Insects at Work:

Beneficial Insects in Small-Scale Farms and Community Gardens

XERCES SOCIETY
for Invertebrate Conservation

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Beneficial Insects in Small-Scale Farms and Community Gardens

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The Xerces Society for Invertebrate Conservation

xerces.org

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Cover Photo

A soldier beetle foraging on a blanketflower. (Photo: Debbie Roos, NCSU-CES.)

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1 Introduction

Decision-making on farms can be a balancing act, often with limited time, labor, and resources. Installing native plants to support beneficial insects can provide stability for a small-scale farm or community garden. Lacewings, predatory and parasitic wasps, flies, beetles, native bees, and other insects play a vital role, day and night, in the production of agricultural crops through pollination, pest control, and building healthy soils. Many of the foods, vitamins, and minerals we consume on a regular basis are enhanced thanks to the free services of beneficial insects. They also contribute conservation biocontrol worth billions of dollars a year to farms. In addition, habitat for these wild animals boosts farm aesthetics and nutrient recycling, reduces farming costs.

Insect pests thrive in monoculture settings, but beneficial insects that counter the pests cannot survive on crops alone. Diverse habitat offering food, shelter, and protection from pesticides is needed for beneficial insects to thrive. Farms and community gardens with habitat on site (or nearby) and pesticide protection methods in place can support a diverse community of insects. In turn, these insects contribute to the health of the farm or garden. For example, a diverse community of native bees increases the stability of pollination over time and can buffer pollination from yearly fluctuations in pollinator abundances, resulting in more reliable pollination services than dependence upon a single species.

Native perennial habitat amongst vegetable and fruit production in a community garden. (Photo: Xerces Society / Sarah Nizzi.)

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What Role do Beneficial Insects Play on my Farm or in my Garden?

Similar to the multiple roles friends and neighbors play in our local communities, beneficial insects can offer many services to a farm or garden. Below are descriptions of the various roles beneficial insects play throughout their life cycle.

- Pollinators transfer pollen between flowers, assisting in plant reproduction. The seeds and fruits that are the product of pollination are also important food sources for a variety of wildlife, as well as for people. Pollinators contribute to pollination by incidentally moving small portions of pollen picked up while feeding on sugary nectar or the protein-packed pollen of flowers. Bees are highly efficient pollinators; females actively collect pollen to provide for their young.

- Decomposers feed on dead plant and animal materials. They break them down into smaller pieces that are accessible to bacteria and fungi for further consumption, releasing nutrients into the soil and making them available for plants to use.

- Predators hunt or capture and consume other animals. They help to regulate population sizes of crop pests and can contribute significantly to controlling them.

- Parasitoids are insects that lay their eggs on or inside another insect. Most parasitoids are wasps, flies, or beetles. After hatching, the parasitoid larva feeds on—and ultimately kills—the host insect before emerging as a fully developed adult.

- Soil engineers burrow or tunnel through the soil, improving soil structure and helping to move water and air to deeper soil layers. Soil engineers help soil fertility by mixing nutrients and minerals between soil layers and influence microbial communities by dispersing microorganisms throughout soil layers.

- Herbivores consume living plant material, feeding on roots or aboveground vegetation. Some herbivores specialize in eating a particular part of a plant, a particular plant species, or a closely related group of plants, while others feed on a wide range of plants. Herbivores are important food sources for animals large and small, and also play a role in influencing the structure of plant communities.

Many beneficial insects play multiple roles, which may differ between adults and immature stages. Often, the most visible stage is the adult, with its six legs and wings. However, in their immature stages, some insects can live in different habitats, consume different foods, and have a very different appearance from adults.

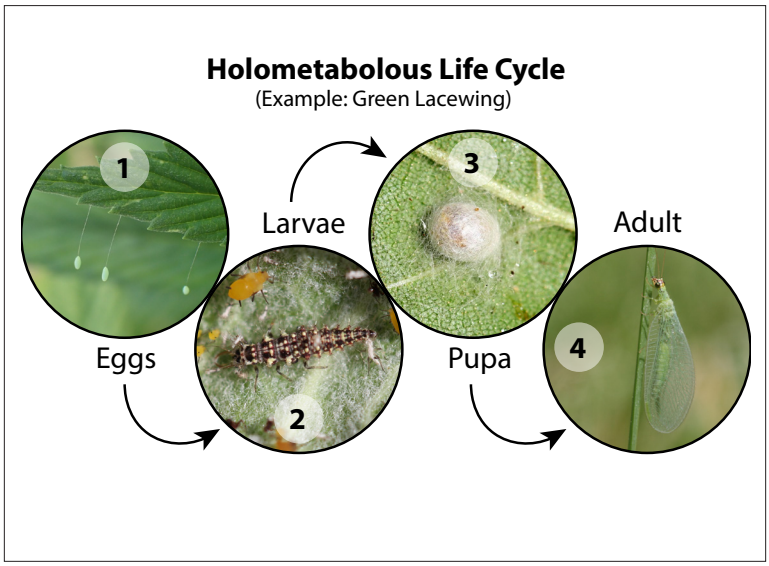
Insects, along with other arthropods, have a thick, hard outer body covering known as an exoskeleton. In order to grow from egg to adult, insects must periodically shed their exoskeleton, or molt, to grow larger. An instar is a developmental stage in between molts, and the number of instars an insect or other arthropod species grows through before it reaches the adult stage varies by species. Non-insect arthropods such as spiders or millipedes emerge from eggs resembling small adults and add growth with each molt.

