Fruit, Vegetable, and Greenhouse Insects

This laboratory session covers just a few of the major insect pests of fruits, vegetables, and greenhouse crops. As is true for other topics, these are only representative species among many that are important in these crops.

Fruit

- Key direct pests of apples and/or peaches:
    - plum curculio**,** *Conotrachelus nenuphar* (Herbst) (Coleoptera: Curculionidae)
    - codling moth, *Cydia pomonella* (L.) (Lepidoptera: Tortricidae)
    - oriental fruit moth, *Grapholitha molesta* (Busck) (Lepidoptera: Tortricidae)
    - apple maggot, *Rhagoletis pomonella* (Walsh) (Diptera: Tephritidae)
- Important indirect pests of fruits
    - European red mite, *Panonychus ulmi* (Koch) (Acari: Tetranychidae)
    - San Jose scale, *Quadraspidiotus perniciosus* (Comstock) (Hemiptera: Diaspididae)
- Direct pest of many fruits and vegetables
    - lygus bug**s,** *Lygus* spp. (Hemiptera: Miridae)
    - spotted wing Drosophila, *Drosophila suzukii* (Diptera: Drosophilidae)

Other often-important direct and indirect pests of fruits in the Midwest not covered in this lab include grape phylloxera, peachtree borers, Japanese beetle, potato leafhopper, aphids, spotted tentiform leafminer, white apple leafhopper, and various leafrollers.

Vegetables

- Colorado potato beetle, *Leptinotarsa decemlineata* (Say) (Coleoptera: Chrysomelidae)
- Lepidoptera on plants in the cabbage family:
    - diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae)
    - cabbage looper, *Trichoplusia ni* (Hubner) (Lepidoptera: Noctuidae)
    - imported cabbage worm, *Pieris rapae* (L.) (Lepidoptera: Pieridae)
- beetles that transmit plant pathogens
    - spotted and striped cucumber beetles**,** *Diabrotica undecimpunctata howardi* Barber and *Acalymma vittatum* (Fabr.) (Coleoptera: Chrysomelidae)
    - corn flea beetle**,** *Chaetocnema pulicaria* Melsheimer (Coleoptera: Chrysomelidae)
- onion maggot, *Delia antiqua* (Meigen) (Diptera: Anthomyiidae), and related *Delia* species (seedcorn maggot and cabbage maggot).
- squash bug**,** *Anasa tristis* (De Geer) (Hemiptera: Coreidae)
- corn earworm, *Helicoverpa zea* (Boddie) (Lepidoptera: Noctuidae)

Other important pests of vegetables in the Midwest not covered in this lab include cutworms, corn rootworms, aphids, potato leafhopper, European corn borer, stink bugs, thrips, and bean leaf beetle.

Greenhouse Crops

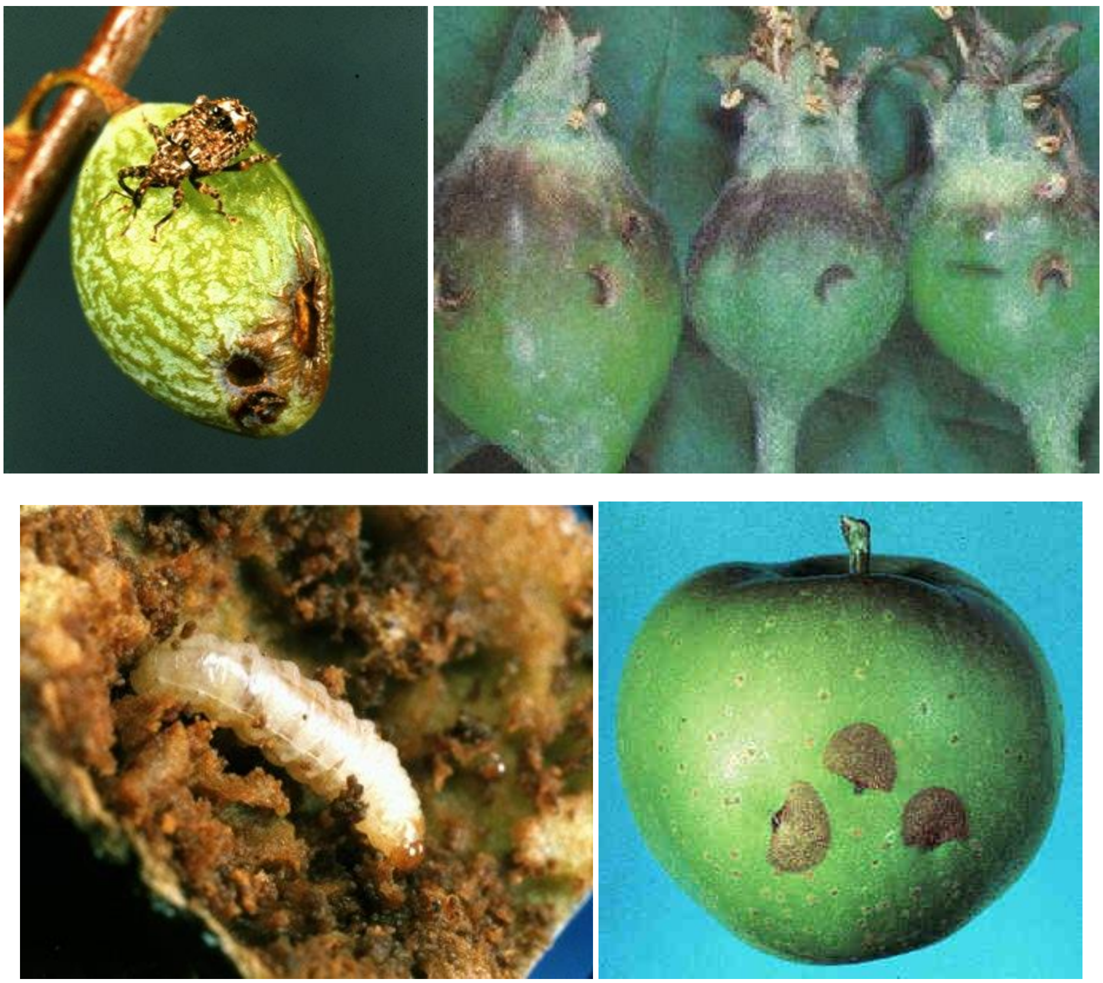
- Greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood) (Hemiptera: Homoptera: Aleyrodidae)
    - *Encarsia formosa* (a key biological control agent for greenhouse whitefly)
- Western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae)
- Mealybugs -- in greenhouses, often the longtailed mealybug, *Pseudococcus longispinus* (Targioni Tozzetti) (Hemiptera: Homoptera: Pseudococcidae)
- Twospotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae)

