Mortality of Obliquebanded Leafroller Due to Natural Enemies in Orchards Treated with Conventional or Reduced-Risk Insecticides

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Obliquebanded leafroller is a serious pest of apple in part due to its development of resistance to common insecticides. Although OBLR populations appear to be persistent in wild habitats, densities apparently are very low, particularly during the summer. This is due to high natural predation and parasitism; however, in commercial orchards insecticides kill most predators and parasites. Therefore, it should be possible to develop biologically based management programs for OBLR in commercial apple orchards if selective insecticides that are not toxic to indigenous natural enemies can be developed. It is therefore important to test newer more selective insecticides for toxicity to OBLR predators and parasites.

Obliquebanded leafroller (OBLR) [*Choristoneura rosaceana* (Walsh)] is a serious pest of apple in several regions of New York, and is of increasing importance in Washington, California, Michigan, British Columbia, Ontario, and Quebec. The pest status of OBLR is in part due to its development of resistance to insecticides. Populations of OBLR from commercial apple orchards show varying resistance to organophosphate insecticides (Guthion, Imidan), synthetic pyrethroids (Asana), and even newer insecticides such as Confirm and Intrepid. Currently, treatments of Intrepid and Spinosad provide adequate control of OBLR; however, more integrated management strategies are desirable to counter the problem of insecticide resistance and to lower management costs.

OBLR is native to North America and is widely distributed on many uncultivated species of trees and shrubs. In New York, OBLR are found throughout the state on uncultivated apple trees and in thickets of gray dogwood. Casual observations suggest the dynamics of OBLR in these uncultivated habitats is very different from those observed in commercial orchards. Although OBLR populations appear to be persistent in wild habitats, densities apparently are very low, particularly during the summer. In contrast, OBLR populations in commercial orchards appear to persist at damaging levels from year to year, even when treated with insecticides. Commercial apple orchards are excellent food sources for leafrollers, and treatments of some insecticides, such as organophosphates, are not highly toxic to OBLR but will destroy natural enemies (parasitoids and predators) that help regulate OBLR densities. In native habitats, vegetation may be less concentrated and nutritious for OBLR, and a diverse array of plant species may provide habitats that allow high densities of natural enemies to limit leafroller numbers (Figure 1).

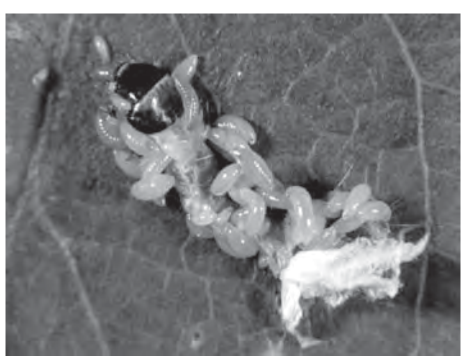

Figure 1. Two natural enemies of Obliquebanded leafroller larvae. A parasitoid, (*Colpoclypeus florus*), on the left and a predator, an immature reduviid bug (*Phymata fasciata*) .

In 2002 and 2003, studies were conducted to identify factors that limit an abundance of OBLR in habitats devoid of insecticides. Our intent was to use this information to develop a more biologically-based management program in commercial apple orchards. These studies confirmed that although low numbers of OBLR larvae consistently occur on gray dogwood plants in the spring, it was impossible to find larvae from the subsequent summer generation during July and early August. Similar results were observed on apple trees that had not been treated with insecticides. Concurrent laboratory studies showed that OBLR larvae could develop equally well on foliage from apple trees and dogwood plants, which suggested that the nutritional quality of apples and dogwood plants was similar and not a factor limiting OBLR populations.

Experiments were also conducted to compare the abundance and diversity of natural enemies in uncultivated dogwood habitats and in orchards not treated with insecticides. Small potted apple trees infested with OBLR larvae were placed in the orchards and in thickets of dogwood. Larvae were recollected after 96 hours, reared in the laboratory, and emerging parasitoids were identified. We found that levels of parasitism and the species composition of parasitoids were similar in unsprayed apple orchards and in dogwood thickets and that parasitism rates were as high as 72 percent.

These studies suggested that natural enemies could substantially contribute to the control of OBLR in commercial orchards if the deleterious effects of insecticides on OBLR natural enemies could be reduced. More selective, reduced-risk insecticides are currently being tested to replace organophosphates, carbamates and pyrethroids (see details in Agnello et al., 2004). We made use of these trials to determine whether these reduced risk compounds (Table 1) allow for greater natural enemy-caused mortality of OBLR.