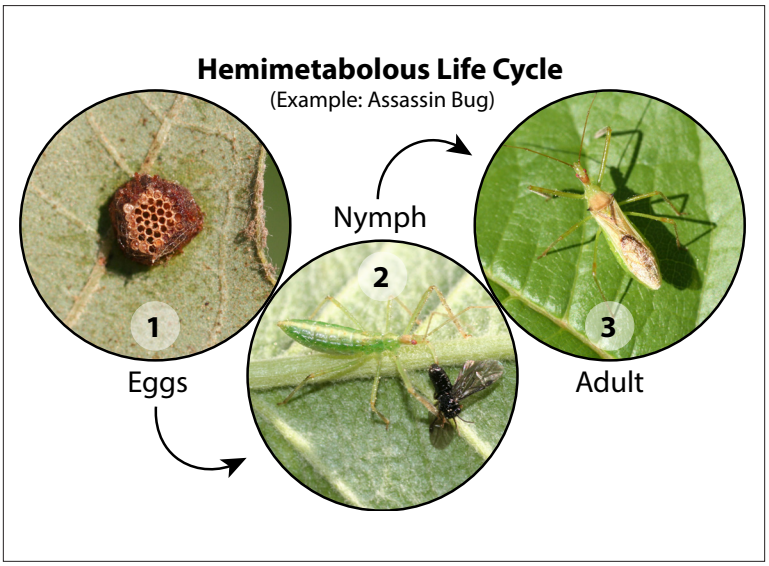
Insects transform between life stages during their lives, with two main forms of transformation, complete metamorphosis (*holometaboly*) or incomplete metamorphosis (*hemimetaboly*).

- Insects with complete metamorphosis go from egg to larva to pupa to adult. Larvae are wingless and look quite different than adults, often living in different habitats and consuming different food sources than adults. The pupal stage is typically a nonfeeding stage, and is the phase when an insect's body changes drastically both inside and out, before emerging as an adult. Holometabolous insects may have very different ecological and agricultural roles as larvae than their adult stage. Some flower flies, for example, are predators as larvae and hunt aphids and small prey on vegetation, while the adults visit flowers to drink nectar or eat pollen.

- The immature stages of insects with incomplete metamorphosis are called nymphs. These juveniles often resemble adults but with smaller body proportions, and no wings or genitalia. Later instars of nymphs will have wing buds. There is no pupal stage between nymph and adult. Hemimetabolous insects include groups like true bugs, grasshoppers, mantids, and leafhoppers, and nymphs and adults are often found in similar habitats and eat similar foods.

Examples of holometabolous (left) and hemimetabolous (right) life cycles. (Photos: Whitney Cranshaw, CSU, Bugwood.org.)

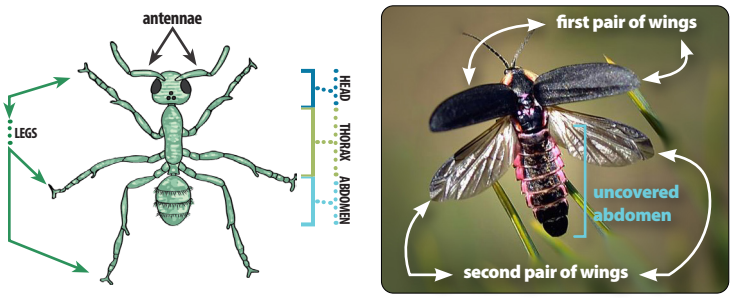




3

How do I Find These Animals?

Understanding the diet and life cycle of beneficial insects can help us find them on flowers, plants, near host prey that are on plants, and in leaf layers or within the soil. Here we organize key groups of beneficial insects that contribute to crop pollination, healthy soils, and pest control by where they are most often easily observed, within habitat and within crops.



Wingless insect body plan example, worker ant (left). Winged insect body plan example, firefly (right). Note that nymph and larval stages are wingless; some species lack wings as adults or have wingless castes. Size in the profiles below refers to the range of body length for the group of animals, and does not include antennae or legs. (Illustrations: Sara Morris.)

Key

- Insects Found on Flowers
- Insects Found on Vegetation (Leaves and Stems)
- Insects Found Inside Hosts, Often on Plants
- Insects and Other Arthropods Found in the Leaf Layer or Within Soil

Insects Found on Flowers

Bumble Bees


Photo: Xerces Society / Jennifer Hopwood.

Order: Hymenoptera | **Family:** Apidae | **Genus:** *Bombus*

Roles: Pollinators, Soil Engineers

How to recognize: Bumble bees are a charismatic and easily recognized group. They are medium to large in size (up to 1.06 in. [27 mm] in length in queens) and robust. The head, thorax, and abdomen are black with yellow, white, orange, or rusty brown hairs. Female bumble bees collect pollen on a flattened, concave plate on the upper hind leg known as a pollen basket or corbicula. Workers and males are smaller in size compared to queens and may vary in their color patterns.