Other important pests of greenhouse crops include a wide variety of scales and aphids.

1. Plum curculio.

The plum curculio is a native pest of stone fruits (peaches, plums, cherries), blueberries, and apples, and it damages these crops wherever they are grown in eastern North America. It overwinters in woody areas outside orchards and is most common in more wooded areas of the state and region.

Plum curculio adults re-enter apple and peach orchards at petal fall each spring, and females lay eggs on fruits as soon as they begin to develop. To do so, they chew a crescent-shaped slit through the "skin" of apples and peaches, then place their eggs under the resulting flap of tissue. Larvae that hatch from these eggs tunnel within peaches, plums, and other stone fruits, and mature by late summer. In many apple cultivars, plum curculio larvae die soon after hatching, mostly because of the pressure of the rapidly growing fruit. Damage in these apples is therefore limited to the scar that develops at the egg-laying site (a significant problem when numerous scars cause fruit deformities). Where larvae survive, fruit usually drops in early summer.



Upper left: plum curculio adult (Clemson Univ.,); upper right: oviposition scars on young apples (OMAFRA); lower left: plum curculio larva in fruit (Clemson Univ.); lower right: oviposition scars on mature apple (West Virginia Univ.).

<u>Plum curculio management:</u> Cover sprays applied as soon as bloom and pollination are complete and fruits begin to develop are the primary means of plum curculio management. Scouting programs and thresholds for this pest have been difficult to implement ... most Midwest orchardists routinely use an insecticide at petal fall (and sometimes again 10 days later) for curculio control if this insect has been a problem at their location.

Reference:

- Bessin, 2003. Plum curculio. ENTFACT-202, University of Kentucky. http://www.ca.uky.edu/entomology/entfacts/ef202.asp

2. Codling moth.

Left: codling moth adult (Univ. of Minnesota); center: codling moth larva (Utah State Univ.); right: pheromone trap used to monitor codling moth flight (Virginia Tech.).

The codling moth was inadvertently introduced to North America over 200 years ago, and it is a major pest of apples wherever they are grown on this continent. Mature larvae overwinter in silken cocoons under loose bark and on packing crates in warehouses. They pupate in the spring, and moths emerge during bloom and petal fall. They mate, then females lay eggs on twigs, leaves, and developing fruits. Larvae hatch, crawl to a fruit, chew through the skin, and tunnel to the core to feed on seeds. When mature, the larvae exit the fruit to find a sheltered place to pupate. A second generation of moths emerges in midsummer, and subsequent larvae tunnel into ripening fruits. In southern Illinois (and often in much of the state), a third generation of moths may develop before the season ends. The timing and number of generations (2 versus 3) depends on the temperature each season.

<u>Codling moth management:</u>

- The standard approach to codling moth control is to use insecticides as "cover sprays" so that residues are present on fruits whenever codling moth larvae are hatching. Organophosphate insecticides such as Guthion and Imidan (and others) have been used since the 1960s for this purpose, but codling moth populations in many areas are now resistant to these insecticides. Newer insecticides used for codling moth control include neonicotinoids (for example, Assail and Calypso), the growth regulator Rimon (novaluron), and other "reduced-risk" chemicals (categorized as such by the US EPA as replacements for organophosphates). "Organic" insecticides also are available … Entrust is an OMRI-listed formulation of spinosad, and codling moth granulosis virus is sold as Cyd-X and other formulations. These are more expensive and not as effective as the conventional synthetic insecticides listed above, but they do provide significant control of codling moth.
- Key steps in timing (and often reducing) the use of insecticides for codling moth control include the use of pheromone traps and degree day models. Traps baited with lures containing a synthetic mimic of the sex pheromone that females produce to attract males are placed in orchards when trees begin to bloom. At least 3 traps are used per orchard, and several more in orchards greater

than 10 to 15 acres in size. Capturing males indicates that females are flying too, and mating and egg-laying are presumed to be underway. Traps are checked at least twice weekly, and when they begin to consistently catch moths (at least an average of 2 per trap in a week's time), the biofix date is set for that orchard. Weather data are used to calculate degree-days based on a 50-degree F threshold, and egg hatch begins 220-240 DD after moth flight began (the biofix date). Insecticides are applied to (1) place a residue on the surface of fruit before eggs are laid if the insecticide's effectiveness depends on poisoning newly laid eggs, or (2) place a residue on the surface of fruit by the time eggs hatch if the insecticide's efficacy depends on poisoning larvae as they crawl on the fruit before entering. Most insecticides applied to tree fruits provide an effective residue for around 2 weeks, and the need to reapply can be based on looking back at trap captures and degree-day accumulations to determine if protecting the fruit is necessary.
- A different approach to codling moth control is mating disruption. Dispensers or sprays of a synthetic version of the codling moth sex pheromone are applied throughout an orchard (400 Isomate C-Plus "ties" per acre, for example), and the constant presence of pheromone throughout the orchard prevents male moths from finding females for mating. This approach works best in larger orchards and where codling moth densities are not too great.

