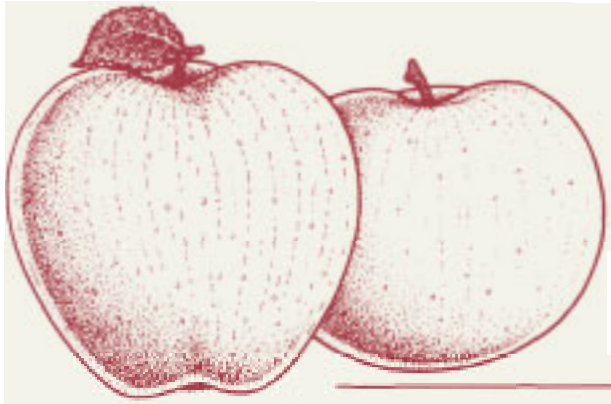

Biological Control of Mites on Apples in North Carolina

In North Carolina, the European red mite, *Panonychus ulmi* (Koch), and the twospotted spider mite, *Tetranychus urticae* (Koch), are two major indirect apple pests. When populations are large, leaves become bronzed. If the infestation becomes intense, trees may be defoliated. Although the fruit is not attacked directly, mite injury can decrease the size and number of fruit, reduce bud set the following season, and decrease fruit set, fruit firmness, soluble solids content, and fruit color. Damage severity depends on a number of factors, including crop load, cultivar, timing of mite injury, tree moisture stress, and the intensity of foliar diseases and insect pests. Healthy, properly thinned trees can tolerate mite injury better than stressed trees.

Sole reliance on chemicals for control of mites on apples is expensive and risky in view of rising miticide costs, the need for multiple applications if the infestation is intense, and the potential for mites to become resistant to the few miticides currently available. A preferred alternative is biological control. Conservation of natural mite predators has been an important component of the integrated mite-management program for more than 20 years.

Taking advantage of the mites' natural enemies requires an understanding of pest mites and their natural enemies, as well as the biotic and abiotic factors that affect these populations. This publication describes how to enhance the activity of mite predators in North Carolina apple systems, and how to determine if natural enemies alone can maintain pest mites below damaging levels, or if miticides also will be needed.

Identification and Biology

Plant-Feeding Mites

European red mite. This mite is the most common and destructive mite in North Carolina orchards, whereas the twospotted spider mite is occasionally a problem later in the season. The European red mite overwinters in the form of bright red eggs that are laid by females in the autumn on twigs and small branches, frequently near bud bases (Figure 1). Immature mites hatch when Delicious varieties begin to bloom. Adult female mites are red and oval with white spots at the base of dark bristles. Immature stages and adult males vary in color and may appear as

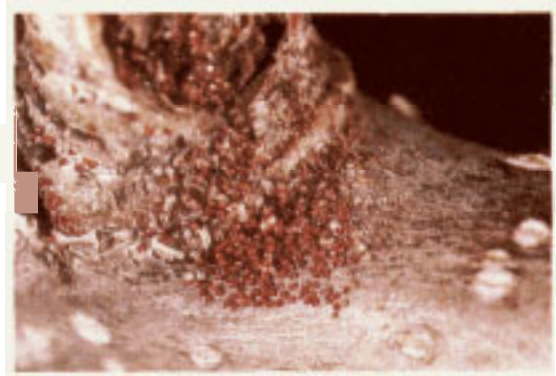

Figure 1.Overwintering European red mite eggs.

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red, greenish, or black. (Male and female adults are shown in Figure 2.)

All motile stages feed on apple leaves during the growing season, and females will lay reddish eggs on leaves throughout this period. There may be more than 10 generations per season, with populations usually peaking in mid-June to early August. Hot and dry weather promote rapid population increases.

An oil application at the 1/2-inch green-tip stage of fruit bud development will kill most of the overwintering eggs and can effectively reduce early-season European red mite populations. However, for the oil to be effective, it must be applied dilute and in high volume to obtain thorough coverage on all tree surfaces.

Twospotted spider mite. Adults and immatures are often cream or ivory, with an irregularly shaped dark spot on each side of their oval bodies (Figure 3). These mites overwinter as adults on plants and debris on the orchard floor. In the spring and early summer, populations increase in the ground cover. In mid- to late summer, the mites migrate up into trees. Infestations are usually accompanied by a silken webbing on leaves. In the spring, populations that develop on vegetation in the orchard floor also serve as a food source for *Amblyseius fallacis*, one of the beneficial mites discussed in the next section.