Crops they pollinate: Apple, bean, blueberry, canola, cherry, cotton, cranberry cucumber, currant, eggplant, gooseberry, pepper, plum, squash, strawberry, sunflower, tomato, and watermelon.

Habitat Needs: Bumble bees are social and live in annual colonies founded by a mated queen in the spring. A queen bumble bee will search for and find an insulated cavity above or below ground in which to build her nest; nests can be in abandoned rodent nests, under vegetation or thatch on the soil surface, or other sites that provide insulation. As a queen grows her colony, her female worker offspring will take over duties of foraging, caring for young, and more while the queen focuses on reproduction. The colony will grow and peak at 25–400 individuals, depending on the species, before the colony's life dwindles after new males and new queens are reared and leave the nest. Bumble bees are active from early spring to late fall, and so they need a wide range of flowering trees, shrubs, and wildflowers as sources of nectar and pollen.

Mining Bees

Photo: Xerces Society / Mace Vaughan.

Order: Hymenoptera | **Family:** Andrenidae | **Genus:** *Andrena*

Roles: Pollinators, Soil Engineers

How to recognize: Mining bees are small to medium (0.28–0.51 in. [7–14 mm]) in length and relatively narrow in size. Mining bees are dark in color with gold, orange, white, or light gray hairs on their thorax, and many have bands of pale hair on their abdomen. Females carry pollen on long hairs on their upper hind legs and the back of the thorax. Males have dense hairs on their face below the antennae, sometimes referred to as a "mustache," while females have two parallel depressions covered in short dense hairs between their eyes.

Crops they pollinate: Apple, blueberry, pear, raspberry, and strawberry.

Habitat Needs: Mining bees are ground-nesters and require patches of bare soil. Female mining bees may construct nests in dense aggregations. Many species of these bees are active in the spring and late summer, drinking nectar and collecting pollen. Some mining bees are pollen specialists, collecting pollen only from groups of closely related plants to feed their young (e.g., ephemeral wildflowers in the spring, or sunflowers and relatives in the late summer).

Mason Bees

Photo: Xerces Society / Emily May.

Order: Hymenoptera | **Family:** Megachilidae | **Genus:** *Osmia*

Roles: Pollinators

How to recognize: Most mason bees are small to medium in length (0.32–0.59 in. [8–16 mm]) and are blue, green, or copper in color with a metallic sheen, with no prominent hair bands on their abdomen. Females carry pollen on long, dense hairs (scopa) on the underside of their abdomen. Males have longer antennae and dense hairs below the antennae.

Crops they pollinate: Almond, apple, blueberry, cherry, plum, pepper, and strawberry.

Habitat Needs: Mason bees nest in cavities above ground, often using moistened soil or chewed leaves in nest construction. Nesting sites include pithy plant stems, standing dead trees, abandoned mud dauber wasp nests, areas between a rock and soil, inside snail shells, and inside man-made cavities (e.g., screw holes in tables). Most mason bee species fly in the spring. Some species specialize on the pollen of a particular genus of plants or a family of plants (e.g., *Penstemon*; plants in the legume family Fabaceae).

Squash Bees

Photo: Katharina Ullmann.

Order: Hymenoptera | **Family:** Apidae | **Genera:** *Peponapis*, *Xenoglossa*

Roles: Pollinators, Soil Engineers

How to recognize: Squash bees are small to medium in length (0.25–0.71 in. [6–18 mm]). The head, thorax, and abdomen are black with dense orange hairs, and they have pale stripes on the abdomen. Females carry pollen on long, orange hairs on their hind legs. Males have a pale-yellow patch on their face.

Crops they pollinate: Squash bees are particularly efficient and important pollinators of plants in the genus *Cucurbita*, such as squash and pumpkin.

Habitat Needs: Squash bees are ground nesters. Nests are typically close to food sources (squash flowers), and these bees can nest in aggregations amongst one another. Nests can be several inches under the soil or more (4–12 in. [10–30 cm]), and can be disturbed or destroyed by tillage. In addition to the squash pollen they collect to feed their young, these bees need nectar sources during their flight season (squash bloom period). These bees are early risers, often flying to visit squash blossoms before the sun has fully risen, and males are frequently found sleeping inside wilted flowers after the flowers have closed midday.

Sweat Bees, Furrow Bees

Photo: David Cappaert, Bugwood.org (CC BY-NC 3.0).

Order: Hymenoptera | **Family:** Halictidae

Roles: Pollinators, Soil Engineers

How to recognize: Sweat bees can vary in size from tiny to medium (0.20–0.7 in. [5–18 mm]). The coloration of these bees can be dull metallic (blue, green, or gold), dull brown or black with pale stripes on the abdomen, or a stunning, bright metallic green. Males of several metallic green sweat bee species, which become common in midsummer and fall, have yellow abdomens with black stripes.

Crops they pollinate: Apple, eggplant, pepper, potato, raspberry, squash, tomato, and watermelon.

Habitat Needs: Most sweat bees are ground nesters, except the pure green sweat bee, *Augochlora pura*, which nests in rotting logs or soft wood. Ground nesting sweat bees may also nest amongst one another. While many sweat bee species are solitary, with each female building and provisioning her nest alone, other species have varying degrees of sociality, some living cooperatively and others in small colonies with a female that primarily lays eggs. Sweat bees visit a wide variety of flowers. Sweat bees can be found from spring to fall, and some species have multiple generations in a growing season.

