scaffolds

Update on Pest Management and Crop Development

F R U I T J O U R N A L

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INSECTS

THE ENEMY OF MY ENEMY

LOCAL TALENT
(Art Agnello, Entomology, Geneva; ama4@cornell.edu)

❖❖ There are many insects present in apple orchards that provide a benefit to growers by feeding on pest species. It is important that growers and orchard managers be able to recognize these natural enemies, so that they are not mistaken for pests. The best way to conserve beneficial insects is to spray only when necessary, and to use materials that are less toxic to them (see Tables 6.1.2 & 7.1.2, pp. 57 and 66 of the Recommends). This brief review, taken from IPM Tree-Fruit Fact Sheet No. 18 (available online at: http://hdl.handle.net/1813/43074), covers the major beneficial insects that are likely to be seen in N.Y. orchards, concentrating on the most commonly seen life stages. Factsheet No. 23, "Predatory Mites" (online: http://hdl.handle.net/1813/43122), reviews mites that are important predators of leaf-feeding mites. Photos and biological information on these and other beneficial species can also be found using the online (hosted by MSU) search engine version of the "Tree Fruit Field Guide to Insect, Mite, and Disease Pests and Natural Enemies of Eastern North America": http://www.ipm.msu.edu/search. A hard copy of the Tree Fruit Field Guide (formerly NRAES-169) can be purchased from PALS Publishing in Ithaca; a link to their site can be found at: http://palspublishing.cals.cornell.edu/nra_order.taf?_function=detail&pr_id=158

CECIDOMYIID LARVAE
(*Aphidoletes aphidimyza*)

These gall midge flies (Family Cecidomyiidae) are aphid predators, and overwinter as larvae or pupae in a cocoon. Adults emerge from this cocoon, mate, and females lay eggs among aphid colonies. The adults are delicate, resembling mosquitoes, and are not likely to be seen. The eggs are very small (about 0.3 mm or 1/85 in long) and orange. They hatch into small, brightly colored, orange

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larvae that can be found eating aphids on the leaf surface. These predacious larvae are present from mid-June throughout the summer. There are 3–6 generations per year. In addition to aphids, they also feed on soft-bodied scales and mealybugs.

SYRPHID FLY LARVAE (Family Syrphidae)

The Family Syrphidae contains the "hover flies", so named because of the adults' flying behavior. They are brightly colored with yellow and black stripes, resembling bees. Syrphids overwinter as pupae in the soil. In the spring, the adults emerge, mate, and lay single, long whitish eggs on foliage or bark, from early spring through midsummer, usually among aphid colonies. One female lays several eggs. After hatching, the larvae feed on aphids by piercing their bodies and sucking the fluids, leaving shriveled, blackened aphid cadavers. These predacious larvae are shaped cylindrically and taper toward the head. There are 5–7 generations per year. Syrphid larvae feed on aphids, and may also feed on scales and caterpillars.

LADYBIRD BEETLES (Family Coccinellidae)

• *Stethorus punctum*: This ladybird beetle is an important predator of European red mite in parts of the northeast, particularly in Pennsylvania, and has been observed intermittently in the Hudson Valley of N.Y., and occasionally in western N.Y. *Stethorus* overwinters as an adult in the "litter" and ground cover under trees, or in nearby protected places. The adults are rounded, oval, uniformly shiny black, and are about 1.3–1.5 mm (1/16 in) long. Eggs are laid mostly on the undersides of the leaves, near the primary veins, at a density of 1–10 per leaf. They are small and pale white, and about 0.3–0.4 mm (1/85 in) long. Eggs turn black just prior to hatching. The larva is gray to blackish with numerous hairs, but becomes reddish as it matures, starting on the edges and completing the change just prior to pupation. There are 3 generations per year in south-central Pennsylvania, with peak periods of larval activity in mid-May, mid-June and mid-August. The pupa is uniformly black, small and flattened, and is attached to the leaf.