Apple rust mite. The apple rust mite, *Aculus schlechtendali* (Nalepa), is a very small, pear-shaped mite that is difficult to observe even with a hand lens. These mites overwinter as adults under apple bud scales. Before bloom they move to leaves where they feed and reproduce. Although populations can become very large (more than 500 per leaf), they do not inflict serious damage. Conversely, the apple rust mite is believed to serve as an early-season food source for predators, and thus assists natural enemy populations when the European red mite and the twospotted spider mite are scarce.

Mite Predators

When conditions are favorable and mite predators are allowed to flourish, they can play an important role in keeping European red mite and twospotted spider mite populations below damaging levels. In North Carolina, important mite predators include the two predaceous mites *Amblyseius fallacis* (Garman) and *Zetzelia mali* (Ewing), and the predaceous lady beetle *Stethorus punctum* (Le Conte). The *A. fallacis* mite and the *S. punctum* beetle are the most common predators and are likely to have the greatest impact on pest mites. They both overwinter in vegetation on the orchard floor. Predators do not move into the tree canopy until later in the spring when plant-feeding mites infest trees.

A. fallacis mites are pear shaped and slightly smaller than the European red mite (Figure 4). They may appear transparent to pinkish or red, depending on how recently they have fed. This predator moves more quickly than pest mites and can be seen with the aid of

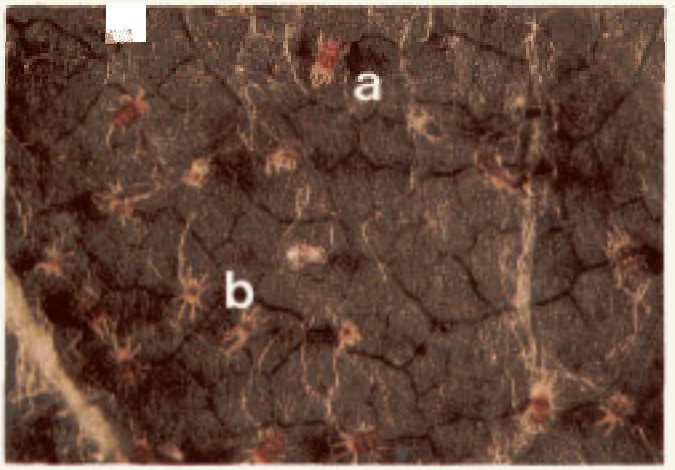

Figure 2. European red mite adults: female (a) and male (b).

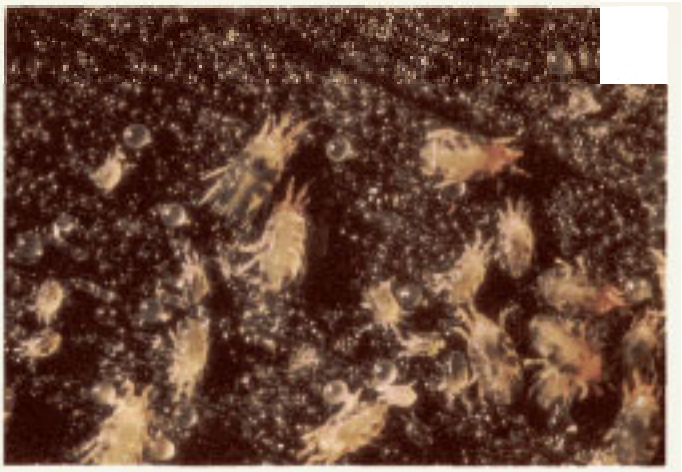
Figure 3. Twospotted spider mites.

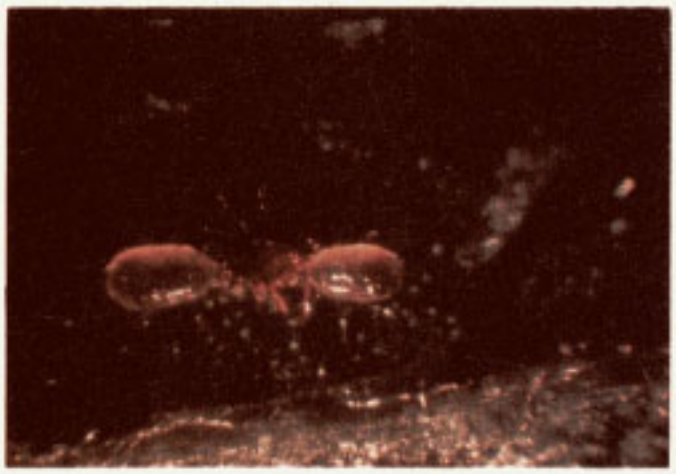

Figure 4. *Amblyseius fallacis* feeding on a European red mite.