Honey Bees

Photo: David Cappaert, Bugwood.org (CC BY-NC 3.0).

Order: Hymenoptera | **Family:** Apidae | **Genus:** *Apis*

Role: Pollinators

Crops they pollinate: Honey bees can visit a wide range of flowers and are pollinators of many crops (e.g. apple, blueberry, squash).

Honey bees (*Apis mellifera*) are a **domesticated**, highly-social species maintained by beekeepers and widely used for crop production and honey production within the United States. Honey bees have long been domesticated around the world, and were **introduced** to North America by European settlers.

Hunting Wasps

Photo: Xerces Society / Jennifer Hopwood.

Order: Hymenoptera | **Families:** Vespidae, Sphecidae

Roles: Predators, Pollinators, Soil Engineers

How to recognize: Adult vespid wasps are medium to large (0.39–0.98 in. [10–25 mm]) in size, have a notch along the inner margin of their eyes, a thin waist, and are black or brown with white, yellow, red, or orange markings. Vespid wasps fold their two pairs of wings in half lengthwise when at rest (appearing to have only one narrow pair of wings). Adult sphecid wasps are medium to large (0.39–1.18 in. [10–30 mm]) in size, have a very thin, elongated waist, and are fully black, slightly metallic, or black with red, yellow, or white markings. Sphecids tend to be more slender than vespid wasps, and do not have notched eyes.

What they eat: Adult females hunt prey to bring back to their nests as food for their carnivorous larvae. Some species are generalists, feeding on caterpillars, beetles, flies, or true bugs, while others may hunt more selectively on particular pest groups such as grasshoppers, caterpillars, or aphids.

Crops they pollinate: Wasps are known to contribute to apple, pumpkin, and mustard pollination. The role of wasp pollination in crop systems is not yet well understood.

Habitat Needs: Adult wasps feed primarily on nectar, although some species also feed on rotting fruit or the juices of prey. Adult female wasps build nests, leaving insect and other arthropod prey within nest chambers for their young. Nests of solitary vespid species are constructed out of clay or chewed foliage on twigs, stems, crevices of walls, or between rocks, while many solitary sphecid wasps will build nests in stems or tunnels in wood cavities or in the ground, and may utilize pieces of grass, mud, or resin in the construction of their nest. All sphecid wasps and most vespid wasps are solitary, with each female constructing and provisioning her own nest; these wasps do not defend their nests. Yellowjackets, hornets, and paper wasps in the family Vespidae are social species, with colonies founded by a queen who reproduces, and with a division of labor among female worker wasps. Social wasps can be aggressive in defending their nests.

Scarab-Hunter Wasps

Photo: Xerces Society / Jennifer Hopwood.

Order: Hymenoptera | **Families:** Scoliidae, Tiphiidae

Roles: Parasitoids, Pollinators, Soil Engineers

How to recognize: Adults are found on flowers. Scoliid wasps are large to very large (0.79–2 in. [20–50 mm]), with black bodies, bright yellow, orange, or red colorations, and spiny, bristly legs. Their wings are usually dark, often with a slight blue sheen. Tiphiid wasps are small to large (0.24–0.98 in. [6–25 mm]) with slender bodies, and often have elongated abdomens. They are black, some species with yellow markings and color bands on their abdomens, and wings that are slightly darkened but not opaque (some females are wingless).

What they eat: Adult females search for scarab beetle grubs, digging through soil to find, paralyze, and lay an egg on them. Wasp larvae are external parasitoids of scarab beetles. Adults consume nectar for energy.

Crops they pollinate: Wasps are known to contribute to apple, pumpkin, and mustard pollination. The role of wasp pollination in crop systems is not yet well understood.

Habitat Needs: Adults need nectar-producing flowers. Larvae are found in the soils of lawns and fields, wherever scarab beetle grubs are eating plant roots, and may be sensitive to pesticides.

Flower Flies, Syrphid Flies

Adults. Photo: Xerces Society / Sarah Foltz Jordan.

Order: Diptera | **Family:** Syrphidae

Roles: Predators, Pollinators, Decomposers

How to recognize: Adult flies, often found on flowers, are small to large in length (0.32–0.79 in. [8–20 mm]) and have two wings; short, stout antennae; and large, broad eyes. Adults often have bright coloration, and many species mimic the coloration of bees or wasps, some to a striking degree. Larvae are often on plants near prey or in the leaf layer, and are legless, with brown-gray-green coloration and distinctive markings, stripes, or spines.

Larva. David Cappaert, Bugwood.org (CC BY-NC 3.0).

What they eat: Flower fly larvae will hunt aphids, mites, scales, mealybugs, spider mites, and thrips on plants or in the leaf layer. Other larvae are decomposers in soil or filter feeders in ponds.

Food crops they pollinate: Flower fly adults also contribute to the pollination of strawberries, peppers, tomatoes, blackberries, raspberries, peaches, plums, and pears.

Habitat Needs: Adults drink nectar and sometimes eat pollen, and rely on areas with a continuous bloom of flowering plants. Eggs are laid singly or in small clumps on foliage near prey (e.g., next to an aphid colony). Larvae, pupae, or adults overwinter in the leaf layer or in the soil. These flies can be sensitive to tillage.