References:

- Bessin, R. Undated. Codling Moth. http://www2.ca.uky.edu/entomology/entfacts/ef203.asp
- Weinzierl, R. Codling moth phenology. Illinois Fruit and Vegetable News 13:7. http://www.ipm.uiuc.edu/ifvn/volume13/frveg1307.html#fruit

3. Oriental fruit moth.

The oriental fruit moth (OFM), another introduced pest, is very similar to the codling moth in its life history, appearance, and role as a pest. In general, the codling moth is much more prevalent in apples than in peaches, and in contrast, the oriental fruit moth is more prevalent in peaches than in apples. Both can, however, infest either of these fruits (as well as several other hosts), and in the last decade oriental fruit moth has become more common than it used to be as an internal pest of apples in the eastern United States, including Illinois.

Oriental fruit moth adults are slightly smaller than codling moth adults, and they are more or less uniformly a mottled gray in appearance, without the chocolate or bronze area at the tip of the forewing that characterizes coding moth. Larvae of the two species also are very similar in appearance, but oriental fruit moth larvae bear an "anal comb" not found on codling moth larvae.

Oriental fruit moths overwinter as pupae that develop and emerge as moths a little earlier in the spring than codling moth, and first generation larvae feed in new shoots of peaches, causing the tips to "flag." Three or more generations develop wherever this insect is found in Illinois, and second and later generations tunnel into fruits of peaches and other stone fruits (and later in the summer into apples). Monitoring with pheromone traps (with an OFM-specific pheromone, of course), interpreting population patterns using phenology models, and the use of insecticide cover sprays and mating disruption are similar to practices used in codling moth management.

Upper left: oriental fruit moth adult (Washington State Univ.); upper right: oriental fruit moth larva (Michigan State Univ.); lower left: anal comb of larva (Univ. of California); lower right: flagging of infested peach shoot (Univ. of Georgia).

Reference:

- Anon. 2007. Oriental fruit moth in stone fruit. Washington State Univ. http://entomology.tfrec.wsu.edu/Cullage_Site/OFM.html

4. Apple maggot.

The apple maggot is found in North America east of the Rocky Mountains but not in the intensive apple production region of eastern Washington. In the eastern U.S. it is a more serious pest in northern than southern states; in Illinois, it can be a serious pest from Champaign northward, but it is rarely or never a problem south of I-70.

The apple maggot is univoltine ... only one generation develops each year. Pupae overwinter in soil on the orchard floor, and adult flies emerge in the early summer. They normally fly out of the orchard, mate, and then return to the orchard to lay eggs. Females insert eggs directly under the "skin" of apples, and larvae (maggots) tunnel through the flesh, leaving tracks that discolor and decay.



Top left: apple maggot adult (Cornell Univ.); top right: apple maggot larvae (Cornell Univ.); above center: sticky-coated apple maggot trap with bait dispenser on twig (Univ. of Illinois).

<u>Apple maggot management:</u> Summer "cover sprays" comprise the standard approach to apple maggot control, with timing determined by the use of traps. For apple maggot, the traps are attractive because of their appearance (bright red spheres); volatile compounds that resemble the odors of apple can be used to increase the attractiveness of the spheres. Traps are placed in orchards in early June and monitored through August. In small orchards or back yard trees, red sphere traps can be used in "removal trapping" -- catching most flies before they lay eggs and greatly reducing damage to fruit. One to three traps per tree are needed in dwarf or semi-dwarf trees to accomplish removal trapping.

Reference:

- Anon. 1991. Apple maggot. Cornell University, Suffolk Co. Extension, Insect Identification Sheet No. 7. http://nysipm.cornell.edu/factsheets/treefruit/pests/am/am.asp

5. European red mite.

The European red mite is the "poster child" for illustrating the idea of a "secondary pest" ... an insect or related arthropod that is a pest only because insecticides have killed its natural enemies and allowed it to reach densities that did not occur under previous levels of natural biotic control. It is most often a problem in apples, but it also may infest peaches, other stone fruits, grapes, and brambles (raspberries and blackberries).

Left: European red mite eggs on bark (Virginia Tech.); right: European red mite adult. (Univ. of California)

European red mites overwinter as eggs, exposed on the surface of twigs. They begin hatching as apple trees begin to bloom, and they develop from egg to adult in 10 to 25 days. Six to eight generations develop each season. Immature stages and adults rasp away the leaf epidermis and feed on plant sap, causing leaves to turn yellow, bronze, or brown. Where leaves are damaged or drop, photosynthesis is reduced, fruit sizing is diminished, and sunburn of fruit may occur.