Methods

The objective of the investigation was to determine whether predators and parasitoids caused greater mortality of OBLR larvae in orchards treated with reduced-risk insecticides compared to orchards treated with conventional insecticides. This required a methodology that would allow placing large numbers of larvae in orchards and exposing them to natural enemies therein. Following exposure, remaining larvae needed to be retrieved to monitor development and emergence of parasitoids. We accomplished this by placing laboratory-reared larvae on insecticide-free apple foliage and then placed the foliage and accompanying larvae into experimental plots. Following exposure, we recollected the larvae and reared them on artificial diet. With this procedure, which we termed outsourcing, we could determine the proportion of larvae that were parasitized. We could also estimate the proportion of larvae that were lost during the exposure period, a reduction in larvae that was due to the additive effects of dispersal and predation. If an estimate of dispersal loss was known, then predation loss could be determined.

Two outsourcing methods were used. In 2003, two apple leaves were placed in florist waterpicks and a single larva was allowed to develop a feeding site for 24 hours and then the leaves and larva were placed in trees in and around orchards. In 2004, a one meter long apple branch was placed in a capped PVC pipe filled with water and two-three larvae were allowed to develop feeding sites for 24 hours and then placed in trees in the research plots. In both years larvae were left in the research plots for 48 hours and then retrieved.

Dispersal loss of larvae from the leaves in waterpicks and from branches was estimated in the absence of any predators. This was done so that loss due to predation could be separated from loss due to dispersal. To preclude predators, the experiment was conducted in a screenhouse, which did however allow air movement. Larvae were placed on either the two leaves in waterpicks or on branches and allowed to develop feeding sites. The foliage and larvae were then placed in a screenhouse for 48 hours and subsequently examined to determine the proportion of larvae that had dispersed away. The experiment was repeated several times and overall, 550 larvae on leaves in waterpicks and 300 larvae on branches were used. Dispersal loss was very consistent among replicates and between the two placement methods, averaging 7 percent from foliage in

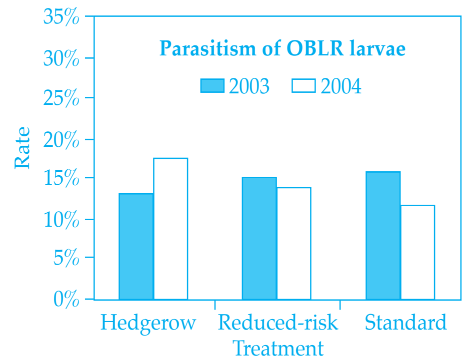

Figure 2. Percentage of OBLR larvae placed in plots in orchards that were killed by parasitoids. Percentages are based on 5 replicate orchards and 50 larvae per treatment plot outsourced 3 times each year. Treatments were wild habitats on the edge of orchards (hedgerow), approximately 10 acre plots treated with reduced-risk insecticides (reduced risk), and 10 acre plots treated with conventional insecticides (organophosphates, carbamates and pyrethroids) (standard).

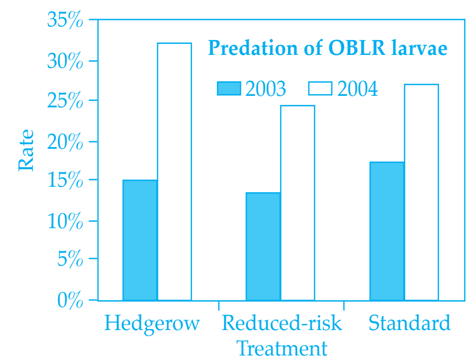

Figure 3. Percentage of OBLR larvae placed in plots in orchards that were killed by predators. Percentages are based on 5 replicate orchards and 50 larvae per treatment plot outsourced 3 times each year. Treatments were wild habitats on the edge of orchards (hedgerow), approximately 10 acre plots treated with reduced-risk insecticides (reduced risk), and 10 acre plots treated with conventional insecticides (organophosphates, carbamates and pyrethroids) (standard).

TABLE 1

Selective insecticides and their proposed target pests.