Soldier Beetles, Leatherwings

Adult. Photo: Julie Metz.

Larva. Photo: Judy Gallagher, Flickr (CC BY 2.0).

Order: Coleoptera | **Family:** Cantharidae

Roles: Predators, Pollinators

How to recognize: Adult soldier beetles are tiny to medium in size (0.04–0.71 in. [1–18 mm]), and have soft bodies with leathery wing covers. Adults have black, brown, yellow, or orange coloration and elongated bodies. They resemble fireflies, without the light-emitting segments, but they do have glands at the end of their abdomen that secrete defensive chemicals. Larvae are dark colored with elongated, flattened bodies.

What they eat: The larvae eat eggs and larvae of insects (such as aphids), snails, and slugs. Adults consume nectar and pollen.

Food crops they pollinate: These beetles may contribute to carrot pollination, but their contributions to crop pollination are not well known at this time.

Habitat Needs: Soldier beetles lay their eggs in moist soil or in the leaf layer. Larvae hunt for insects in loose soil, leaf layer, under rocks or debris, or under bark, and overwinter in the leaf layer. Adults need habitat with a variety of wildflowers with open, shallow floral structures, such as yarrow, golden alexander, and sunflowers.

Insects Found on Vegetation (Leaves and Stems)

Lady Beetles

Adult. Photo: Whitney Cranshaw, CSU, Bugwood.org.

Order: Coleoptera | **Family:** Coccinellidae

Roles: Predators, Pollinators

How to recognize: Adults are tiny to small in size (0.04–0.32 in. [1–8 mm]), with oval, convex bodies. They normally are brightly colored red or orange with dark spots or other markings, or black or beige with red or yellow markings. Some species are highly variable in coloration (e.g., the introduced multicolored Asian lady beetle, *Harmonia axyridis*). Larvae have an elongated, flattened, alligator-like body and dark coloration.

Larva. Photo: Katja Schulz, Flickr (CC BY 2.0).

What they eat: Most larvae and adults are specialist predators of aphids, whiteflies, or scales, but some also consume mites, thrips, and insect eggs in the absence of their preferred prey. Adults of many species also consume pollen, nectar, and aphid honeydew.

Habitat Needs: Eggs are laid on leaves or stems near prey, and there are one to five generations a year. Lady beetles overwinter as adults in protected locations, such as leaf layer, in rock crevices, behind bark, or in the eaves of homes. Adults need non-cropped areas or plantings with flowering plants that provide alternate prey and non-prey food.

Larva. Photo: David Cappaert, Bugwood.org (CC BY-NC 3.0).

Note: *Lady beetles purchased for augmentative biocontrol releases should only be used within confined spaces such as greenhouses. In field settings, having permanent habitat available is most effective for supporting lady beetle populations over time.*

Assassin Bugs, Ambush Bugs

Assassin bug. Photo: Lisa Brown, Flickr (CC BY-NC 2.0).

Ambush bug. David Cappaert, Bugwood.org (CC BY-NC 3.0).

Order: Hemiptera | **Family:** Reduviidae

Roles: Predators

How to recognize: Adult assassin bugs are tiny to very large (0.20–1.42 in. [5–36 mm]) in size and may be a drab gray or brown color (some with bright colorations), with an elongated head and a long, slender beak that is used to pierce prey. Ambush bugs (subfamily Phymatinae) are small to medium (0.28–0.39 in. [7–10 mm]) in size. They are sit-and-wait predators, and their colors and shape provide excellent camouflage as they lurk in flowers; they have swollen, spiny "raptorial" front legs for grasping prey (similar to a praying mantid). Nymphs of both assassin and ambush bugs may somewhat resemble adults, but lack wings.

What they eat: Generalist predators of aphids, grasshoppers, caterpillars, beetles, and various other insects, including other beneficial insects such as bees. Assassin bugs are aggressive predators and will often hunt and kill more prey than they need for consumption.

Habitat Needs: Eggs are laid on leaves or branches. Assassin and ambush bugs overwinter as eggs, nymphs, or adults at the base of plants, under leaf layer, or under tree bark. Ambush bugs may drink nectar when prey are scarce. They need permanent habitat for shelter, overwintering, and alternative prey.

Green/Brown Lacewings

Adult. Photo: Whitney Cranshaw, CSU, Bugwood.org.

Eggs. Photo: Whitney Cranshaw, CSU, Bugwood.org.

Order: Neuroptera | **Families:** Chrysopidae, Hemerobiidae

Roles: Predators

How to recognize: Adults are small to large (0.24–0.98 in. [6–25 mm]). Green lacewing adults have a pale green body; eyes that are coppery metallic in color; long, threadlike antennae; and delicate, membranous wings. Adult brown lacewings are very similar to green lacewings, although smaller in size and brownish in color. Lacewing larvae are gray-green or brown with alligator-like bodies and long, sickle-shaped jaws used to capture prey.

What they eat: Aphids, small caterpillars, beetles, thrips, mites, whiteflies, mealybugs, and other small, soft-bodied insects. Adults are either predaceous or feed on nectar, pollen, or aphid honeydew.

