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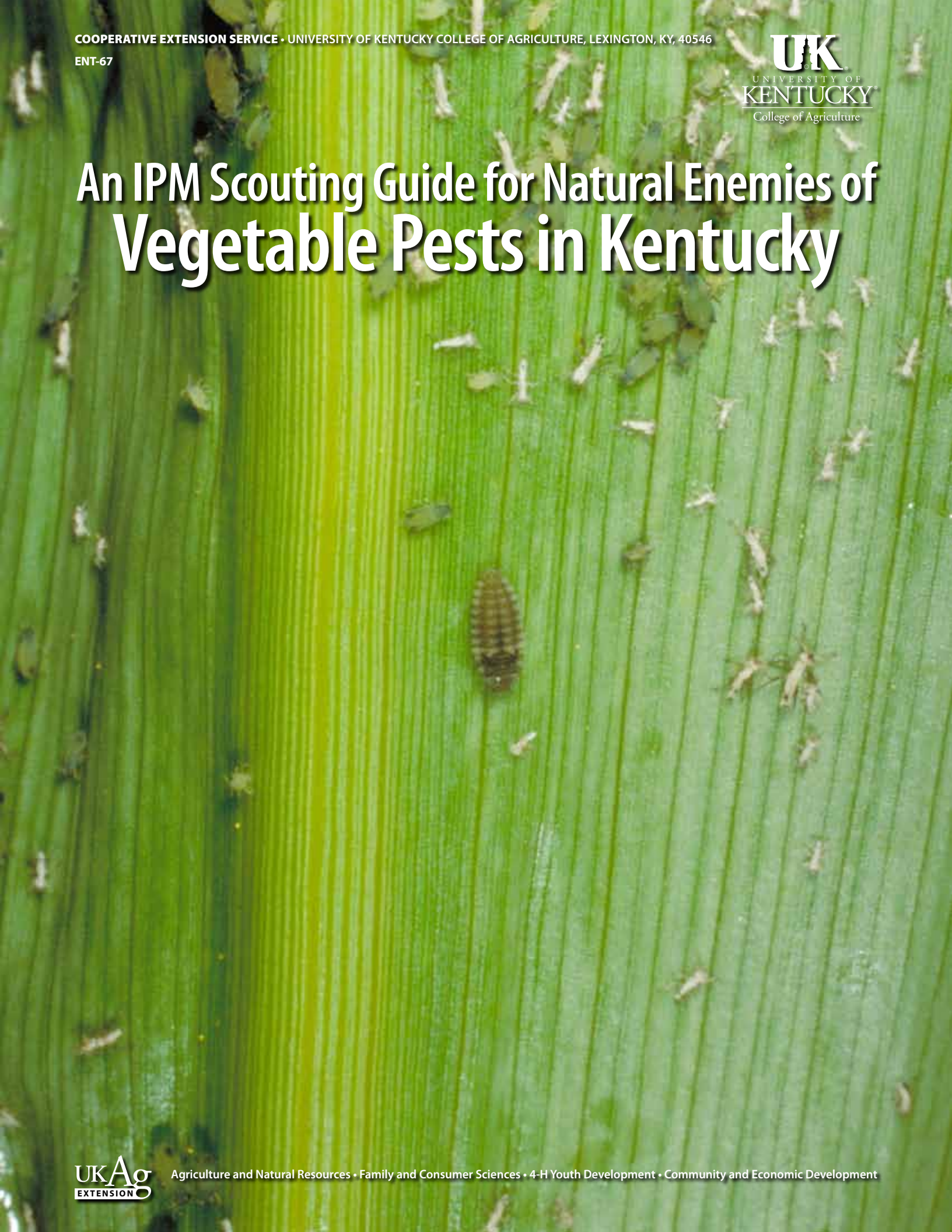
An IPM Scouting Guide for Natural Enemies of Vegetable Pests in Kentucky



Cover: A lady beetle larva searching for corn leaf aphids.

An IPM Scouting Guide for Natural Enemies of Vegetable Pests

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Natural enemies play a crucial role in the management of insect and other arthropod pests of vegetable crops grown throughout Kentucky. The control they exert on pest populations is realized on every farm every day. Often the value of natural enemies may be overlooked or taken for granted, but as a group they slow the buildup of pest populations and keep some pests from reaching economic levels.

Integrated Pest Management (IPM) programs have played an important role in vegetable production and have enabled growers to improve quality and minimize input costs. IPM uses a combination of biological, cultural, physical, and chemical methods to reduce and/or manage pest populations. **These strategies are employed in such a way as to minimize environmental risks, economic costs, and health hazards.** Pests are "managed," but not necessarily eliminated, in order to reduce their negative impact on the crop.

The first, and possibly most important, step in managing a vegetable crop is being able to properly identify what is happening in your fields, including common pest problems *and* their natural enemies. Proper identification of beneficial as well as pest insects is important and may help growers avoid unnecessary and costly insecticide applications. Once insects are correctly identified, a world of information becomes available through the Cooperative Extension Service and the internet. Essential to the IPM approach is frequent scouting and monitoring of crop diseases, insects, weeds, and abiotic disorders to identify potential problems before they result in serious losses. Understanding which natural enemies are active and whether or not their populations are increasing plays an important role in crop management as well. This guide covers the common groups of natural enemies that occur on vegetables in Kentucky.

Please contact your local Cooperative Extension agent should you need additional assistance or you encounter insects that are not in this guide. Guides are available to identify crop diseases, insect pests, and abiotic disorders of specific vegetable crops:

- *An IPM Scouting Guide for Common Problems of Solanaceous Crops in Kentucky* (ID-172)
- *An IPM Scouting Guide for Common Problems of Cucurbit Crops in Kentucky* (ID-91)
- *An IPM Scouting Guide for Common Problems of Sweet Corn in Kentucky* (ID-184)

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Natural Enemies of Vegetable Pests on Your Farm

There may be more species of natural enemies that attack insect pests than there are species of insect pests on a particular farm. Natural enemies play a crucial role in the regulation of insect pest populations. Many insects have incredibly high reproductive rates and without natural enemies or diseases have the ability to explode in number very quickly. We often don't realize the value of natural enemies unless they are not present. Generally, insects that feed on or kill other insects are considered beneficial. There are a few exceptions that primarily attack beneficial insects.

