common control tactic — especially in systems where the use of pesticides is restricted, pesticide options are limited, or the target pest is resistant to pesticides.

Biocontrol tactics include importing, releasing, and conserving natural enemies. The goal: to have them consume the pest, thus reducing plant damage. Now we've seen that the fear of predation alone has the potential to lessen plant damage. A prey's response to the risk of predation is termed the *non-consumptive effect (NCE),* whereas predation itself is the *consumptive effect.*

Non-consumptive effects can be observed in nearly all predator-prey interactions, both on land and in water. In fact, researchers seeking to measure these effects found on average that NCEs had an equal or greater influence on prey than actual consumption did. Here, we focus on NCEs in agricultural settings, providing an overview of some of the recent examples where pest herbivores are significantly affected simply by the threat imposed by predators.

Before prey can respond to predators, they must first detect and identify the threat. Cues that prey use to detect predators include

- what they see (visual)
- what they hear (acoustic: sound and vibration)
- what they smell (olfactory: odors)

The NCEs that odors provoke are highlighted here due to the heavy reliance of insects on such cues and the possibility of using predator odor treatments in gardens and agricultural fields.

Three Basic Biocontrol Strategies Using Natural Enemies

Importation

Outbreaks often occur when a species is introduced to a new environment that lacks its natural enemies. Importation aims to bring the parasites, pathogens and predators from the pest's native range to an outbreak to suppress the population and become established in the new environment.

Conservation

Most environments have native enemies of pests. Conservation is an important tool that preserves and promotes native enemies to keep pest populations low.

Augmentation

The supplemental release of natural enemies may be needed when pest populations are too large for the present natural enemies.

The potential of NCEs:

Two model pests — aphids and Colorado potato beetle — will illustrate the potential of NCEs.

Aphids

Aphids are a focal species in studies of NCEs due to their ill repute as pests — and their strong behavioral responses to predation risk. They respond to threats by dropping off of the plant to the ground (Fig. 1); with prolonged threats, offspring are more likely to be born with wings. Since aphids are fragile, dropping off of their host plant greatly increases the chance of mortality.

In a recent study, researchers investigated the effects of predator odors on the bird cherry-oat aphid (Ninkovic et al. 2013). The bird cherry-oat aphid is the most common aphid found on small grains in the United States and internationally, attacking wheat, oat, rye, and barley. The predator used was the sevenspotted lady beetle *(Coccinella septempuctata),* which is regularly deployed as a biocontrol agent.

Aphids on barley plants previously visited by the lady beetles — which leave "chemical footprints" in their path — respond defensively. But their response depended both on

- the number of lady beetles that left footprints and
- the gender of beetles

This suggests that aphids are able to assess the level of risk and respond accordingly. Overall, the numbers of aphid settling on barley plants dropped by 40 to 53% in response to the prior presence of lady beetles.

Others have also found a strong response by aphids to the threat of the seven spotted lady beetle. For example, 60% of pea aphids feeding on alfalfa plants dropped off in the presence of this lady beetle (Losey & Denno 1998).

Figure 1. Sevenspotted lady beetle pursuing aphids. Photo: A. Gómez.

Colorado Potato Beetle

Colorado potato beetle *(Leptinotarsa decemlineata)* (Fig. 2) is one of the most damaging agricultural pests worldwide. Because of its remarkable ability to quickly become resistant to insecticides (Alyokin et al. 2008), researchers are keen to identify novel control methods — and NCEs are in the spotlight. Several studies have illustrated promising results.

One recent study on potatoes found a substantial response using the chemical cues from a common naturally occurring generalist predator, the spined soldier bug *(Podisus maculiventris)* (Fig. 3), which is marketed and used as a biocontrol agent (Hermann & Thaler 2014). Colorado potato beetle feeding was reduced by 24% when the area was previously exposed to the spined soldier bug, while volatile predator odors reduced leaf consumption by 16%.

Field tests of predator odors revealed an even greater response. Plants that were next to 10 spined soldier bug predators contained in a breathable bag (only allowing predator odors on a plot) had 64% less plant damage by adult Colorado potato beetles when compared to control plots (Hermann & Thaler in prep).

Other agricultural pests with strong responses to predation risk include thrips and tobacco hornworm.

Figure 2. Adult Colorado potato beetle (yellow and black stripes) under attack by a spined soldier bug. Photo: P. Greb, USDA.

Are we there yet?

Not quite. Management recommendations are still being developed. But these control options will likely be ready soon. Their intent: to create a 'scary environment' for pests that reduces colonization, reproduction, and plant damage. For instance, one approach might use artificial sources of predator odors much like pheromones are currently used to control pests.

Research now underway seeks to maximize the total predator effect of biocontrols via the direct consumption of pests and the effects of predation risk. But three areas need improvement. They include:

- isolating and testing predator odors
- a greater understanding of the dynamics of NCEs
- the distance over which predator cues are effective

Even so, predator cues might soon be an effective addition to integrated pest management strategies. In systems where push-pull tactics are used (where both attractants and deterrents are creatively utilized), the addition of predator odors would be yet another means of increasing their effectiveness.

Figure 3. Spined soldier bug consuming a Colorado potato beetle larva. Photo: N. Aflitto.

References

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