Habitat Needs: Lacewing eggs are laid on foliage near prey (e.g., near aphid colonies). Lacewings overwinter as prepupae within cocoons attached to leaves, or as adults in sheltered areas such as the leaf layer. In the absence of pollen and nectar provided by flowering plants, adult lacewings may not lay eggs and may disperse elsewhere in search of food. Nearby trees may offer additional habitat.

Minute Pirate Bugs

Photo: USDA-ARS, Jack Dykinga.

Order: Hemiptera | **Family:** Anthocoridae

Roles: Predators

How to recognize: Adult minute pirate bugs are tiny (0.08–0.12 in. [2–3 mm]) long, with a flattened, oval-shaped body, a triangular black head, and triangular patterns on the wings. Nymphs are brown or orange in color, have a teardrop-shaped body, and are wingless.

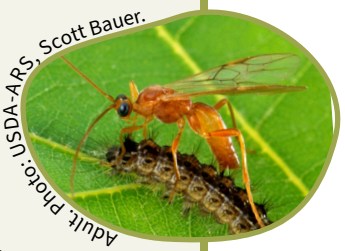
What they eat: Both nymphs and adults consume thrips, mites, scales, aphids, plant lice, small caterpillars, and various insect eggs.

Habitat Needs: Eggs are inserted into plant tissue or under bark. Adults overwinter in the leaf layer or under bark. Minute pirate bugs will also consume pollen, nectar, or plant sap as alternative food sources, and need herbaceous vegetation, as well as a leaf layer or wooded areas near cropped areas, to thrive. Occasionally in autumn, minute pirate bugs can be a nuisance to people; while searching for prey at a time when their prey numbers are decreasing, their pokes can cause a minor irritation.

Insects Found Inside Hosts, Often on Plants

Parasitoid Wasps

Eggs. Photo: Zach D'Amico.



Adult. Photo: USDA-ARS, Scott Bauer.

Order: Hymenoptera

Families: Ichneumonidae, Braconidae, Proctotrupidae, Aphelinidae, Trichogrammatidae, and otherse

Roles: Parasitoids

How to recognize: Adults range in size from extremely tiny to large (0.02–0.79 in. [0.05–20 mm]), with slender, narrow waists. Larger parasitoid wasps in the families Ichneumonidae and Braconidae have dark coloration with red, orange, or yellow markings, and long, threadlike antennae. Tiny parasitoid wasps in families such as Aphelinidae, Trichogrammatidae, Encyrtidae, and Chalcididae are usually dark brown or black, but are sometimes metallic green in color. Female wasps have an ovipositor, a stinger-like appendage used to deposit eggs into hosts. Due to the very small size of some parasitoids, it is often easier to see the evidence of their presence (e.g., aphid mummies, the dry shell left behind after a parasitoid wasp emerges from an aphid host, or a caterpillar with wasp pupae on its back) than to see the wasp itself.

Hosts: Parasitoid wasps lay their eggs on or in the bodies of other insects at various life stages. Many parasitoid wasps are host-specific and are highly effective in regulating the populations of specific pests. Hosts include caterpillars and the eggs, nymphs, larvae, or adults of aphids, whiteflies, scales, flies, beetles, leafhoppers, stink bugs, as well as nearly every genus of other insects.

Habitat Needs: The life cycles of parasitoid wasps are closely synchronized to those of their hosts. An adult female wasp finds a host at the appropriate life stage and deposits one or several eggs on, inside, or near the host. The larvae develop on or inside the host, feeding on it, but usually not killing the host until the wasp larvae reach maturity and pupate. Adult wasps emerge and seek new hosts to repeat the cycle. These wasps overwinter as an egg or larva within or on their host, as a pupa within their cocoon, or as adults. Adults feed on nectar, aphid honeydew, and occasionally pollen. Permanent plantings with a succession of flowering plants that bloom throughout the season, especially species with shallow flowers or nectaries or extra-floral nectaries, will support adult parasitic wasps and increase their longevity and reproduction.

Insects and Other Arthropods Found in the Leaf Layer or Within Soil

Fireflies, Lightning Bugs

Adult. Photo: Xerces Society / Katie Lamke.

Larva. Photo: Katja Schulz, Flickr (CC BY 2.0).

Order: Coleoptera | **Family:** Lampyridae

Roles: Predators, Herbivores, Pollinators

How to recognize: Adult fireflies are tiny to large (0.20–0.79 in. [5–20 mm]) in length, with soft, leathery wing covers. They typically are black with red or pale brown markings, with light-producing segments near the end of their abdomen. Female fireflies have shorter wings and fewer luminous segments than males, and many species are wingless. The predatory larvae have strong, sickle-like jaws and are referred to by some as "glowworms" because they are also luminescent.

What they eat: Larvae seek snails, slugs, caterpillars, and other soft-bodied invertebrates in moist soil. Depending on species, adults may not feed, may feed on nectar or plant tissues, or may be predators of other fireflies.

Habitat needs: Eggs may be laid just under soil or among grass roots; larvae overwinter under bark or in the soil. Firefly larvae need undisturbed soil and other habitat to hunt prey. Night-active firefly species have specific flashing patterns used to attract mates, while daytime-active fireflies rely on pheromones to attract mates. Areas of permanent vegetation, such as meadows, wetlands, or forested edges, can support adults with places to perch or take shelter and can provide larvae with undisturbed soil and other places to hunt.