• Other Ladybird Beetles: Ladybird beetles are very efficient predators of aphids, scales and mites. Adults are generally hemisphere-shaped, and brightly colored or black, ranging in size from 0.8 to over 8 mm (0.03–0.3 in). They overwinter in sheltered places and become active in the spring. Eggs are laid on the undersides of leaves, usually near aphid colonies, and are typically yellow, spindle-shaped, and stand on end. Females may lay hundreds of eggs. The larvae have well-developed legs and resemble miniature alligators, and

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Dept. of Entomology
NYSAES, Barton Laboratory
Geneva, NY 14456-1371
Phone: 315-787-2341
FAX: 315-787-2326
E-mail: ama4@cornell.edu

Editor: A. Agnello

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are brightly colored, usually black with yellow. The pupal case can often be seen attached to a leaf or branch. There are usually 1–2 generations per year. One notable species that is evident now is *Coccinella septempunctata*, the sevenspotted lady beetle, often referred to as C-7. This insect, which is large and reddish-orange with seven distinct black spots, was intentionally released into N.Y. state beginning in 1977, and has become established as an efficient predator in most parts of the state.

LACEWINGS (Family Chrysopidae)

Adult lacewings are green or brown insects with net-like, delicate wings, long antennae, and prominent eyes. The larvae are narrowly oval with two sickle-shaped mouthparts, which are used to pierce the prey and extract fluids. Often the larvae are covered with "trash", which is actually the bodies of their prey and other debris. Lacewings overwinter as larvae in cocoons, inside bark cracks or in leaves on the ground. In the spring, adults become active and lay eggs on the trunks and branches. These whitish eggs are laid singly and can be seen connected to the leaf by a long, threadlike "stem". Lacewings feed on aphids, leafhoppers, scales, mites, and eggs of Lepidoptera (butterflies and moths).

TRUE BUGS (Order Hemiptera)

There are many species of "true bugs" (Order Hemiptera) such as tarnished plant bug, that feed on plants, but a number of them are also predators of pest species. The ones most likely to be seen are "assassin bugs" or reduviids (Family Reduviidae), and "damsel bugs" or nabids (Family Nabidae). These types of predators typically have front legs that are efficient at grasping and holding their prey.

PARASITOIDS

Parasitoids are insects that feed on or in the tissue of other insects, consuming all or most of their host and eventually killing it. They are typically small wasps (Order Hymenoptera; e.g., families Ichneumonidae, Braconidae, Chalcididae), or flies (Order Diptera; e.g., family Tachinidae). Although the adult flies or wasps may be seen occasionally in an orchard, it is much more common to observe the eggs, larvae, or pupae in or on the parasitized pest insect. Eggs may be laid directly on a host such as the obliquebanded leafroller, or near the host, such as in the mine of a spotted tentiform leafminer. After the parasitoid consumes the pest, it is not unusual to find the parasitized larvae or eggs of a moth host, or aphids that have been parastized ("mummies"). Exit holes can be seen where the parasitoid adult has emerged from the aphid mummy.

GENERALIST PREDATORS

There is a diversity of other beneficial species to be found in apple orchards, most of which are rarely seen, but whose feeding habits make them valuable additions to any crop system. The use of more selective pesticides helps to maintain their numbers and contributes to the level of natural control attainable in commercial fruit plantings. Among these beneficials are:

• Spiders (Order Araneida): All spiders are predaceous and feed mainly on insects. The prey is usually killed by the poison injected into it by the spider's bite. Different spiders capture their prey in different ways; crab spiders (Thomisidae and Philodromidae) and jumping spiders (Salticidae) forage for and pounce on their prey — the crab spiders lie in wait for their prey on flowers —

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and web-building spiders (e.g., Araneidae, Theridiidae, and Dictynidae) capture their prey in nets or webs.

• Ants (Family Formicidae): The feeding habits of ants are rather varied. Some are carnivorous, feeding on other animals or insects (living or dead), some feed on plants, some on fungi, and many feed on sap, nectar, honeydew, and similar substances. Research done in Washington has shown certain species (*Formica* spp.) of ants to be effective predators of pear psylla.

• Earwigs (Family Forficulidae): Although these insects may sometimes attack fruit and vegetable crops, those found in apple orchards are probably more likely to be scavengers that feed on a variety of small insects. ❖❖

MODEL BUILDING
Insect model predictions for Highland[H]/ Geneva[G]
[Source: NEWA Apple Insect Models, http://newa.cornell.edu/index.php?page=apple-insects]

Obliquebanded Leafroller 50% egg hatch @ 630 DD43 from biofix; 90% egg hatch @ 810 DD43 (currently @ 869[H] / 550[G]).