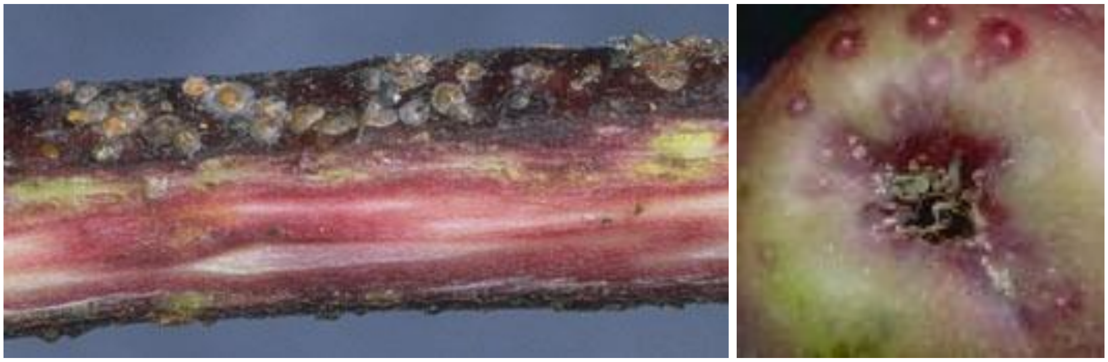
European red mite management:

- Application of emulsifiable oils distilled particularly for use as insecticides or miticides is a key step in European red mite management. Sprays applied to cover twigs uniformly and completely just as green foliage is beginning to emerge in the spring (a "delayed dormant" application) coat the eggs of European red mite and rosy apple aphid and the hard covering of San Jose scale, suffocating these pests.
- Because using insecticides to control primary pests such as codling moth, apple maggot, and oriental fruit moth is necessary in many orchards, choosing insecticides that are effective against these pests but do not kill predaceous mites (*Amblyseius fallacis* = *Neoseiulis fallacis*) has been a key step in orchard IPM. Insecticides considered to be low in toxicity to predaceous mites include the organophosphates Imidan (phosmet) and Guthion (azinphosmethyl). Among the insecticides to avoid because they destroy populations of predaceous mites are pyrethroids, Sevin, Lannate, Vydate, and Carzol.
- Predaceous mites can be reintroduced into orchards if they are entirely lacking.
- Scouting guidelines and thresholds for mite control are based on the time of season, the density of pest mites, and the density of predators. Selective miticides that kill European red mite and are relatively low in toxicity to predators include Apollo, Savey, Nexter, Acramite, and Agri-Mek. Although these miticides are very effective, they also are very expensive.

Reference:

- Anon. 1980. Cornell University Insect Identification Sheet No. 10. http://www.nysipm.cornell.edu/factsheets/treefruit/pests/erm80/erm80.pdf

Station 6. San Jose scale.



Left: San Jose scale and twig injury; right: San Jose scale on an apple (Univ. of Kentucky).

San Jose scale is an indirect pest of apples, pears, peaches, plums, and many other woody plants, but it sometimes feeds directly on apple fruits as well. As it feeds, it injects a toxin into plants that kills cells and causes localized discoloration. Left uncontrolled, San Jose scale can kill entire trees. Purplish-red halos on young bark or fruit are indications of scale infestation. Often this very small insect goes unnoticed until large populations have developed.

San Jose scales overwinter as immatures. In the spring, tiny winged males emerge and mate with wingless females that never leave their scale covering. Females give birth to live young called crawlers about one month later. The tiny yellow crawlers move around randomly on bark and foliage before settling down permanently. A few days after settling down, they start to secrete a waxy covering over their body that will protect them from most pesticides. From this point on, female scales will not move. Males will remain in one location until maturity, at which time the winged males will seek out females and the cycle will begin again. Additional generations develop as the summer progresses.

Key steps in San Jose scale control include application of a “dormant oil” spray between green tip and bloom to suffocate these insects under their protective coverings. Later applications of insecticides must be timed to coincide with activity of crawlers.

Reference:

- Bessin, R. 2003. San Jose scale. Univ. of Kentucky ENT FACT 204. http://www.ca.uky.edu/entomology/entfacts/entfactpdf/ef204.pdf

7. Lygus bugs.

Lygus bugs can be pests of several fruits and vegetables. Adults overwinter in most of the region, and they move to orchards and other fruit crops as they begin to bloom (or when weeds on the orchard floor begin to bloom). Along with stink bugs, they feed by inserting their beak into developing fruits; cells around the wound are killed, and the fruit grows abnormally around the site of injury. Examine the printed materials provided and describe the damage caused by lygus bugs in strawberries, apples, and peaches.

Weed management is key to lygus bug control in several fruit crops. Growers are encouraged to control the weeds that bloom just before the fruit crop, because Lygus bugs often move from blooming weeds to apples, peaches, or strawberries. However, where blooming weeds have already attracted lygus infestations, growers are cautioned not to mow orchard aisles or similar drive rows during bloom or petal fall because doing so triggers lygus movement to the fruit crop.

Lygus bug on strawberry flower (Cornell Univ.).

Left to right: Lygus injury to strawberry (Cornell Univ.), apple (Michigan State Univ.), and peach (Clemson Univ.).

