生物安全学报
JOURNAL OF BIOSAFETY

2012, 21(4): 245 - 246
http://www.jbscn.org

DOI: 10.3969/j.issn.2095-1787.2012.04.001

Thoughts of a Travelling Ecologist, 4

The tale of the aphid predators: why can we expect transgenic crops to cause environmental effects?

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First, let me state the obvious: ecologists have been too polite to tolerate intrusion by colleagues from other fields (mostly from molecular biology) who felt it necessary to pontificate about the ecological impacts of transgenic crops. Such pieces usually present, often in forceful language, the author's belief that transgenic technology is beneficial, without negative effects, and is only opposed by dark forces, that often also are portrayed as "unscientific", enemies of progress or worrisome, misinformed persons. Without dwelling too much on causes, or arguing about mixing facts with beliefs and interpretation, let me just remind the readers that overconfidence in one's field can result in the infamous "infallibility syndrome", when the affected starts to have illusions about the range of things s/he understands, and typically better than anyone else. This usually afflicts otherwise successful senior academics. The problem, as the eminent ecologist, Sir John Lawton observed (Lawton, 1992), is that persons suffering from the infallibility syndrome are not aware of it. The ecological effects of transgenic crops have long been an area with more than its usual share of contributions by such afflicted persons. However, ecology is a field that has a well-articulated toolkit, and conceptual frameworks that can be usefully employed to understand the environmental effects of transgenic crops. These tools need to be learned, just as in any other field, before one can meaningfully contribute to discussing or solving its pertinent problems. Certainly, the effect of humankind's activities on other living beings and their habitats is a very important area of concern for ecology. It is not an exaggeration to call it vital. Field growing of transgenic crops is a fast-spreading agricultural innovation, and as other agricultural innovations, will have environmental consequences. Thus it is a legitimate area of study for ecology. It seems that the numerous participants in the so-called "GM debate" entered the arena possibly urged by the urgency of the above problem, but in less than perfect command of the ecological armoury. This frequently resulted in "trying to speak Arabic while not knowing Arabic".

Why do ecologists expect ecological effects caused by transgenic crops via tri-trophic interactions? And why is the toxicological approach, with its focus on the direct effects of an isolated "GMO stressor" (i.e. a toxin) on a few selected non-target species, ecologically defective? The evidence can be classified into three types. First, because ecological theory tells us that indirect effects in ecological systems exist, and such effects can be stronger than direct interactions (Palomares *et al.*, 1995). Thus if direct interaction studies indicate no effect, we still have to test for indirect ones. From the point of view of analytically understanding why an effect occurs, research can be informative. From a management or monitoring point of view, however, it is indifferent: if a positive or negative effect is registered, action has to be taken, irrespective of our detail of understanding.

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A second line of evidence can be found by looking at analogous studies using plant alkaloids. Such studies often indicate that predators are sensitive to prey quality. In this context, it is interesting to consider the experimental results presented by Malcolm (1992). He kept the same aphid, *Aphis nerii*, on two different host plants. On oleander, the aphid accumulates a plant toxin —on peas, it does not. The same aphid, coming from the two different host plants, was offered the same nine aphid predators: three species each of coccinellids, syrphids and lacewings. There can be 18 different responses.

The predator responses were actually of three types: for some predators, the oleander-originating aphid prey was lethally toxic, while the pea-originating one was not. For others, there was a difference in prey quality, and they grew slower on one prey than on the other one. For the third group, the growth responses showed no difference in prey quality. This bodes well for risk assessment —not all species will react in different, idiosyncratic ways to prey quality (and thus to transgenic crop plants). With experience, classification of the responses into a smaller number of types is possible.

However, the three groups did not conform to taxonomic categorisation. Not all coccinellids reacted the same way to prey quality differences. Therefore, while generalisation is possible, it cannot simply be made on the basis of taxonomy: not all coccinellids, nor lacewings react the same way. This is also an important (and long ignored) message to practitioners of biosafety assessment of transgenic plants.

Direct experimental studies constitute the third type of evidence. These also indicate that there can be, and in same cases, there are, non-zero effects, as this is repeatedly demonstrated by our detailed analyses of laboratory experiments on natural enemies (Andow *et al.*, 2009; Lövei *et al.*, 2009). These analyses replaced a verbal summary of opinions, until then common practice, with the analysis of the original experimental data, thereby making them less subjective.

Thus we have multiple reasons to believe that transgenic crops can have considerable environmental impacts. We also have good reason to believe that we should not always remain at a " case by case " approach. As Malcolm's experiments indicate, generalisations could be possible, given a sufficiently large knowledge base. Currently, we are still far from this situation (Lövei *et al.*, 2009).

The overall environmental impact of growing transgenic crops will, for quite a while, remain an area of dispute, and one can only hope that more sophisticated studies will be presented in more measured tone than some incidents suggest (Waltz, 2009). Ecological effects need to be carefully assessed, and there are serious methodological issues to be clarified or developed. How to characterise " ecological importance"? How to detect unexpected effects? How long and how intensively should monitoring programs run? These are exciting scientific challenges for the field. The level of ecological sophistication in this field is still increasing. The current practice shows some signs of " trickling down", when concepts or techniques that have been long outdated in modern ecology continue to be used (see, for example, the case of diversity characterisation). This is a problem for ecologists to sort out. At the same time, they have to speak up. Environmental risk assessment of GMOs firmly belongs to ecology, and ecologists need to be more assertive, demanding a hearing at the discussion table.

Ecology will not be a final arbiter on the use of the technology, nor should it be, although under some scenarios a veto power is not unimaginable. In any case, ecologists (and not the usurpers) have a place, and will have to be heard, at the decision table. Anything else will lead to a distorted outcome, with more losers than winners.

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