With IPM it is important for growers to recognize the common insect pests of the crops they grow. By identifying pests and plant diseases correctly they can choose appropriate management recommendations. But the same argument can be made for identifying beneficial insects, particularly the natural enemies of crop pests. By recognizing these insects, growers have the opportunity to encourage them and possibly avoid unnecessary pesticide applications. Natural enemies can help to slow the rate of pest population growth, reduce production costs, and aid in preventing or delaying development of insecticide resistance.

When scouting vegetable crops, it is important to maintain records of common natural enemies just as it is with plant pests. Changes in natural enemy populations from one week to the next can be just as important as changes in pest populations.

Natural enemies of crop pests can be divided into three broad groups: predators, parasitoids, and entomopathogenic diseases. Predators are those natural enemies that hunt and kill more than one prey. They may be specific to one species or may be generalists. Usually they are larger than the prey. Parasitoids live in or on another insect during their immature stage, need a single host (victim), and kill their host. Usually they are more host specific than predators. Both predators and parasitoids can be very important to IPM programs. Entomopathogenic diseases are caused by pathogens that attack and usually kill insects. Fortunately, these diseases, whether caused by bacteria, fungi, viruses, or nematodes do not affect other animals or plants; only insects are susceptible.

Parasitoid pupae on hornworm larva.

There are too many natural enemies of vegetable insect pests in Kentucky to list in this publication, so common groups have been listed here. All of the photographs are of Kentucky insects.

True Bugs (Hemipteran Insects)

True bugs have gradual metamorphosis (egg, nymph, and adult stages), piercing-sucking mouthparts, and hold their two pairs of wings flat over their abdomen. One key to recognizing true bugs in the field is the front pair of wings. Where the two wings overlap (a diamond-shaped area to the rear), they are thin and membranous; otherwise the front wings are thickened.

1. Minute Pirate Bugs (Family Anthocoridae). Minute pirate bugs are small (generally no more than 1/10 of an inch) and are easily overlooked because of their size, but they can be abundant in some vegetable crops. They have a distinctive black and white color pattern. As with other true-bug natural enemies, they feed on other insects both as nymphs and adults. Minute pirate bugs actively search plants for insect prey. Minute pirate bugs are sold commercially for control of thrips in greenhouses.

A minute pirate bug, *Orius* sp.

Pests attacked—They feed on a wide range of prey including spider mites, insect eggs, thrips, aphids, and small caterpillars. Despite their small size, minute pirate bugs are considered important predators in many agricultural systems.

Vegetables benefited—Minute pirate bugs can be important in sweet corn, solanaceous crops, and other vegetables.

2. Big-Eyed Bugs (Family Geocoridae). Big-eyed bugs are small (about 1/8 of an inch), and have a distinctive appearance. As expected by their name, big-eyed bugs are recognized by their size and the large prominent eyes on the sides of their heads. They are generally gray or black in color and may drop to the ground when disturbed. These insects are very common in many types of agricultural fields and can be found on and under the plastic in raised bed systems or searching on the plants for insect prey. Growers often encounter these insects while scouting for vegetable pests as these are active predators that are frequently seen searching plants for insect eggs. At least one species, *Geocoris punctipes*, has been available commercially for innudative releases.

Pests attacked—Some big-eyed bugs prefer to feed on insect eggs but will also attack aphids, thrips, leafhopper nymphs, and spider mites to a lesser extent. They do feed on plants on occasion as a water source and include pollen in their diet and may be affected by systemic insecticides. Some feed heavily on corn earworm eggs.

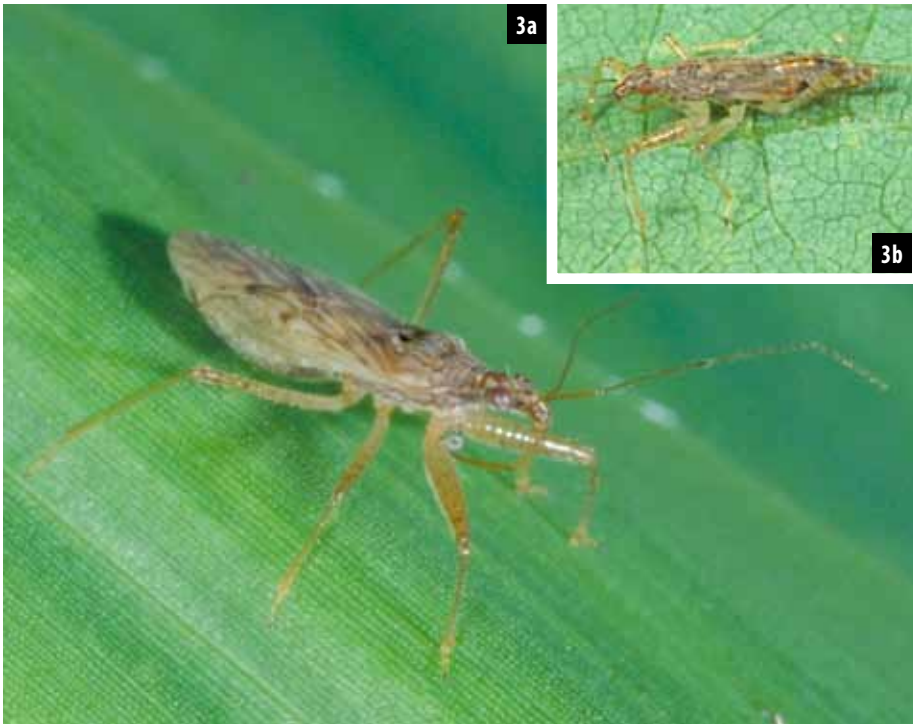
Vegetables benefited—Big-eyed bugs are common and important in many vegetable and other agricultural crop systems including sweetcorn, leafy greens, and solanaceous crops.

3. Damsel Bugs (Family Nabidae). Damsel bugs are long and slender with thickened front legs for grasping insect prey. They are tan to gray in color and reach almost ½ inch in length. Despite their relatively small size, damsel bugs are aggressive predators that actively search plants for insect eggs and soft bodied prey and can be quite common by mid-season. They can deliver a bite if handled.