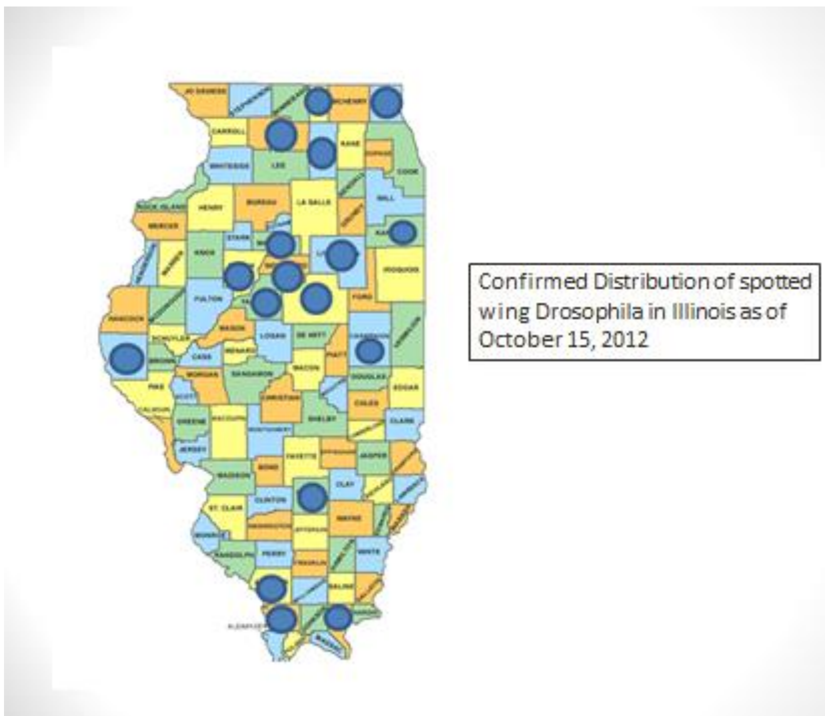
Reference:

- Spangler, S., R. Weires, and A. Agnello. 1991. Tarnished Plant Bug. Insect Identification Sheet No. 21. Cornell University, http://nysipm.cornell.edu/factsheets/treefruit/pests/tpb/tpb.asp

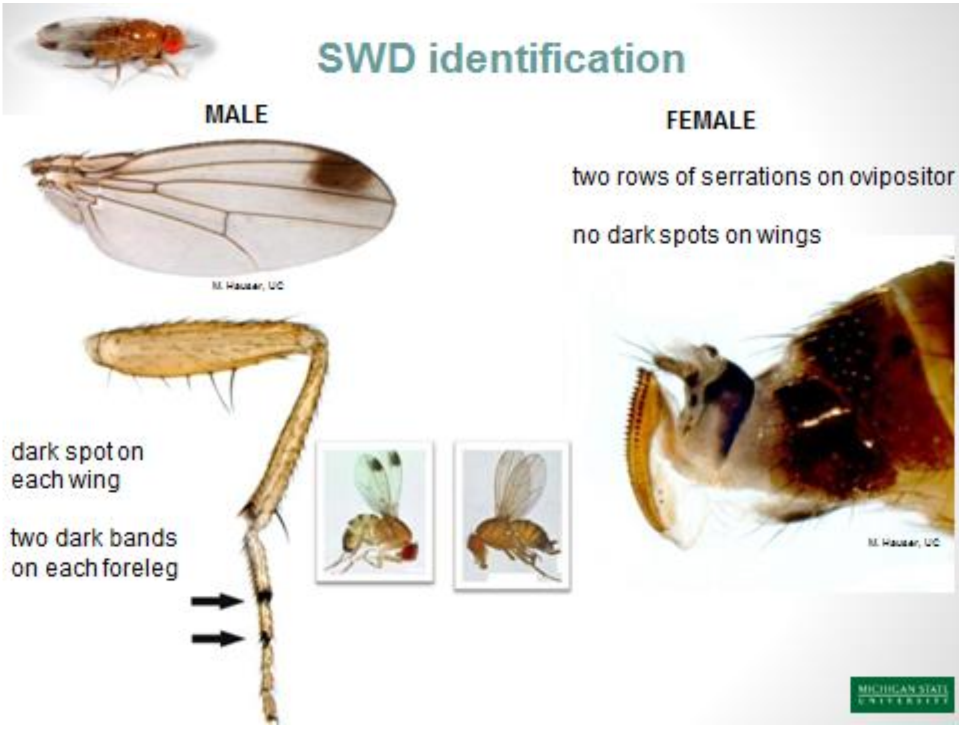
8. Spotted wing Drosophila.

During the summer and fall of 212, detections of spotted wing Drosophila, *Drosophila suzukii*, and reports of larval damage to fruit (particularly fall raspberries) were reported from Illinois and nearby states including Iowa, Wisconsin, and Minnesota. Infestations have posed problems in Michigan since 2010. In Illinois, the counties where this is insect has been collected are indicated on the map below. It is likely that this insect is now present in most if not all of the counties in Illinois.

Spotted wing Drosophila adult and larvae.



Michigan State University's web site on SWD provides extensive information about this pest at http://www.ipm.msu.edu/swd.htm. Links provided on the main page of this site provide access to fact sheets, monitoring guidelines, and control recommendations.



Spotted wing Drosophila is a destructive pest of thin-skinned fruits because unlike other *Drosophila* species, it lays eggs into ripening fruit before it's ready for harvest. Infested fruits "melt down" from larval feeding in just a few days. Adult flies live for up to 2 weeks, and females can lay up to 300 eggs. Development from egg to adult can occur in in little as 8 days, and 10 or more generations may develop within a season.

Where SWD is present (see the MSU recommendations for building and using traps at http://www.ipm.msu.edu/SWD/SWD-monitor.htm) and fruit is nearing harvest, management is limited primarily to sanitation and insecticide application. Removing over-ripe fruit and wild hosts (plants with thin-skinned berries such as pokeweed) in and around small fruit plantings reduces the potential for population buildup. Examples of insecticides that might be used to control SWD in raspberries include:

Insecticides for SWD control in brambles	Preharvest interval	Days of residual activity
Malathion	1	5-7
Mustang Max (zeta-cypermethrin)	1	7
Danitol (fenpropathrin)	3	7
Brigade (bifenthrin)	3	7
Delegate (spinetoram)	1	7
Entrust (spinosad) – OMRI-approved	3	3-5
Pyganic (pyrethrins) – OMRI-approved	0	1-2

9. Colorado potato beetle.

The Colorado potato beetle is native to western North America, but it is now a pest of potatoes, tomatoes, peppers, and eggplant wherever they are grown. Adults and larvae feed on plant foliage, but it is the larvae that are most damaging.