Insecticide	Target Pest(s)
Actara	rosy apple aphid, spotted tentiform leafminer, plum curculio
Avaunt	spotted tentiform leafminer, internal lepidoptera, plum curculio, Apple maggot, white apple leafhopper
Dipel	obliquebanded leafroller
Intrepid	internal lepidoptera, obliquebanded leafroller
Provado	aphids, spotted apple leafminer
Spinosad	codling moth, obliquebanded leafroller, apple maggot

waterpicks and 8.5 percent from branches.

An experiment was also conducted to determine whether the outsourcing methods would bias estimates of parasitism or predation. Bias might occur if the placement method influenced searching by natural enemies. While knowledge of bias is useful, the occurrence of bias would not invalidate the methods because they were to be used to compare relative estimates of predation and parasitism among treatments and not to obtain absolute estimates of mortality. The experiment was conducted in an insecticide-free orchard. Leafroller larvae were placed in trees two ways. The first by using one of the two outsourcing methods previously described and the second by placing larvae directly on foliage of trees. In the latter case, larvae were caged on the trees and allowed to develop feeding sites for 24 hours before being exposed to natural enemies. These trials were repeated three times each year in 2003 and 2004. We found that the waterpick and PVC pipe placement methods resulted in a 55 and 30 percent underestimation of predation loss, respectively. The waterpick method resulted in about a 50 percent underestimation of parasitism whereas the PVC pipe methods underestimated parasitism by ca. 20 percent.

The experiment to compare the mortality of OBLR larvae from parasitoids and predators was conducted in five orchards each of which contained three plots; one treated with conventional insecticides, one treated with reduced-risk insecticides, and a habitat (e.g., hedgerow) adjacent to the orchard that was not treated with insecticides. Fifty larvae were placed into each of these habitats using the outsourcing methods previously described (waterpick in 2003, PVC pipe in 2004). Larvae were left in the orchards for 48 hours, and those remaining were retrieved and reared. This process was repeated three times each year. Data were analyzed using a mixed models analysis of variance.

To determine the abundance and diversity of potential arthropod predators, collections were made from 50 randomly chosen branches in each orchard plot (15) four times in 2004 [7/13 (daytime collection); 7/19 (day & night collection); 8/3 (daytime collection)]. Two-foot-long branch-tips were vacuumed for three seconds each using an insect vacuum. All the collected insects were identified and predators were separated into seven groups: lacewing larvae, tree crickets, ants, spiders, predacious flies, predacious true bugs and lady beetles. An additional study verified that vacuuming provided a representative sample of the predators present on the branches.

Results

Parasitism of OBLR larvae was not significantly different among the hedgerows, reduced-risk treatments and plots treated with conventional insecticides during 2003 or 2004 (Figure 2). Rate of parasitism in all three treatments was remarkably similar during both years of the study (13,16 & 15 percent in 2003 and 17, 12, & 14 percent in 2004, respectively in the hedgerows, reduced risk, and standard).

Wasps and flies parasitized the outsourced larvae. In 2003, wasps parasitized a higher percentage of OBLR larvae in the hedgerows and reduced-risk pesticide treatments than in the standard plots, but rates of parasitism were similar in all plots in 2004. Parasitoid flies parasitized the same proportion of larvae in all three treatments in both years. The relative importance of the two parasitoid groups (wasps and flies) varied between two regions in which the experiment was conducted. In the two orchard sites located in one of these regions (Lafayette), flies (Tachnidae) were the most important parasitoids, and in one orchard 50 percent of larvae were parasitized by this group of insects. Wasps were less active in the Lafayette orchards, parasitizing a range of 0-16 percent of the larvae in different treatments. In contrast, flies were considerably less active in the three orchards in the second region (Wayne), and the rates of larval parasitization ranged from 0- 9 percent. In these orchards, wasps were relatively more important parasitoids and larval parasitization reached a maximum of 22, and 30 percent, respectively in 2003 and 2004.

Larval mortality from predators was higher than that from parasitoids during both years of the study in all of the treatments (Figure 3). The estimated levels of predation in hedgerows, reduced-risk treatments, and standard plots were similar in both years of the study, although the average estimated percentages of larval loss from predation were higher in all treatments in 2004 than in 2003. This difference may be attributed to the use of branches in pipes for outsourcing larvae in 2004, which resulted in higher estimates because it may have more closely mimicked larval infestations on actual tree branches.