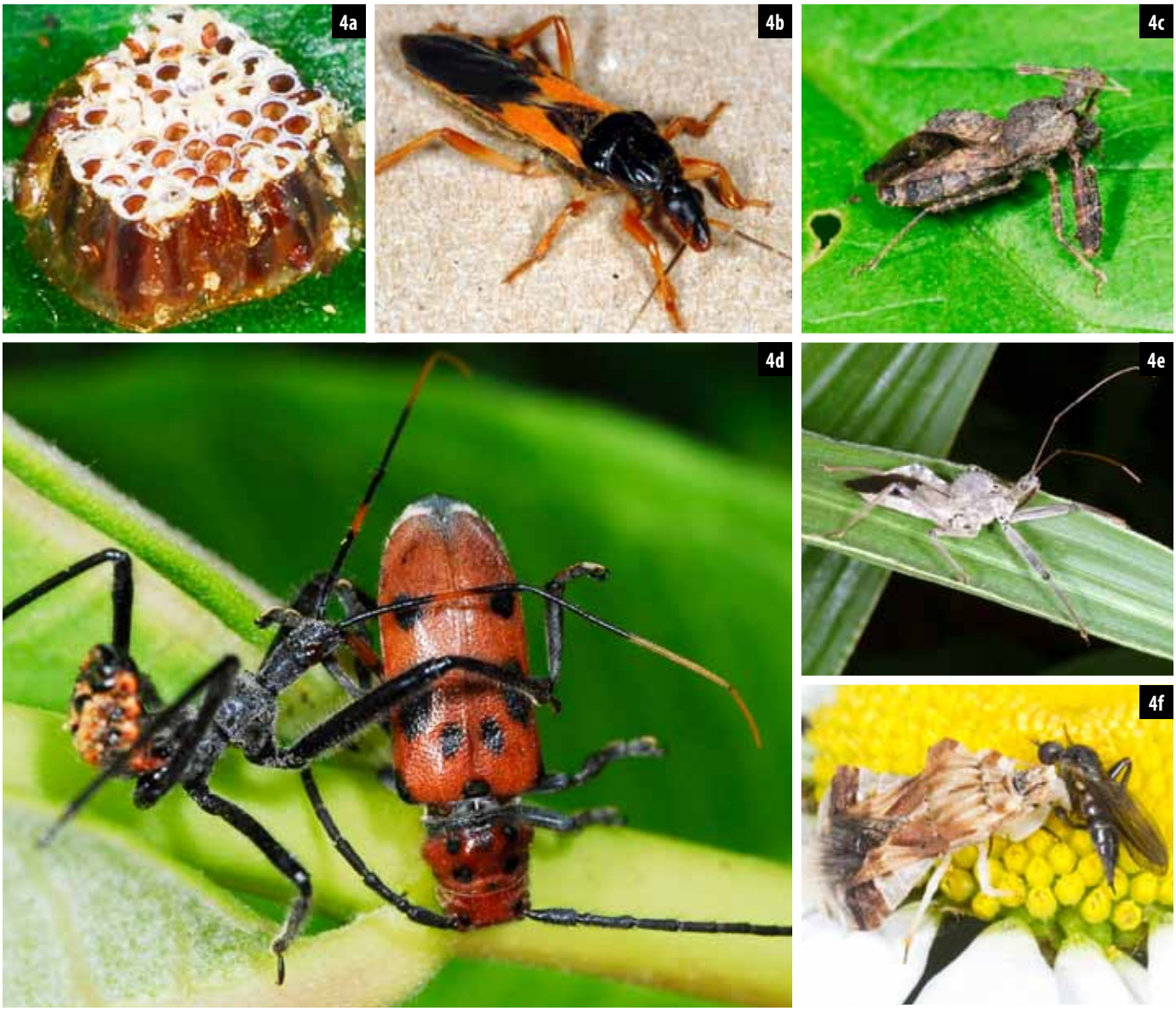
Pests attacked—Damsel bugs feed primarily on insect eggs, small caterpillars, mites, thrips, and aphids.

A big-eyed bug, *Geocoris punctipes* (a). *Geocoris uliginosus* (b) is a dark big-eyed bug commonly found in vegetable crops.

Vegetables benefited—Damsel bugs can be common in many vegetable croping systems, including legume, cole, and solanaceous crops.



An adult damsel bug, *Nabis* sp. (a). Note the wings. A damsel bug nymph (b). Note the absence of wings.



Assassin bug eggs that have hatched (a). An assassin bug, *Sirthenea carinata* (b). A spined assassin bug waiting for prey with its front legs folded (c). A wheel bug nymph (immature) killing a much larger beetle (d). The wheel bug, *Arilus cristatus* (e). An ambush bug, *Phymata pennsylvanica,* feeding on a fly (f).

4. Assassin Bugs (Family Reduviidae). The assassin bugs are true bugs and have stout beaks from the front of the head that they use to feed on other insects. Many species are common in Kentucky. They range in size from ½ to 1 ¾ inches. The largest of the assassin bugs is the wheel bug, named for the cog-like wheel on its back. Assassin bugs are recognized in part by the front legs that are enlarged relative to the other legs and used to seize and hold their victims. Also the beak is shorter and stouter than the beak of most other true bugs. An assassin bug inserts its beak into its prey to drain the body fluids. Some of the assassin bugs may inflict a painful bite if handled. Eggs are upright in tight clusters, often laid on leaves. Often assassin bugs wait for insect prey to approach, and several are considered ambush predators. While generally more common in wooded areas and on flowering plants, assassin bugs are found in vegetable systems.

Pests attacked—These insect predators feed on a wide range of insects including some beneficial insects. Several species are found in vegetable fields in Kentucky and as a group their prey includes caterpillars and other soft-bodied insects, leafhoppers, moths, and beetles.

Vegetables benefited—Can be found in most vegetable crops.

Spined soldier bug, *Podisus maculiventris,* feeding on an imported cabbageworm (a). Spined soldier bug nymph in sweet corn (b). The two-spotted stink bug, *Perillus bioculatus,* is a specialist on Colorado potato beetle (c).

5. Stink Bugs (Family Pentatomidae). The stink bug family contains many serious plant-feeding pest species as well as insect-feeding (predatory) beneficial species. As stink bugs are true bugs, they all feed with piercing sucking mouthparts. Stink bugs are recognized by their distinctive shield-back shape. Two insect-feeding stink bugs can be found in Kentucky vegetable crops, the spined soldier bug and the two-spotted stink bug. The spined soldier bug has pointed shoulders and a distinctive dark marking on the membranous part of the front wings. The two-spotted stink bug ranges in color from yellow and black to red and black and has two dark spots on a colored background behind its head.