Adults overwinter within cells well below the surface of the soil. They emerge in May, at about the time early-planted potatoes are emerging. In June they lay yellow eggs on foliage, and larvae feed for 10 to 20 days before dropping to the soil to pupate. A new generation of adults emerges 2 to 3 weeks later; they feed more heavily than overwintered adults did, and they continue to lay eggs through mid-August. Larvae of this generation feed and pupate; as adults they may remain in their pupal cells in the soil to overwinter, or they may emerge and then return to the soil. Summer adults may also return to the soil to pass the winter. (One to two generations develop each year in the upper Midwest.)

Left: Colorado potato beetle adult (Univ. of Kentucky); right: larvae (Univ. of Minnesota).

Colorado potato beetle is resistant to MANY insecticides, and cultural control practices are especially important in its management. Crop rotation, trenching, mulching, and flaming are among several cultural practices used in management of this insect.

Reference:

- Bessin, R. 2003. Colorado potato beetle management. Univ. of Kentucky, http://www.ca.uky.edu/entomology/entfacts/entfactpdf/ef312.pdf

10. Lepidopterans on plants in the cabbage family.

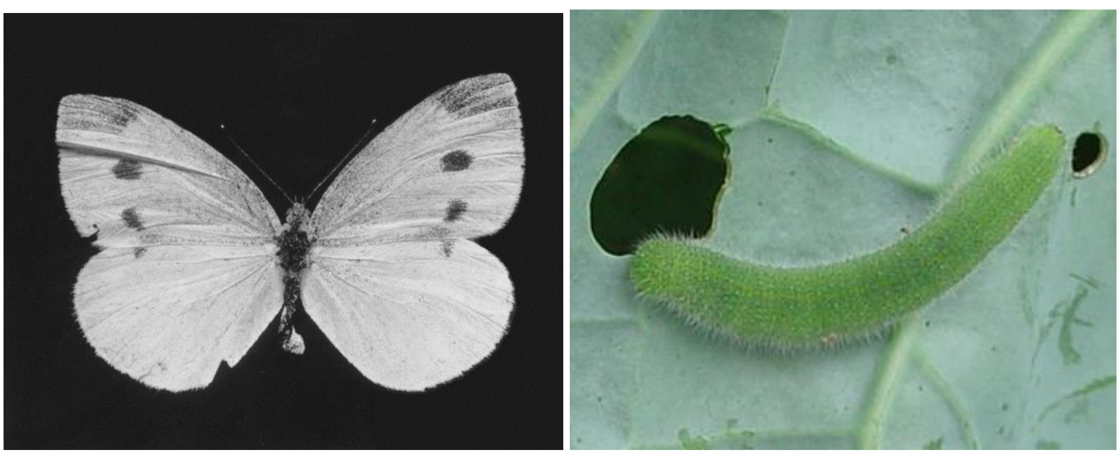
The diamondback moth is the smallest of the three major lepidopteran pests of crucifers (cabbage, broccoli, etc.), but it is the most damaging in areas where insecticide resistance has rendered it difficult to control. Adults overwinter in protective vegetation, and migrations from the south supply additional numbers each season. Diamondback moth larvae may also be introduced on transplants shipped in from southern states.

Eggs laid on foliage produce larvae that feed on leaves and heads of crucifers; egg-to-adult generation time is 3 to 4 weeks, and 4 to 6 generations may develop each year in the Midwest. Diamondback moth populations are often greatest in hot, dry seasons.

Left: diamond back moth adult (USDA); right: larvae on cabbage leaf (Illinois Natural History Survey)

The other key "leps" on cabbage and related plants are the imported cabbageworm and the cabbage looper. Check the references provided for information on the life cycles of these insects.

Left: Cabbage looper adult (Univ. of Minnesota); right: larva (Univ. of Kentucky).



Left: imported cabbageworm adult (Cornell Univ.); right: larva (Colorado State Univ.).

To prevent cosmetic damage and larval contamination of the harvested crop, cabbage, broccoli, and other crucifers may be treated frequently with insecticides to control diamondback moth, imported cabbageworm, and/or cabbage looper. Doing so provides lots of "selection pressure" for resistance and also removes the natural enemies that might control these pests. As a result, diamondback moth resistance to insecticides has resulted in control crises in many parts of the world. Key steps in control and resistance management include:

- Scouting and using insecticides only when populations exceed thresholds
- Relying as much as possible on *Bacillus thuringiensis* treatments early in the season to allow natural enemy survival
- Rotating insecticides
- Irrigation to kill moths
- Crop residue destruction

References:

- Hutchison, W.D., P. C. Bolin, and R. L Hines. 2007. Diamondback moth. Univ. of Minnesota. http://www.vegedge.umn.edu/vegpest/colecrop/diamond.htm
- Hutchison, W.D., P. C. Bolin, and R. L Hines. 2007. Imported cabbageworm. Univ. of Minnesota. http://www.vegedge.umn.edu/vegpest/colecrop/cabbworm.htm .
- Hutchison, W.D., H. Hoch, P.C. Bolin, R.L. Hines, and S.J. Wold-Burkness. 2007. Cabbage looper. Univ. of Minnesota. http://www.vegedge.umn.edu/vegpest/colecrop/looper.htm

11A. Beetles that transmit plant pathogens: Striped and spotted cucumber beetles.