Nine parasitoid species were recorded from the research sites, but only three of them, the ichneumonid wasp *Exochus albifrons*, the tachinid fly *Actia interrupta* and the braconid wasp *Oncophanes americanus* parasitized rela tively high numbers of larvae in both years. *O. americanus* was present in all three treatments. This parasitoid was collected from late June until mid-August, parasitizing every larval stage of OBLR. *E. albifrons* was present only in July, reaching a peak parasitism level in mid-July, and disappearing by August. The only important parasitic fly, *A. interrupta*, was abundant in the two Lafayette orchards, but rare in Western NY sites. This parasitoid fly was present in both July and August in both years.

The most common groups of predators collected were true bugs, ants, and tree crickets. Ants and tree crickets were more commonly collected in hedgerows and true bugs were the most common predaceous species collected in all treatments. Although significantly higher numbers of predators were collected from hedgerows than orchards, this higher population density apparently did not result in a higher predation of OBLR larvae.

Discussion

Levels of mortality inflicted on outsourced OBLR larvae from parasitoids and predators were not significantly higher in our 10 acre orchard plots treated only with selective insecticides for two to three growing seasons compared to nearby plots treated with standard insecticides. The estimates of larval mortality from predation were consistently higher than estimates of mortality from parasitoids. Two factors could account for this pattern. First, it is possible that changes in natural enemy abundance in orchards will not occur as a result of changes in management practices imposed on relatively small acreages. The plots used in this study were approximately 10 acres in size, but were surrounded by many acres of orchard that were treated with conventional insecticides. While 10 acres would seem to be a large area, patterns of natural enemy abundance may be determined by processes that occur on a much larger scale. The fact that estimates of natural enemy-caused mortality of OBLR larvae were not greater in hedgerows is evidence that supports this explanation. It is also possible that some or all of the selective, reduced-risk insecticides are more toxic to natural enemies than currently thought. Plots were treated with several different types of selective insecticides some of which might be toxic to beneficials as conventional insecticides. These variables will have to be investigated more thoroughly in future studies.

Larval mortality from natural enemies in nearby hedgerows that were presumably not treated with pesticides, was also not significantly greater than that observed in the two insecticide-treated plots. It is possible that the population of natural enemies in hedgerows is relatively low because they are a small, localized unsprayed part of the landscape near an extensive acreage of apple orchards and other agricultural land that has repeatedly been treated with pesticides. Perhaps it is necessary to have large unsprayed areas with a diverse plant structure that are geographically isolated from pesticide treated areas to enhance the abundance of natural enemies of leafrollers.

This study also showed that there were differences in the overall levels of activity of beneficials and the species of most important parasitoids associated with OBLR larvae among orchards in different geographical locations. This variability may be due to differences in the overall landscape environment outside of orchards, or variability in the acreage and size of apple orchards within the region. Future studies should be done in more locations to determine if variables associated with regional orchard plantings, or host plant or geographic variables in the external landscape near orchards can be identified that will enhance the likelihood of improving biological control of leafrollers.

Summary

Biological studies conducted in research plots of unsprayed apple trees and thickets of gray dogwood showed that overwintering OBLR larvae were common in these two types of natural habitats, but persisted at relatively low levels. Later during the season, larvae from the summer generation were not usually detectable. Subsequent studies showed that the quality of the two host plants was suitable for the survival of the summer generation of larvae, but high levels of parasitism and a similar composition of parasitoid species were observed when larvae were set out on both host plants in these habitats. These studies suggested that natural enemies can regulate populations of OBLR at low levels on unsprayed apple trees, particularly during the summer when most fruit damage occurs. Therefore, it should be possible to develop biologically based management programs for OBLR in commercial apple orchards treated with more selective insecticides that are not toxic to indigenous natural enemies. Studies were conducted during the 2003 and 2004 growing season to compare the mortality of OBLR larvae from predators and parasitoids in three habitats: (1) Unsprayed hedgerows adjacent to commercial orchards. (2) Plots treated only with reduced-risk insecticides for 2-3 consecutive seasons. (3) Plots treated with conventional insecticides. Larval mortality from both predators and parasitoids was not significantly different among untreated hedgerows, reduced-risk insecticide plots, and standard plots. Estimates of larval mortality from predation were consistently higher during both years of the study in all three treatments than that from parasitoids. This study also showed that there were differences in the species of most important parasitoids associated with OBLR larvae among orchards in different geographical locations. These results suggest that future studies should be done to compare the toxicity of individual reduced-risk insecticides to natural enemies, and to identify variables associated with orchard plantings or the landscape surrounding orchards to determine their effects on populations of predators and parasitoids.

References

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