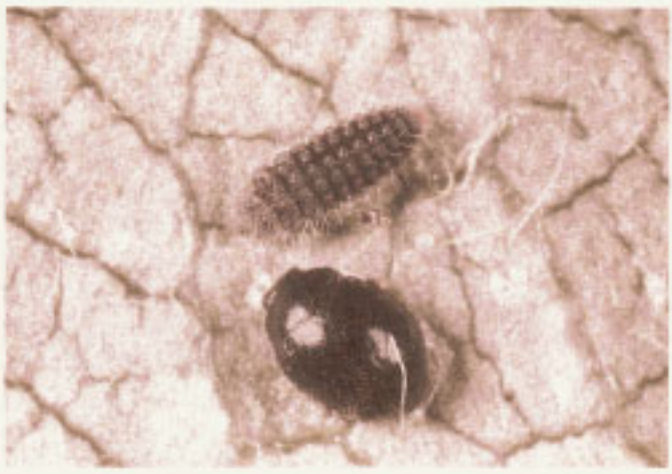

Figure 5. *Stethorus punctum* adult and larva.

a hand lens when the leaf is held in the sunlight. *A. fallacis* populations usually do not fluctuate greatly and are most effective at low to moderate European red mite densities.

S. punctum beetles are easily seen with the naked eye. Adults are oval and shiny black, whereas larvae are grey to blackish with numerous bristles (Figure 5). As larvae become older, they may turn reddish. Pupae are teardrop shaped and black; they often attach in groups of two to five per leaf. Adult beetles and larvae are both predaceous. *S. punctum* beetles usually do not appear in trees until pest mites are well established in the tree canopy. However, they are excellent predators; a single adult may consume more than 100 mites per day. Consequently, *S. punctum* populations are most effective at moderate to high prey populations.

Factors Affecting Predator Populations

The buildup and maintenance of predator populations in apple orchards should be viewed as a long-term commitment. Careful consideration must be given to pesticide-use patterns, ground cover management, fertilization schemes, and arthropod scouting programs. In orchards where few or no predators have previously existed, it may take years to establish an effective predator complex. Similarly, resurgence of predator populations after they have been destroyed by improper pesticide use may take two to three years.

Pesticides

In commercial apple orchards, extensive use of pesticides to control insects, diseases, and weeds is most often the cause of low natural enemy populations. Not only are certain pesticides highly toxic to predators, but some directly affect plant-feeding mites and the nutritional quality of apple foliage, encouraging the buildup of European red mite or twospotted spider mite populations.

In general, both *A. fallacis* and *S. punctum* are more tolerant and resistant to organophosphate (OP) insecticides than to other classes of insecticides. Unfortunately, certain insect pests are not controlled by OP insecticides, which means that other classes of chemicals (such as carbamates and organochlorines) must be used. To minimize their adverse affects on predators, these alternative insecticides should be used only early in the season (preferably before bloom) before predators have entered the apple canopy. Avoid pyrethroid insecticides at all times because of their high toxicity to predators and their long persistence.

Although certain OP insecticides are relatively safe to predators, avoid unnecessary applications when predators are present in trees. Even small reductions in predator populations may allow pest mites to "escape" natural control. Proper timing can most easily be accomplished by regularly scouting for insect pests and making applications only at recommended action threshold levels. (See *Scouting Apples in North Carolina*, North Carolina Cooperative Extension Service, Pub. V1.1).

Certain fungicides and herbicides also can harm predator populations, both as direct toxins to *A. fallacis* and by affecting reproduction. Field studies to determine how certain herbicides affect predator populations have been inconclusive, but it is logical to assume that applications made during the winter and spring are most harmful because *A. fallacis* mites are concentrated in the ground cover at those times. To learn how various pesticides affect predator populations, consult the *Pest & Orchard Management Guide for North Carolina Apples* (Extension Service publication AG-37), or contact your county Extension agent.

Ground Cover Management

A. fallacis, *S. punctum*, and the twospotted spider mite overwinter in vegetation on the orchard floor. Thus, ground cover management is important in conserving mite predators. Orchards with poorly managed ground covers (for example, those with large numbers of broadleaf weeds and no herbicide use) generally have more abundant predator populations than well-managed ground covers with little vegetation and a clean herbicide strip.