ORCHARD RADAR DIGEST
[H = Highland; G = Geneva]:

Roundheaded Appletree Borer
RAB peak hatch roughly: July 4-July 22 (H)/July 10-July 30 (G).
Dogwood Borer
Peak DWB egg hatch roughly: July 21 (H)/July 29 (G).
Codling Moth
Codling moth development as of July 10:
2nd generation adult emergence at 5% (H)/0% (G) and 1st generation egg hatch at 100% (H)/96% (G).
Lesser Appleworm
2nd LAW flight begins around: July 12 (G).
Oriental Fruit Moth
2nd generation second treatment date, if needed: July 9 (H)/July 18 (G).
Redbanded Leafroller
2nd RBLR peak catch and approximate start of egg hatch: July 12 (G).
Spotted Tentiform Leafminer
Second optimized sample date for 2nd generation STLM sapfeeding mines, if needed: July 10 (H)/ July 19 (G).
White Apple Leafhopper
2nd generation WALH found on apple foliage: July 28 (H)/ August 7 (G).

DISEASES

THE BITTER TRUTH

NEW CONSIDERATIONS FOR CONTROLLING BITTER ROT ON APPLES
(Dave Rosenberger, Plant Pathology, Highland; dar22@cornell.edu)

❖❖ Bitter rot, which can be caused by at least 18 different species of *Colletotrichum* worldwide, continues to be one of the more difficult summer diseases to control on some apple cultivars. Bitter rot is an especially severe problem on Honeycrisp and some of the other early maturing cultivars. An update on what we know about the pathogens causing bitter rot was posted on my blog back in January (See http://blogs.cornell.edu/plantpath-hvl/2017/01/20/recent-changes-in-our-understanding-of-bitter-rot-of-apples/). Based on available evidence, it appears that bitter rot in the northeastern United States and probably in much of the midwest is caused primarily by *Colletotrichum fioriniae*, a species within the broader *C. acutatum* group. South of the Mason Dixon line, bitter rot may be caused by species that include representatives from the *C. gloeosporioides* group that have different fungicide sensitivities and a somewhat different life cycle. The rest of this article pertains primarily to controlling bitter rot in the northeast and midwest where *C. fioriniae* seems to be the predominant pathogen on apples.

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In previous commentary, fungicides recommended for control of bitter rot in the northeast included captan, ziram, and QoI fungicides such as trifloxystrobin (i.e., as Flint or as one component in Luna Sensation) or pyraclostrobin (which is present in both Pristine and Merivon). It is becoming evident, however, that continued dependence on QoI fungicides for controlling bitter rot in apples is probably neither sustainable nor advisable.

Over the past few years, numerous scientists have been reporting that *Colletotrichum* species are developing resistance to QoI fungicides. Resistant isolates have been recovered from apples (Koenig et al. 2012, Kim et al. 2016, Munir et al. 2016) and other fruit crops around the world (Forcelini et al. 2016, Nita and Bly 2016). Because QoI fungicides applied to apples during summer are always recommended in combinations with captan (or perhaps Ziram), one might argue that the mixtures with these multi-site inhibitor fungicides should suffice as an anti-resistance strategy. However, mixtures with captan alone may not be effective for preventing development of QoI-resistant bitter rot due to the unique capabilities of *Colletotrichum* species within the *C. acutatum* group.

Researchers in both Norway (Børve and Stensvand 2007,2016) and New Zealand (Everett et al. 2010) have shown that several species within the *C. acutatum* group can overwinter in bud scales (as well as in rotted fruit and dead twigs) and then can move into leaves during summer without causing any disease symptoms on these leaves. (Glomerella leaf spot, it now appears, is caused primarily by species in the *C. gloeosporioides* group.) It is not clear if the symptomless leaves that are inhabited by *C. acutatum* species play a significant role in producing inoculum for subsequent fruit infections, but *Colletotrichum* present in leaves may play a role in fungicide resistance development. The best evidence to date suggests that inoculum is probably coming from mummified fruit from previous years that survive on the orchard floor, thinned fruit that were dropped to the ground during early summer, and/or infected prunings that are left beneath trees (Everett et al. 2010). However, if Colletotrichum moves into apple leaves during summer, then the fungus present in leaves may get repeated doses of QoI fungicides (every time the orchard is sprayed with a QoI/captan mixture), but it will not be exposed to captan because the QoI fungicide can move into leaves but the captan cannot. It is important to note that I do NOT know for certain if this is occurring, but it seems possible based on the existing literature.