Left: striped cucumber beetle (Univ. of Connecticut); center: spotted cucumber beetle (Univ. of California); right: bacterial wilt of cucumber (OMAFRA).

Striped and spotted cucumber beetles overwinter as adults and become active in the spring. The pathogen that causes bacterial wilt of cucurbits, *Erwinia tracheiphila*, survives the winter only in the gut of these cucumber beetles. As they move into cucumber and muskmelon fields each spring, they carry the pathogen to young plants and start the disease cycle anew. Insecticidal control of cucumber beetles IS a moderately effective approach to limiting losses to bacterial wilt. (No horticulturally acceptable resistant varieties of cucumbers or muskmelons are available.)

Reference:

- Bessin, R. 2004. Cucumber beetles. Univ. of Kentucky ENTFACT 311, http://www.ca.uky.edu/entomology/entfacts/entfactpdf/ef311.pdf .

11B. Beetles that transmit plant pathogens: Corn flea beetle.

Left: corn flea beetle; right: systemic Stewart's wilt (J. Pataky, Univ. of Illinois).

A similar vector-pathogen relationship exists for the corn flea beetle and the bacterium that causes Stewart's wilt of sweet corn. (A "vector" is an organism that carries a pathogen from one host to another.) The corn flea beetle generally overwinters very successfully in the milder winters of southern Illinois but not in northern Illinois. The likely severity of Stewart's wilt can be predicted in Illinois based on average winter temperatures. Stewart's wilt resistance is universal in field corn and available in certain types of sweet corn, but some sweet corn production regions and market types are not well-supplied with resistant hybrids. Certain inbreds used in field corn hybrid development also are susceptible to Stewart's wilt. Insecticides – especially those applied as seed treatments – can be used to reduce disease transmission and losses to Stewart's wilt, but insecticides are not as effective as resistant hybrids.

Reference:

- Cook, K., and R. Weinzierl. 2004. Corn flea beetle. Univ. of Illinois, http://ipm.uiuc.edu/fieldcrops/insects/corn_flea_beetle/index.html

11C. Aphids as vectors of plant pathogens.

Identifying aphids to the species level is difficult ... well beyond the scope of this class. Remember that aphids often have separate "winter" and "summer" hosts and that much of the time females give birth to live young without mating. When colonies of aphids develop on crop plants, they may be important for their direct impacts on plant growth, yield, and crop quality. Often, however, aphids are most important because they transmit plant viruses. When they do so in a persistent manner (retaining the virus for an extended period and inoculating plants for the remainder of their [the aphids'] lives), insecticides can be useful in slowing disease outbreaks. This is true for certain viruses in potatoes. Where virus transmission is NONPERSISTENT (the virus is lost from the vector after feeding only one or two times on an uninfected plant), INSECTICIDES ARE NEARLY USELESS IN DISEASE MANAGEMENT. Trap crops, stylet oils, reflective mulches, and row covers represent the only effective ways to reduce disease transmission. (See Weinzierl, R. 2006. Aphids and Whiteflies in Fall Vegetables, http://www.ipm.uiuc.edu/ifvn/volume12/frveg1214.html) .

12. Onion maggot (and related species)

Onion maggot, cabbage maggot, and seedcorn maggot are among the serious pest species in the genus *Delia* – the seed and root maggots. Use the specimens and the references provided to describe their life cycles.

Left: onion maggot injury to seedling (Univ. of California); right: adult and eggs (Straub and Eckenrode).

References:

- Andalaro, J, and C. Eckenrode. 1983. Onion maggot. Cornell Univ., http://www.nysipm.cornell.edu/factsheets/vegetables/onion/om.pdf .
- Van Wychen Bennett, K., E. C. Burkness, and W. D. Hutchison. 2007. Cabbage maggot. Univ. of Minnesota, http://www.vegedge.umn.edu/vegpest/colecrop/cabmag.htm .
- Van Wychen Bennett, K., E. C. Burkness, and W. D. Hutchison. 2007. Seedcorn maggot. Univ. of Minnesota, http://www.vegedge.umn.edu/vegpest/seedmag.htm .

13. Squash bug

The squash bug is a difficult-to-control pest of summer and winter squash varieties and of pumpkins. Unmated adults overwinter, then mate and lay eggs on host plants in early to mid summer. In most of Illinois, a single generation develops each season. Populations are greatest during hot, dry summers.

Left to tight: squash bug eggs, nymphs, and adult.

Squash bugs are difficult to control because ...

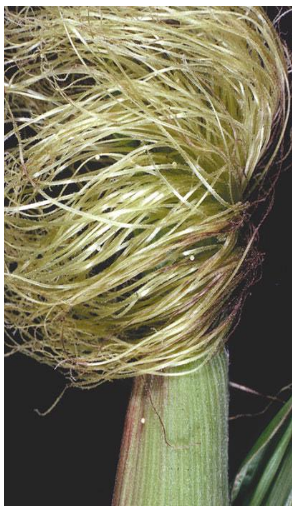
- they feed underneath leaves of a dense plant canopy ... it is difficult to reach them with an insecticide application.
- older nymphs and adults are highly tolerant of many insecticides. (This is not resistance, but simply species-wide tolerance.)

Reference:

- Bessin, R. Undated. Squash vine borer and squash bug. http://www2.ca.uky.edu/entomology/entfacts/ef314.asp.