Fireflies are known for their glowing flight patterns at night. (Photo: Mike Lewinski, Flickr [CC BY 2.0].)

Ground Beetles

Adult. Photo: Lee Elliott, Flickr (CC BY-NC-SA 2.0).

Larva. Photo: Jacy Lucier.

Order: Coleoptera | **Family:** Carabidae

Roles: Predators, Decomposers, Herbivores

How to recognize: Adult ground beetles range in size from tiny to very large (0.12–1.38 in. [3–35mm]), and have threadlike antennae, prominent eyes, a head narrower than their thorax, an extended-oval abdomen, and ridged wing covers. Their coloration is dark and shiny, usually black or brown, with green, blue, or purple iridescence in some species. Larvae are cream to brown in color, with a round head with large hooked jaws, long legs, and bristly posterior projections.

What they eat: Larvae and adults consume insects, including fly and beetle larvae (e.g., Colorado potato beetle), caterpillars (e.g., tent caterpillars), grasshoppers, and aphids, as well as snails and slugs. Some species will also eat detritus, fungi, and plant seeds, and can be beneficial at reducing weed seeds in the soil seed bank.

Habitat needs: Ground beetle eggs are laid in moist soil, inside crevices, or under debris. Larvae feed under or on the soil surface. Adults feed under debris or logs, or on vegetation. Native bunch grasses provide a favorable microclimate for overwintering larvae or adults.

Hunting Spiders

Photo: Xerces Society / Jennifer Hopwood.

Class: Arachnida | **Order:** Araneae

Families: Gnaphosidae, Lycosidae, Salticidae

Roles: Predators, Soil Engineers

How to recognize: Hunting spiders range in size from tiny to very large (0.12–1.4 in. [3–35mm]). Spiders have eight walking legs and two body regions, known as the cephalothorax (the head and thorax combined) and the abdomen. Silk-spinning organs are found at the rear end of the abdomen. Most spiders have eight eyes, the arrangement of which can help identify spider groups. Spiders use their jaws, called chelicerae, to hold prey and inject venom, or to help burrow into soil.

What they eat: Hunting spiders pursue and capture other arthropods, including many flies, beetles, grasshoppers, crickets, and other insects. Hunting spiders are very agile and often have excellent eyesight. They use venom to stun or kill their prey, with enzymes that help to speed up the digestion of prey body tissues.

Habitat needs: Hunting spiders may lay eggs within silken sacs in the leaf layers or attached to their body. Adults or eggs overwinter in silken nests in soil, grass clumps, and in leaf layers, under bark, or inside hollow stalks of vegetation. Hunting spiders are often found on the soil surface or in the leaf layer, and some may also hunt prey on plants.

Millipedes

Photo: D. Fletcher, Flickr.

Phylum: Arthropoda | **Subphylum:** Myriapoda

Class: Diplopoda

Roles: Decomposers

How to recognize: Millipedes range from tiny to very large (0.08–6.5 in. [2–165 mm]) in length. They have an elongated, segmented body with many legs; each body segment has two pairs of legs. They have one pair of antennae and lack structures to bite people, but they do have mandibles for chewing organic matter. Millipedes are often black, brown, or gray, and sometimes with bright, colorful legs or patterns.

What they eat: Millipedes eat debris, like decaying fallen leaves, algae, and fungi. They are selective feeders, preferring leaf layers with high calcium and avoiding freshly fallen leaves.

Habitat needs: Millipedes primarily occur in moist habitats. They live under bark, logs, stones, and in the leaf layer and upper soil layers. Millipedes are powerful diggers and can excavate deep tunnels, with some species found in deep soil layers. A female millipede covers her eggs in a ball made of soil particles and droppings and places them in a nest, which she guards. When millipedes molt, they create their own nests for shelter during the process.

Collembola

Photo: Katja Schulz, Flickr (CC BY 2.0).

Class: Collembola | **Orders:** Entomobryomorpha, Neelipleona, Poduromorpha, Symphypleona | **Families:** Entomobryidae, Hypogastruridae, Onychiuridae, Sminthurididae

Roles: Decomposers

How to recognize: Springtails are very tiny in size (0.01–0.2 in. [0.25–5mm]), range in body shape from elongate to globular and compact, and in color from white to purple to brown or gray. Many have a structure that looks like a tail and extends from the back of the body, called a furcula, used as a spring to propel them. Simple eyes are present in many species, but species that dwell deep in the soil are blind and have a reduced or absent furcula.

What they eat: Springtails consume decaying plants, fungi, bacteria, and pollen. Some are predators of rotifers, nematodes, and other springtails. A few species may consume plant roots, occasionally becoming economically damaging.

Habitat needs: Springtails occur in all terrestrial habitats. Springtails in the orders Entomobryomorpha and Symphypleona live in soil surface layer and vegetation, decaying logs, and fungi, as well as under bark. Those in the orders Podurmorpha and Neelipleona dwell within the soil.

Centipedes

Photo: Xerces Society / Jennifer Hopwood.