Fortunately, we may have at least a partial solution for improving resistance management strategies for *Colletotrichum* species in apples. Recent work by Yoder et al. (2016; see table below) and Ishii et al. (2016) have shown that two of the new SDHI fungicides, Fontelis and Aprovia, have reasonably good activity against pathogens in the *C. acutatum* group. (Ishii's group also showed that the SDHI components in Luna Sensation, Merivon, and Pristine are NOT effective against C. acutatum, so using one of those fungicides against bitter rot has the same effect as applying a QoI alone.) Fontelis and Aprovia have been promoted primarily for controlling early season diseases, but including one or two sprays of either of these products, mixed with Captan or other fungicides, during July or early August might help to slow development of QoI-resistant *Colletotrichum* species in apple orchards. Neither Fontelis nor Aprovia can be applied during the last month before harvest, so the window for using them would be in midsummer, when bitter rot begins to build up in leaves and forms quiescent infections on fruit. QoI-containing fungicides could

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then be used in mixtures with captan for sprays closer to harvest, thereby providing a rotation of products that are absorbed into leaves and protect fruit.

Bitter rot suppression is listed on the Aprovia label. Fontelis is not labeled for bitter rot, although it can be applied during summer to control apple scab. Aprovia is not labeled in New York, so New York growers seeking an alternative to QoI fungicides for bitter rot control will need to either use higher rates of Captan alone or include Fontelis to suppress secondary scab in midsummer. Only limited quantities of Aprovia and Fontelis can be applied each year (three or four applications, depending on rates used), so growers who used these products in multiple early season sprays may not be eligible to apply them during summer this year.

It is important to note that while Aprovia plus captan at the rates tested by Yoder's group provided excellent control of sooty blotch and flyspeck (SBFS) in addition to controlling fruit rots (see the table below), Fontelis plus captan did not provide adequate control of flyspeck. Thus, to protect against the full range of summer diseases (SBFS and fruit rots), NY growers who opt to use Fontelis in summer sprays may need to increase the rate of captan-80 in the Fontelis/captan mixture from 3 lb/A as used by Yoder to 4 or 5 lb/A. Or they may need to include a third fungicide in the tank mixture (e.g., a phosphite or Topsin M, if the latter is allowed by the sales group who will be handling the fruit). Since I have no first-hand experience in using a Fontelis/captan/ phosphite tank mix, this option should be approached with caution. Fontelis/ captan mixtures have caused some leaf injury when applied to lush foliage right after bloom, but it seems unlikely that Fontelis plus captan alone will cause problems when applied during summer. Yoder reported no phytotoxicity issues with either the Fontelis/captan or the Fontelis/Prophyt mixtures, but the three-way mix remains untested so far as I know.

In conclusion, the concept of using alternations of SDHI and QoI fungicides in tank mixes with captan to slow selection pressure for resistance in *Colletotrichum* species in apple orchards seems logical based on the published literature, but the effectiveness of this approach remains unproven, both as it relates to season-long control of bitter rot and as it relates to resistance management. I have presented the concept here primarily because I am concerned that QoI-resistant bitter rot may predominate in orchards before the concept can be fully field-tested, and alternative strategies may need to be implemented as soon as possible.

In the table below, I have abstracted some of the data from Dr. Yoder's 2015 field trial report. Note that he applied many of the tested products and tank mixes in eight consecutive sprays for research purposes only. Labels for both Fontelis and Aprovia limit the number of consecutive applications than can be used, as well as the total amount that can be applied per season. The product concentrations in the table below are amounts per 100 gal of dilute spray: multiply by 4 to arrive at the amount/A that was evaluated in the trial.

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Results from a field trial conducted by Dr. Keith Yoder in Virginia in 2015 showing the effectiveness of Fontelis and Aprovia used alone and in various combinations for controlling sooty blotch, flyspeck, and summer fruit rots on 'Fuji' apples harvested 30 September. Data was abstracted from Yoder et al. (2016).