Obviously, poorly kept orchard floors are not conducive to the overall health and productivity of the orchard, and a compromise must be found. Studies to determine the most suitable ground cover to promote predator conservation and tree productivity are in progress. For now, we recommend that you control broadleaf weeds and, during the spring, avoid herbicides that are toxic to predators.

Cultural Practices

Proper fertilization, pruning, and thinning practices all play important roles in apple mite management. Avoid excessive fertilization, particularly with nitrogen, because elevated element levels in foliage provide a more nutritious food source for mite pests and promote rapid population buildup. As previously mentioned, excessive crop loads stress trees and make them more susceptible to mite injury. Pruning is important for overall orchard productivity, and it also facilitates thorough coverage with delayed dormant oils.

Determining Biological Control Potential

Sampling Procedures

Sample orchards regularly for both pest mites and predators to determine (1) the potential for biological control when pest mites increase in numbers, and (2) the need for miticide applications when it is determined that natural enemies alone will not suppress potentially damaging mite populations.

Sample trees weekly, beginning shortly after petal fall and continuing until early August. Divide the orchard into 15- to 25-acre blocks, and within each 10 trees to sample. Choose trees that represent the tree age and variety occurring within the block. Be sure to select some trees where you expect mites to be a problem or to occur first. From each of the 10 trees, select five leaves (50 leaves total). Choose leaves from random locations on the tree, from both the interior and periphery. Use a hand or visor lens to examine the upper and lower leaf surface for live mites.

You can estimate the number of mites per leaf by determining the percentage of leaves with more than one mite. Rather than counting the number of mites on each leaf, simply keep a running total of the number of leaves sampled and the number of leaves with more than one mite. When you are done sampling, divide the number of mite-infested leaves by 50 and multiply by 100 to determine the percentage of infested leaves. This percentage is correlated with the actual mites per leaf, so that percentages of 80, 85, 90, and 95 translate to approximately 5, 7, 11, and 26 mites per leaf, respectively.

It is not necessary to sample for predators until mite densities have reached the *decision threshold level* (discussed in the next section). When this threshold is reached, sample trees for *S. punctum* by recording the number of adults and larvae observed during a 3-minute search. Conduct searches around the periphery of the trees, observing both the upper and lower leaf surfaces. If *S. punctum* populations are determined to be insufficient to reduce mite populations, examine leaves for *A. fallacis*. Count the actual number of *A. fallacis* on

leaves; do not use the percentage method discussed earlier.

Decision Threshold Level

Before July 1, the recommended decision threshold level is 7 mites per leaf (about 85 percent of leaves are infested). After July 1, the recommended threshold is 10 mites per leaf (about 90 percent of leaves are infested). When populations reach these levels, decide whether or not predators are present in sufficient numbers to control the mites.

When European red mite and twospotted spider mite populations range from 7 to 10 mites per leaf, a *S. punctum* population of 15 to 25 adults plus larvae per 3-minute search is needed to prevent mites from building to damaging levels. In most situations, both adults *and* larvae must be present to reduce mite populations sufficiently.

For *A. fallacis*, a predator-to-prey ratio of 1 to 5 will almost certainly provide acceptable control. If there are more than 5 but less than 15 pests for every predator, biological control is still possible. If there are more than 15 pests for every predator, *A. fallacis* is unlikely to control pest mites.

If neither predator population is present in sufficient numbers, a miticide should be applied in the next spray. Regardless of whether or not a miticide is applied, check trees again one week after the first sampling to determine the status of mite and predator populations. Also, consider weather forecasts when making decisions. Cool temperatures and rainfall can suppress mite populations.

Injury Threshold Level

A decision threshold level is not the same as an injury threshold level. Healthy, properly thinned trees can sustain considerably more than 10 mites per leaf. In most situations, trees can tolerate up to 30 mites per leaf without any observable effects on fruit yield or quality. The threshold range from 7 to 10 mites per leaf is used because, in the absence of biological control, it is often difficult to prevent mite infestations from exceeding 30 or more per leaf when miticide applications are delayed. In North Carolina, mite populations are most likely to exceed threshold levels between mid-June and mid-July. For this reason, and the fact that late-season mite injury is not as damaging as early or mid-season injury, miticide applications are not recommended after early August.

The mite sampling procedures and decision guidelines outlined in this publication may at first seem rather complex and time consuming. However, with a little experience the process can become routine. When mite populations are below threshold levels, sampling should take 30 to 45 minutes. When the populations approach decision threshold levels and predators must be counted, sampling takes slightly longer. However, considering the potential savings from biological control, mite sampling is clearly a cost-effective program.

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