Pests attacked—While the spined soldier bug is a generalist predator that attacks a large number of insect pests, particularly caterpillars, the two-spotted stink bug primarily attacks all stages of the Colorado potato beetle and the false potato beetle.

Vegetables benefited—The two-spotted stink bug is beneficial in potatoes, tomatoes, and eggplant, while the spined soldier bug can be found in many vegetable crops including cole crops, legumes, solanaceous crops and sweet corn.

Praying Mantids (Mantodean Insects)

Praying mantids are easily recognized by their large size, triangular head, characteristic grasping front legs, and long pronotum (front section of the thorax just behind the head). These insects have gradual metamorphosis (egg, nymph, and adult stages) and all members are predaceous. In Kentucky they have only one generation per year.

6. Carolina, European, and Chinese Praying Mantids (Order Mantodea). Praying mantids are ambush predators, typically remaining motionless and waiting for prey to approach. They are aggressive predators, feeding on a wide range of insects including pests and beneficial species; they are cannibalistic as well. Although readily recognized as voracious predators, evidence of their value in regulating pest populations in agriculture is lacking. They lay their eggs in large foam-like cases that are frequently found in the fall and winter months. Eggs hatch in the spring, and adults are present in late summer and fall.

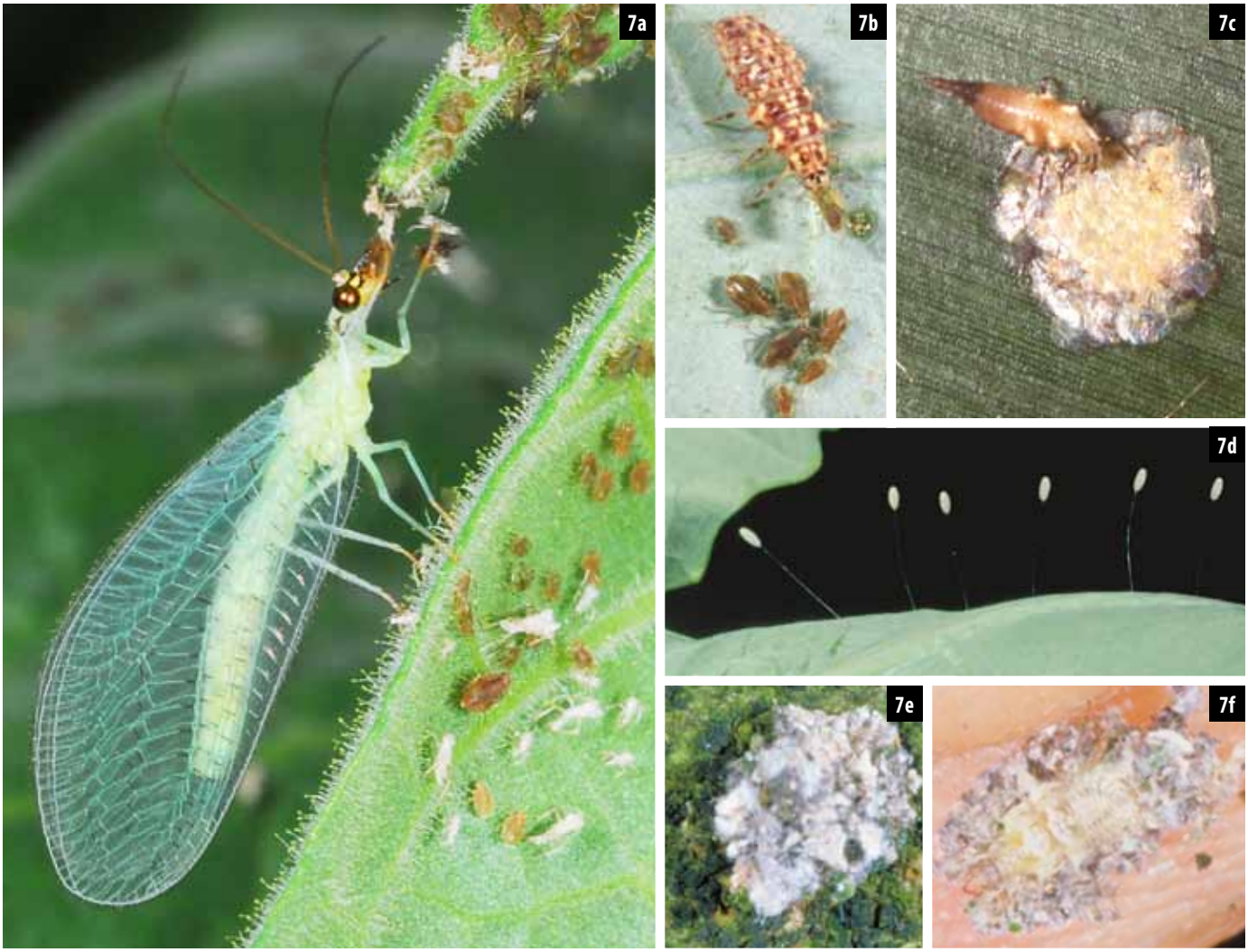
Pests attacked—Mantids feed on a wide range of insects including pests and beneficial species. Moths and bees are commonly preyed upon. Mantids are highly cannibalistic.

Vegetables benefited—Praying mantids are more common in home gardens and mixed plantings rather than monocultures. They may be found on a wide variety of vegetable crops, but their overall value in terms of reducing pest populations is questionable.

European praying mantid, *Mantis religiosa* (a). Praying mantid egg cases are found in the fall and winter. This is a Chinese mantid egg case (b). Carolina praying mantid, *Stagmomantis carolina* (c). Chinese praying mantid, *Tenodera aridifolia* (d).

Lacewings (Neuropteran Insects)

The insect order Neuroptera is a relatively small group in terms of numbers of species and gets its name from the many veins in the wings of its members. Neuropterans have many more wing veins than most insects, with numerous cross-veins that interconnect with the longer veins. Neuropterans have complete metamorphosis (egg, larval, pupal, and adult stages).