Trt. no.	Treatment and rate per 100 gal dilute spray	Spray timing	% fruit at harvest with: sooty blotch	flyspeck	% fruit w/ rot after 14 days of postharvest incubation at 70.7°F: bitter rot	any rot
1.	Control: No fungicide	-	100 g	100 g	20 e	52 f
2.	Fontelis 1.67SC 4 fl oz	Bl-6C	57 f	76 f	8 d	18 de
3.	Fon. + Manzate 12 oz	Bl-3C				
	Fon. + Ziram 76DF 12 oz	4-6C	13 de	34 de	3 abcd	6 bc
4.	Fon. + Ziram 76DF 12 oz	Bl-6C	13 de	35 de	1 ab	5 bc
5.	Fon. + Captan 80WDG 12 oz	Bl-6C	3 abc	27 cde	3 abcd	4 b
6.	Fon. + ProPhyt 1 pt	Bl-6C	12 cde	11 b	2 abc	4 ab
7.	Aprovia 0.83EC 1.75 fl oz	Bl-6C	20 e	15 bc	2 abcd	6 bc
8.	Aprv. + Manzate 12 oz	Bl-3C				
	Aprv. + Ziram 76DF 12 oz	4-6C	4 abcd	3 a	0 a	3 ab
9.	Aprv. + Ziram 76DF 12 oz	Bl-6C	8 bcde	2 a	4 abcd	4 ab
10.	Aprv. + Captan 80WDG 12 oz	Bl-6C	2 ab	2 a	0 a	0 a
11.	Aprv. + ProPhyt 1 pt	Bl-6C	4 abcd	3 a	2 abc	7 bc
12.	Manzate 12 oz	Bl-3C				
	Ziram 76DF 12 oz	4-6C	2 a	2 a	6 cd	9b cd
13.	Ziram 76DF 12 oz	Bl-6C	12 de	40 e	6 bcd	28 e
14.	Captan 80WDG 12 oz	Bl-6C	15 e	39 e	5 abcd	15 cde
15.	ProPhyt 1 pt	Bl-6C	10 bcde	25 bcde	1 ab	10 bcd

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replications, 25 fruit per tree picked 30 Sep. Application dates: 29 Apr (late bloom); 12 May (late petal fall); 1st-6th covers (1-6C): 27 May, 10 Jun, 24 Jun, 8 Jul, 22 Jul, 13 Aug.

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INSECT TRAP CATCHES
(Number/Trap)

Geneva, NY

	7/3	7/7	7/10
Redbanded leafroller	26.0	53.0	28.5
Spotted tentiform leafminer	312.5	282.0	184.0
Oriental fruit moth	42.5	43.5	25.5
Codling moth	2.0	12.5	2.0
Lesser peachtree borer	5.0	-	10.5
Peachtree borer	24.0	-	8.5
Dogwood borer	2.0	4.0	5.0
Obliquebanded leafroller	7.5	6.0	7.0
Apple Maggot	0.0	0.0	0.0

Highland, NY

	6/26	7/3	7/10
Redbanded leafroller	14.5	16.0	22.0
Spotted tentiform leafminer	168.0	177.0	271.5
Oriental fruit moth	2.0	1.5	4.5
Lesser appleworm	6.0	20.0	21.0
Obliquebanded leafroller	18.5	9.5	16.5
Codling moth	29.5	6.0	2.0
San Jose scale	0.0	0.0	0.5*
Sparganothis fruitworm	1.0	0.0	1.5
Variegated leafroller	2.0	2.0	0.0
Tufted Apple Bud Moth	20.0	7.0	1.5
Dogwood Borer	1.5	4.0	3.5
Apple Maggot	0.0	0.0	0.0

* first catch

UPCOMING PEST EVENTS

		43°F	50°F
Current DD* accumulations	(Geneva 1/1–7/10/17):	1643.9	976.6
	(Geneva 1/1–7/10/16):	1663.3	1074.8
	(Geneva "Normal"):	1694.0	1101.5
	(Geneva 1/1-7/17, predicted):	1848.4	1132.1
	(Highland 1/1–7/10/17):	2056.0	1340.0

Coming Events: Ranges (Normal ±StDev):	43°F	50°F
American plum borer 2nd flight starts	1560-2140	1028-1434
Apple maggot 1st catch	1225-1661	774-1072
Apple maggot 1st oviposition punctures	1605-2157	1144-1544
Codling moth 2nd flight starts	1775-2234	1028-1499
Comstock mealybug 1st flight subsides	1818-2132	1216-1418
Dogwood borer flight peak	1434-1864	898-1233
Lesser appleworm 2nd flight starts	1429-2108	924-1405
Obliquebanded leafroller 1st flight subsides	1622-2041	1054-1375
Oriental fruit moth 2nd flight peak	1448-1954	924-1311
Redbanded leafroller 2nd flight peak	1535-1984	987-1329
San Jose scale 2nd flight starts	1629-1979	1058-1336
Spotted tent. leafminer 2nd gen tissue feeders	1378-2035	913-1182

*all DDs Baskerville-Emin, B.E.

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