14. Corn earworm.

The corn earworm is the most serious pest of sweet corn in Illinois (though European corn borer, and fall armyworm, and other direct pests also attack the crop). It may overwinter as a pupa in light soils in southern and southwestern Illinois (and along the Illinois River in west-central Illinois), but it also migrates into the state from the south each season. Adults lay eggs directly on the silks of corn, and newly hatched larvae move directly down the silk channel to feed on the tip of the developing ear. For insecticides to control this insect, they must be on the silks that the larva contacts as it moves into the ear, and they must be applied repeatedly to cover new silk growth. In most instances, growers use pheromone traps to determine the timing of moth flights and the need for insecticide applications. Transgenic Bt sweet corn is also used for earworm control by Illinois growers.


Upper left: corn earworm adult Kansas Dept. of Agric.); upper right: eggs on silks (Cornell Univ.); lower left: larva on ear tip (Univ. of Illinois); lower right: "Hartstack" pheromone trap used to monitor flights (Univ. of Illinois).

Reference:

- Weinzierl, R. 2013. Preseason Reminders for Corn Earworm Management in Sweet Corn. Illinois Fruit and Vegetable News 18:19. University of Illinois, http://ipm.illinois.edu/ifvn/contents.php?id=19#vegetable.

Greenhouse pests.

15. Greenhouse whitefly.

The greenhouse whitefly is a common pest of many greenhouse crops. Adults are 1/16 inch long and have 4 wings that are coated with a white waxy material and held tent-like over the abdomen. Eggs are laid on very short stalks in a circular or crescent-shaped pattern on lower leaf surfaces; they are whitish when first laid but darken before hatching. Newly hatched nymphs are mobile and are called crawlers, but upon inserting their mouthparts into a leaf they settle and become immobile. Transition from immature to adult stage occurs in a pseudopupal stage.

Greenhouse whitefly.

The greenhouse whitefly is resistant to many insecticides, and as a result, cultural and biological control practices are especially important. Use the printed information provided at this station to identify the parasite (parasitoid) commonly used in the biological control of greenhouse whitefly and to learn what stages it attacks. Also learn about other nonchemical control practices used to limit infestations of this insect.

References:

- Fasulo, T.R. Undated. USDA Whitefly Knowledgebase. http://entomology.ifas.ufl.edu/fasulo/whiteflies/wfly0002.htm
- Cranshaw, W. 2013. Greenhouse Whitefly. http://www.ext.colostate.edu/pubs/insect/05587.html.
- Biological Control: A Grower's Guide to Using Biological Control for Silverleaf Whitefly on Poinsettias in the Northeast United States. http://extension.umass.edu/floriculture/fact-sheets/biological-control-growers-guide-using-biological-control-silverleaf-whitefly

In what ways do greenhouse whiteflies damage plants?

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What nonchemical steps are part of greenhouse whitefly management?

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What is *Encarsia formosa*, and what steps are involved in using it successfully?

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16. Western Flower Thrips

The western flower thrips is one of the important pest species of thrips in greenhouses, but other species also are common. Thrips rasp away at the epidermis of leaves and (especially important) blossoms, causing blossoms to be distorted and discolored. Hot, dry conditions favor their buildup. Resistance to insecticides is common, and cultural and biological controls of thrips are used in many greenhouse crops. Yellow or blue sticky cards are used to monitor thrips populations.

Thrips, like greenhouse whiteflies, are the target of many insecticide applications, and as a result many populations have developed resistance to one or more insecticides. Alternative management practices are very important in keeping this insect in check; be sure to read about these alternatives in the reference provided.


Western flower thrips (Texas A & M University).

Reference:

- Western Flower Thrips, Management and Tospoviruses.
  http://extension.umass.edu/floriculture/fact-sheets/western-flower-thrips-management-and-tospoviruses

Summarize the major steps involved in western flower thrips management.

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17. Mealybugs.


Longtailed mealybug (Univ. of Minnesota).

Mealybugs are sedentary insects, much like scales, but without hardened coverings. Mealybugs are coated, however, with a white, waxy covering that provides some degree of protection against insecticides (as do the hardened scales of scale insects). Mealybugs may feed on the roots, stems, or leaves of plants, and the long-tailed mealybug is a common pest of greenhouse plants.

Insecticides are not very effective against heavy infestations of mealybugs ... the mealybug destroyer, *Cryptolaemus montrouzieri* (Coleoptera: Coccinellidae) is used in biological control, as are parasitic wasps. Interestingly, the larvae of the mealybug destroyer resemble the nymphs of mealybugs.

References:

- Anon. 2007. Introduction to Mealybugs. http://www.entomology.umn.edu/cues/inter/inmine/Mbugs.html
- Anon. 2007. Longtailed Mealybug. http://www.entomology.umn.edu/cues/inter/inmine/Mbugsl.html

18. Twospotted spider mite.

Greenhouse conditions often favor the buildup of two-spotted spider mites ... high temperatures during some months trigger spider mite problems; low humidity during other periods may favor problems. The constant availability of host plants and favorable conditions makes spider mite infestations a constant concern in many greenhouses.

Twospotted spider mite (Oregon State University).

Reference:

- Pundt, L. Undated. Managing Two-Spotted Spider Mites in Greenhouses. http://www.hort.uconn.edu/Ipm/greenhs/htms/2spotmite.htm

Study Questions:

- What orders are represented by the pests covered in this lab? "Who" are the pests in each order?
- Do any of these insects migrate into IL each season instead of overwintering? Which one(s)?

- Identify at least one insect pest for which weed control is a significant concern in its management.
- For which of the pests in this lab are traps (pheromone traps or similar traps) important tools for monitoring and management decisions?
- Which of the pests covered in this lab are identified as “introduced” (not North American by origin)?
- Which of the insects in this lab are important as vectors of plant diseases?