Green lacewing, *Chrysoperla* sp., feeding on tobacco aphids (a). Green lacewing larvae are sometimes called aphidlions (b). A lacewing larva feeding on a corn borer egg mass (c). Green lacewing eggs are laid on slender stalks attached to leaves and fruits (d). Some green lacewing larvae produce waxy filaments to carry debris on their back. These are sometimes called trashbugs (e). A view of a trash-carrying green lacewing larva from underneath (f).

7. Green lacewings (Family Chrysopidae). Green lacewings are common and important predatory insects in many agricultural systems and help to manage many potential pest species. Adult green lacewings are recognized by their large golden eyes and long, clear wings with many cross-veins. The adults are nearly 1 inch in length. Larvae of all species and adults of some species are predators. Some adults will feed on nectar, pollen, and insect honeydew. The larvae have a characteristic shape and hollow sickle-shaped mandibles; they actively search plants for prey. Some green lacewing larvae are called trashbugs as they attach bits of various materials, including remnants of their victims, to their body to camouflage them and possibly help them avoid aphid tending ants. The small white eggs (1⁄20 of an inch) are laid on ½-inch hairlike silk stalks attached to plant surfaces typically near a food source for the larvae. Green lacewing eggs and larvae can be purchased commercially for release.

Pests attacked—Green lacewing larvae and adults feed on a wide variety of soft-bodied insect pests including aphids, thrips, and mites as well as the egg stage of pest caterpillars.

Vegetables benefited—Green lacewings are common in many vegetable crops and can respond relatively quickly to increases in pest numbers.

A brown lacewing adult.

8. Brown Lacewings (Family Hemerobiidae). Brown lacewings are not as common as green lacewings. They are similar in appearance to green lacewings except for their color and slightly smaller size (½ an inch in length). They also have fine hairs on their wings. Eggs are laid on the undersides of leaves and lack the hair-like stalk of green lacewing eggs. The larvae do not attach debris to their backs like some green lacewings.

Pests attacked—Brown lacewings feed on various insect eggs and soft-bodied insects including aphids, mealybugs, and whiteflies.

Vegetables benefited—Generally, brown lacewings are more common on woody plants, but they can be found on solanaceous and cucurbit crops.

Beetles (Coleopteran Insects)

Beetles have complete metamorphosis (egg, larval, pupal, and adult stages). The larvae may or may not feed on the same types of food as the adults. Beetles have two pairs of wings; the front pair is hardened to protect the body, and they meet in a straight line down the center of the back.

9. Ground Beetles (Family Carabidae). Ground beetles are active predators and, as their name implies, are particularly effective against pests living in or on the soil, or those that fall to the ground. However, some ground beetles will search plants for insect prey. Ground beetles form a diverse group with size ranging from more than an inch to smaller species less than ¼ inch in size. Adults have long thread-like antennae, and many have a narrow thorax relative to the abdomen. Ground beetle larvae are found in the soil and are also predaceous. Many ground beetles are brown or black, but some are green or blue; their body shapes can be rather diverse. Ground beetles are opportunistic, feeding on a wide variety of insects with a few species feeding on seed or other plant material. They can run quickly across the soil. Many are active primarily at night.

Pests attacked—Ground beetles feed on a range of insects including caterpillars and other insects on the ground. Some of the smaller species search plants for prey items.

Vegetables benefited—Ground beetles are among the most common predators found in many vegetable crops. Research studies have documented that many vegetables may benefit from ground beetle activity.

An adult ground beetle, *Scarites* sp (a). Some smaller ground beetles (*Lebia viridis* pictured here) can be found searching plants for prey (b). A ground beetle larva (c). An adult ground beetle, *Chlaenius* sp (d).

10. Lady Beetles (Family Coccinellidae). Whether they are called lady beetles, ladybird beetles, or ladybugs, this group includes some of our most commonly recognized and important natural enemies of vegetable pests. Many lady beetles found on vegetables are brightly colored ranging from light yellow or pink to dark red; some are spotted, others spotless. Some species, however, are brown or black. Lady beetles range in size from ⅛ to ½ inch. The larvae that commonly feed on aphids have an alligator appearance and are sometimes called aphid-alligators. The eggs are light yellow to orange in color and are laid in clusters on leaves and stems, usually near a food source. Some lady beetles will feed on pollen. The convergent lady beetle is sold commercially.

Two lady beetle species are plant pests in an otherwise beneficial family. These pests are the Mexican bean beetle (which feeds on beans) and the squash bug (which feeds on squash and pumpkins).

Pests attacked—Lady beetles feed on many types of soft-bodied insects and insect eggs, including aphids, meallybugs, and scale insects.

Vegetables benefited—Most vegetable crops in Kentucky benefit from presence of lady beetles, particularly crops prone to aphid infestations.


10a


10b


10c


10d


10e

Pink lady beetles, *Coleomagilla maculata,* gathered in leaf litter at the base of a tree to pass the winter (a). A cluster of lady beetle eggs (b). A fifteen-spotted lady beetle, *Anatis labiculata* (c). Lady beetle larvae are sometimes called aphid-alligators (d). The multicolored Asian lady beetle, *Harmonia axyridis,* feeding on aphids (e).

A seven-spotted lady beetle, *Cocinella septempunctata* (f). A convergent lady beetle and its larva, *Hippodamia convergens* (g). A small, spotless lady beetle, *Cycloneda munda* (h). Lady beetle pupae are often attached to leaf surfaces near where the larvae fed (i).

11. Rove Beetles (Family Staphylinidae). Rove beetles are very common, and there are many species. They are commonly found running quickly on the soil surface and are recognized by their very short front wings. Rove beetles range in size from ⅛ of an inch to more than 1 inch in length. Some rove beetles are active during the day, but most are active at night and can be found hiding under debris during the day. Some rove beetles hold the abdomen curved up over the body, a posture similar to that of a scorpion.

Pests attacked—Rove beetles can feed on several vegetable pests and are noted as predators of see and root maggots and other soft-bodied insects.

Vegetables benefited—May be common in cole crops, onions, beans and sweet corn.

Some rove beetles are an inch or more in length (a). Rove beetles have very short front wings (b).

12. Soldier Beetles (Family Cantharidae). Soldier beetles are common in many vegetable crops. The adults are a little more than ½ inch in length and resemble fireflies in shape, but unlike fireflies their head is visible from above. They are narrow, have leathery wings, and can have orange, red, or black markings. They are frequently found on flowers feeding on pollen. Most soldier beetle larvae are predaceous, feeding on soft-bodied insects on the soil or on/in plants. Some adults are also predaceous but will also feed on pollen. The larvae are mostly black and have a characteristic velvety appearance.

Pests attacked—Soldier beetle larvae feed on a large number of soft bodied insects including aphids, small caterpillars, root maggots, and insect eggs.

Vegetables benefited—Soldier beetles can be found in most vegetable crops and are generally considered beneficial.

An adult soldier beetle, *Chauliognathus pennsylvanicus* (a). A soldier beetle larva found in a damaged pepper fruit, probably searching for a corn borer (b).

Flies (Dipteran Insects)

Flies have complete metamorphosis (egg, larva, pupal, and adult stages). Some types of fly larvae, referred to as maggots, lack legs and eyes. Flies are characterized by having only one pair of wings. Many kinds of flies are pests, but this group also includes species that are beneficial as predators and parasitoids of pests.

13. Hover Flies (Family Syrphidae). Hover flies are very common in many agricultural crops and are frequently observed visiting flowers; many people refer to them as "flower flies" because of this. They also can hover when flying, which leads to their other common name. The adults of most species are colorful wasp and bee mimics, and some resemble yellowjacket wasps. They do not bite or sting. The adults are recognized by the false vein in the center of the wings (a vein with its beginning and end not attached to other veins). The adults feed on nectar (and can act as pollinators) and honeydew from insects. The larvae of many species are predatory, especially on aphids.

Pests attacked—Hover fly larvae are important predators of various aphid species.

Vegetables benefited—Most vegetable crops that include aphids as potential pests benefit from hover flies, a common and important group of aphid predators.

It is common to find hover fly larvae holding aphids on their mouth hooks as they feed on them (a). Hover fly larvae are legless and blind (b). Many hover flies are yellowjacket mimics (c). Hover flies are commonly seen during the middle of the day (d). Hover fly pupae are sometimes found attached to leaf surfaces (e).

14. Tachinid Flies (Family Tachinidae). Unfortunately this group of beneficial flies does not have a common name. This very large family of flies is made up entirely of species that parasitize other insects, usually killing their hosts. Most tachinds are recognized by the stout spines on the end of their abdomen and range in size from ¼ to ½ inch. Some may have yellow or red coloration on their abdomen. The larvae are internal parasitoids, killing their insect hosts. Tachinid eggs are sometimes laid on the body of insect hosts, but some species will place them near insect tunnels in plants or on the leaves of plants for the insect hosts to eat. The pupa is dark brown and football shaped and may be found near the corpse of the insect host.

Pests attacked—There are many species of tachinid flies in Kentucky, all with different groups of insects that they parasitize. Some attack beetles, others caterpillars, and still others true bugs such as stink bugs.

Vegetables benefited—Many vegetable and other crops benefit from tachinid parasitoids.

Spotted cucumber beetle with an emerged tachinid parasitoid (a). A tachinid fly (b). A tachinid fly with characteristic bristles on abdomen (c). Tobacco budworm with several white tachinid eggs (circled) attached to the body behind its head (d). The squashbug fly, *Trichopoda pennipes* (e).

15. Aphid Midges (Family Cecidomyiidae). Aphid midges are long legged, very small, delicate flies, about 1/10 of an inch. They fly at night and are not commonly seen. The larvae are small and orange to red in color and may reach ⅛ of an inch in length. The larvae of a few species can be common in vegetables and are predaceous on aphids. One aphid midge species is available commercially for use in greenhouses.

Pests attacked—In vegetables, aphid midges commonly attack various aphids. On other crops they also can feed on mites, scales, and mealybugs.

Vegetables benefited—Aphid midge larvae feed on a variety of aphid pests of vegetable crops, in particular on cabbage and tomato.

Aphid midge larvae can be common in aphid colonies.

Wasps (Hymenopteran Insects)

Wasps and bees have complete metamorphosis and like some flies, it is often the larval stages that feed on other insects. If we ignore the sawflies, which are not natural enemies of insects, the other Hymneoptera (wasps, ants, and bees) have the typical pinched "waist" and the front and back wings are connected together with tiny hooks. There are too many families of wasps that attack other insects to list in this publication, so only a few common or important groups are discussed here. Some of the larger wasps are predatory, while many of the smaller wasps are parasitiods.

16. Hornets, Yellowjackets, and Paper Wasps (Family Vespidae). This group of wasps includes social species that can form large colonies and can be aggressive and sting if their colony is disturbed. These wasps are predators of insects and spiders and feed their larvae with insect prey. These wasps hold their wings folded lengthwise, and some build paper nests.

Pest attacked—These wasps can attack and kill insect pests that are exposed on the leaves and stems of crop plants such as caterpillars, grasshoppers, and true bugs.

Vegetables benefited—These wasps are predatory, and they can also be a stinging hazard around their nests or overripe or damaged melons. They search a wide range of vegetable crops for insect prey.

Adult paper wasps are often seen as they search for insect prey (a). Paper wasps form an umbrella-like nest hung from a single stalk (b).

17. Braconid Wasps (Family Braconidae). Braconid wasps are very common and important parasitoids of many agricultural pests. The adults are small to medium-sized wasps that may or may not have distinct ovipositors. They lay one or more eggs into or near their hosts, and their larvae feed on and kill the host insect. Larvae can develop internally or externally depending on the species. Some Braconid wasps emerge from the host to spin silken cocoons before pupating, others pupate within the host, and some pupate in the soil.

Pests attacked—Many agricultural pests are attacked by Braconid wasps, including various caterpillars, beetles, plant bugs, and aphids.

Vegetables benefited—Most vegetable crops benefit from Braconid wasps attacking one of more insect pests.

Braconid wasps attacking an imported cabbageworm (a). A Braconid wasp that just emerged from its cocoon (b). A dead imported cabbageworm with the Braconid pupae, *Cotesia glomerata,* that emerged as larvae from its body (c). A dead tobacco hornworm with the familiar wasp cocoons, *Cotesia congregata* (d).

18. Ichneumonid Wasps (Family Ichneumonidae). Ichneumonid wasps are similar to Braconid wasps, but they are generally larger with a longer abdomen. But there is much overlap in the appearance of these groups, making identification in the field difficult. There are many species, and they act as endoparasitoids (feed from inside the insect host) or ectoparasitoids (live outside of the insect host). Ichneumonid wasps use various insect types as host, but they primarily attack caterpillars in vegetable crops.

Pests attacked—Ichneumonid wasps primarily attack caterpillars including diamondback moth, cabbage looper, tobacco hornworm, and corn earworm.

Vegetables benefited—Various vegetables benefit from Ichneumonid wasps, including cole crops, solanaceous crops, and sweet corn.

An Ichneumonid wasp searching corn (a). An Icheumonid cocoon attached to a plant (b).

19. Trichogramma Wasps (Family Trichogrammatidae)—Trichogramma wasps are minute, almost microscopic, parasitoids of other insects' eggs. Many Trichogramma wasps are less than 1⁄50 of an inch in size. They are so small they appear as dust or moving dots with wings. A wasp lays one or more eggs into another insect's egg, where it hatches, completes its entire immature development, and emerges a week or more later as an adult wasp, killing the host egg in the process. After being attacked by Trichogramma, insect eggs will often darken. While it is almost impossible to find the adults in the field, it is relatively easy to identify pest eggs that have been attacked by Trichogramma. Several species are available commercially for release.

Pests attacked—Trichogramma wasps will attack many different insect pest eggs, particularly those of caterpillar pests including, tobacco hornworm, corn earworm, European corn borer, and imported cabbageworm.

Vegetables benefited—Many vegetables benefit from Trichogramma wasps, which help to regulate important crop pests. Because of their minute size, their importance is often overlooked in the field.

Trichogramma wasps laying eggs in European corn borer eggs.

20. Tiphia Wasps (Family Tiphiidae)—Several of the Tiphia wasps are external parasitoids of white grubs. The female wasp will dig through the soil to attach an egg to a white grub where the host feeds. One species, *Tiphia vernalis*, is important in the regulation of Japanese beetle grubs.

Pests attacked—Tiphia wasps can attack white grubs, larvae of scarab beetles.

Vegetables benefits—Those attacked by white grubs, including Japanese beetle larvae.

This Tiphia wasp, *Tiphia vernalis,* can be common in the late summer or fall.

21. Scelionid Wasps (Family Scelionidae)—Scelionid wasps are parasitoids of insect and spider eggs. These minute wasps (1⁄20 of an inch) lay their eggs inside of other insect eggs, and their larvae feed on those eggs. Some species attack eggs of true bugs, including stink bugs and other large bugs.

Pests attacked—Scelionid wasps attack eggs various pests including those of stink bugs, squash bug, and Lepidoptera.

Vegetables benefited—Those attacked by stink bugs, squash bugs, and some caterpillars.

A Scelionid wasp laying eggs inside eggs of other insects.

Spiders (Order Araneae)

Spiders are very common in vegetable crops and easy to recognize in that they have two body regions rather than three like insects, no wings or antennae, and eight legs. Some spiders may bite if handled, but most spiders are not dangerous (with the exception of the black widow and brown recluse) and act as generalist predators feeding on many kinds of insects including moths, plant bugs, leafhoppers, flies, and grasshoppers. Both immature and adult spiders are predaceous. Common spiders in vegetables include orb weavers, jumping spiders, crab spiders, wolf spiders, sheet-weaving spiders, and sac spiders.

22. Wolf Spiders (Family Lycosidae). Wolf spiders are common ground spiders and may be quite large, up to 2 inches in size, although most are smaller. They often have two wide, dark stripes on the portion of the body where the legs are attached. They have a unique eye arrangement of 4-2-2, with the front four eyes in a near straight line. Wolf spiders do not make webs to catch prey but either actively hunt or ambush their prey. The females may be seen carrying their egg sacs with her spinnerets behind the body or transporting the young spiderlings on her back. Some wolf spiders are large and appear formidable, they are not dangerous.

A large wolf spider.

23. Jumping Spiders (Family Salticidae). Jumping spiders are small compact spiders that actively search plants for insect prey. Two of their eight eyes are very large and face forward; they have the best visual acuity of all spiders. They have relatively short legs and the ability to jump short distances. They can be very effective predators capturing a variety of insects.

One pair of the jumping spiders eyes are large and face forward.

A black and yellow garden spider.

24. Orb Weavers (Family Araneidae)—The orb weavers are a large and diverse group of spiders named for their habit of producing orb-like webs; they are commonly seen in some vegetable systems, particularly staked tomatoes. One very large orb weaver is the yellow and black garden spider that makes a large vertical web with a thickened 'zipper' below the center.

25. Crab Spiders (Family Thomisidae)—Crab spiders are also very common in vegetable and other agricultural systems, where they feed on many types of insects. Crab spiders are recognized in the field by their front two pairs of legs, which are longer and heavier than the other two pairs and usually held in a crab-like posture. Some hide in flowers to ambush pollinators. Some remain on the ground; others can be found on plants.

A crab spider feeding on a caterpillar.

26. Sheet-weaving Spiders (Family Linyphiidae). Most sheet-weaving spiders are minute to small, 1/20 to 1/8 inch in size. They characteristically construct small, horizontal (about 1 inch across) sheet-like webs on or close to the ground. Although small, they can be the most abundant group of spiders in vegetable fields. They are known to feed on aphids and leafhoppers.

Many sheet-weaving spiders are minute and often overlooked.

27. Sac Spiders (Family Clubionidae). Sac spiders can be common in vegetable systems and are typically active night hunters searching for prey. They are pale spiders with two claws and may have front legs longer than the other pairs. They build a small silken tube in a protected area to retreat into, hence the name sac spider. Sac spiders may web leaves together or build retreats in debris on the ground. They do not build webs to capture prey. Some older literature lists yellow sac spiders as a dangerous group that can produce a milder form a of a brown recluse–type bite (necrosis), but recent medical research indicates that the bite is more similar to that of a bee sting.

A sac spider on broccoli.

Diseases of Insect Pests

There are a number of viruses, fungi, bacteria, and nematodes that attack insects, and many of these are important in the regulation of insect pest populations. Fortunately, these organisms that infect and often kill insects do not attack other animals or plants. They are specific to insects.

28. Fungal Diseases. Several species of fungi are commonly found attacking insects, particularly during prolonged wet or humid weather. Some species of fungi are specific to groups of insects while others are less specific. When weather conditions are favorable, the fungi can spread rapidly throughout an insect population resulting in its collapse. To infect an insect, fungal spores germinate and penetrate the cuticle of the insect. How fungicides that are used to control plant-pathogenic fungi affect insect-pathogenic fungi is poorly understood. Several strains of *Beauveria bassiana* are available commercially to control crop pests.

29. Insect Viruses. There are main two groups of viruses, the granulosis viruses (GV) and nuclear polyhedrosis viruses (NPV), that frequently infect insects. Depending on the type of virus, these can be specific to a single insect species such as the beet armyworm NPV or infect broader groups of insect species. Insect viruses must be eaten in order to infect an insect and it may take a week of more to kill the insect. But viruses have the ability to quickly spread through insect populations and can cause those populations to crash. Characteristically, insects infected with a virus often climb to a high point on the plant to die, hang from the plant, and leak virus particles onto the plant. Many of the viruses attack insect caterpillars.

Fungal infected aphids (pink and inflated) among healthy aphids (a). A fall armyworm covered in fungal spores (b). Fruiting bodies emerging from a fungus-killed common stalk borer (c). A woolybear caterpillar victim of an insect-pathogenic fungus (d).

A fall armyworm recently killed by a virus (a). A virus-killed insect cadaver in sweet corn (b).

30. Entopathogenic Bacteria. Many species of bacteria attack insects, and some can kill the insect host. One serious spore-forming type is *Bacillus larvae* that causes American foulbrood of honey bees. Another common spore-forming soil bacterium is *Bacillus papillae,* which attacks white grubs and causes milky disease. *Bacillus papillae* is common in our soils, and it is also sold commercially.

A milky disease–infected white grub (below) and a healthy grub (above).

31. Entomopathogenic Nematodes. A large number of entomopathogenic nematodes attack insects. Juvenile nematodes either lie in wait for susceptible insects or actively search for them in soil or in or on plant material. These nematodes enter and infect the host with bacteria that actually kills the insect. These bacterial infections often give the insect a yellow or red color. Nematodes usually require free moisture in order to hunt for and infect insects. These nematodes do not infect plants or other animals. Several species of entomopathogenic nematodes are available commercially and can be applied as sprays or drenches.

A nematode-infected grub (left) and healthy white grub (right).

Purchasing and Releasing Natural Enemies

Many different types of natural enemies can be purchased and released on the farm or in the greenhouse. There are a number of considerations to make before using and selecting commercial natural enemies of insect pests.

Pest level: Natural enemies often take time to build in numbers such that they can regulate pest populations and can be ineffective if released when pest populations are already large. When pest level is high, a short residual insecticide or a selective insecticide can be used to suppress pest levels prior to natural enemy release. However, in the complete absence of pests the natural enemies may leave or starve.

Species of natural enemy to release: The species you release will depend on the pest or pests that need to be managed and on whether the natural enemies are released inside a greenhouse, under a row cover, or in an open field. Winged adults can be confined in the greenhouse to prevent their dispersal off the farm, and non-winged immature stages can be used without worry of them "taking off."

Number of natural enemies to release: This will depend on the species of natural enemy being released, the stage it is in, and the level of the pest. Commercial insectaries have specific guidelines for the natural enemies they sell.

Stage of natural enemy: With some natural enemies, such as green lacewings, you may purchase different stages—eggs or larvae. Larvae are more expensive but can consume more prey in a shorter period of time. Larvae may be preferred when pest levels require more immediate effect. Green lacewing eggs, which are often more economical, could be used at the initial signs of pest population development.

Time of day for release: In the middle of the summer, it is often easier for the natural enemies to adjust to the field if released in the late afternoon or early morning rather than in the middle of the day. Morning releases can provide needed moisture for the natural enemies if dew is present. In early spring or late fall months, a mid-day release may be preferred when temperatures are lower.

Companion plants: Companion plants that provide nectar and pollen for adult natural enemies have been shown to increase the effectiveness of some natural enemies in some vegetable crops. This can help to increase the number of eggs they produce and keep them close to the vegetable crop. Buckwheat and sweet alyssum have been two common companion plants used with vegetables to attract and provide nutritional resources for natural enemies.

Pesticides and natural enemies: Improper use of broad-spectrum insecticides has the potential to wipe out natural enemies in a field. Generally, insecticides impact natural enemies more than pests because not only can they be directly toxic to them, they also eliminate their food source by removing the pest insects. Take care when using insecticides to minimize the impact on natural enemies. For most crops, selective insecticides that are less toxic to natural enemies are available for many pests. Growers should use IPM techniques (cultural controls, scouting, and thresholds) to reduce or delay the need for insecticide sprays. If possible, spot spraying only the areas where pests have reached economic levels will also help to preserve natural enemies.

For more information:

Specific pest management and crop production information can be found in the following University of Kentucky entomology fact sheets available at county extension offices as well as on the internet.

The Wheel Bug (ENTFACT-426). http://www.ca.uky.edu/entomology/entfacts/ef426.asp

Green Lacewing (ENTFACT-148). http://www.ca.uky.edu/entomology/entfacts/ef148.asp

Ground Beetles (ENTFACT-104). http://www.ca.uky.edu/entomology/entfacts/ef104.asp

Ladybugs (ENTFACT-105). http://www.ca.uky.edu/entomology/entfacts/ef105.asp

Praying Mantids (ENTFACT-418). http://www.ca.uky.edu/entomology/entfacts/ef418.asp

Vendors of Beneficial Organisms in North America (ENTFACT-125). http://www.ca.uky.edu/entomology/entfacts/ef125.asp

Soldier Beetles (ENTFACT-625). http://www.ca.uky.edu/entomology/entfacts/ef625.asp

Yard Wasps (ENTFACT-411). http://www.ca.uky.edu/entomology/entfacts/ef411.asp

Cicada Killer Wasps (ENTFACT-104). http://www.ca.uky.edu/entomology/entfacts/ef004.asp

Controlling Wasps, Hornets and Yellowjackets (ENTFACT-620). http://www.ca.uky.edu/entomology/entfacts/ef620.asp

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