Phylum: Arthropoda | **Subphylum:** Myriapoda

Class: Chilopoda

Roles: Predators

How to recognize: Centipedes range from tiny to very large (0.12–8.78 in. [3–200 mm]) in length. Centipede bodies are elongated, flattened, and segmented, with one pair of legs per body segment. They have long antennae, and their first pair of walking legs are modified to inject prey with venom. The young of some species start with a few body segments and pairs of legs and add the rest as they grow and molt, while the young of others start with the number of legs and segments they'll have as adults and grow in size through molting.

What they eat: Centipedes eat earthworms and a variety of arthropods, large and small. Larger centipede species may also prey on small mammals and reptiles. Centipedes immobilize their prey by injecting it with venom and covering it with their digestive fluids before consumption. Some species occasionally feed on plant debris.

Habitat needs: Some species are adapted to live in shallow or deep soil layers, while others live under bark, logs, and stones, or within the leaf layer. Females of some species lay single eggs in the soil, while other species provide parental care for a nest of eggs in soil or rotten wood. Most species are nocturnal and more often seen at night.

Mites

Photo: Xerces Society / Even Dankowicz.

Class: Arachnida | **Subclass:** Acari

Orders: Mesostigmata, Oribatida

Roles: Decomposers (Orbatids) or Predators (Mesostigmata)

How to recognize: Mites are very tiny (0.0024–0.2 in. [61µm–5mm]) and have rounded or pear-shaped bodies with a cuticle that ranges from soft to very hard, but that is typically dark in coloration. Adult mites have eight legs, and larvae have six. Some species have simple eyes, while others are blind and rely on hairlike setae for sensing.

What they eat: Oribatid mites consume bacteria, fungi, algae, and dead plants and animals, while predatory mites of the order Mesotigmata eat soil animals such as insect eggs and larvae, other mites, springtails, and nematodes.

Habitat needs: Soil mites are found on the soil surface, within soil layers, and even in deep soil horizons. Mite fauna vary with soil type, and specialist soil types have unique mite communities. Some of these mites hitch a ride on insects, clinging to their bodies or legs to move to new sites. For example, some mites hold on to dung beetles to move to new dung pats.

4

What are Habitat Options to Support Beneficial Insects and Arthropods?

Each of these groups of beneficial animals relies on habitat for food sources and places to shelter, reproduce, or overwinter. Many groups need plant diversity that supports alternative prey or hosts, or a succession of blooms that provide floral resources. Plant diversity is important for flower visitors because some groups have longer tongues (e.g., bees) and can access resources from tubular or complex flowers, while others have short mouthparts and need shallow flowers. Permanent habitat near crops or orchards can be important for those groups that live within the soil or leaf layer, allowing them to move from habitat into cropped areas since they cannot survive entirely in cropped fields.

There are multiple habitat options available to small-scale growers to give beneficial insects and other invertebrates a space to complete their entire life cycle. The United States Department of Agriculture (USDA) also offers opportunities for growers to receive technical and financial assistance to install habitat.

Annual Insectary Plantings

Annual flower plantings may be integrated into the cropping system or grown adjacent to crops. Annual plantings are temporary and may be moved around the farm from season to season. These plantings are great alternatives for farms unable to commit to long-term perennial native plantings. Flowers are quick to bloom and typically less expensive. Site preparation is also minimal. Examples of recommended annual flowers and herbs are marigolds, zinnias, sunflowers, borage, and basil.

Perennial flowers can also be used in annual insectary plantings. Here, a temporary mass planting of white Dutch clover offers a variety of benefits to this farm, including forage for pollinators and beneficial insects. (Photo: Karin Jokela.)

Photo: Sarah Nizzi.

Flowering Cover Crops

Introducing cover crops into the cropping system has multiple benefits. Utilizing flowering cover crops and allowing them to bloom will provide forage to beneficial insects. Cover crops are typically less expensive, and minimal site preparation is needed. Cool-season flowering cover crops examples are crimson clover, hairy vetch, and oilseed radish. Warm-season flowering cover crops examples are buckwheat, annual sunflower, cowpea, and phacelia.

Perennial Insectary Plantings

These plantings are comprised of native bunchgrasses, sedges, and wildflowers. Native insectary plantings are typically designed with a high proportion of wildflowers to grasses and sedges (e.g., 50–70% of the plant cover). Native wildflowers may be a combination of perennial, biennial, and annuals. The main goal is to create permanent habitat to provide food in the form of pollen and/or nectar and alternative prey to beneficial insects.

Photo: Karin Jokela.

Photo: Sarah Nizzi.

Beetle Banks

A beetle bank is a perennial native planting composed mostly of native bunchgrasses (e.g., 70–100%). Native bunchgrasses provide necessary structure for nesting and undisturbed overwintering habitat for ground beetles and other ground-dwelling arthropod predators like hunting spiders. Native wildflowers can be incorporated into planting mixes (e.g., 25–30%) as an alternative food source for beneficial insects when pests are absent and sources for pollen and/or nectar that benefit pollinators.

Hedgerows

Planting a linear row or multiple rows of flowering shrubs and short trees can provide important floral resources early in the season for pollinators and undisturbed areas for overwintering and nesting habitat. Many shrubs and trees are also caterpillar host plants to butterflies and moths. Hedgerows can be ideal when space is limited and bring valuable habitat to any landscape.

Photo: Xerces Society / Sarah Foltz Jordan.

5

How do Agricultural Practices Influence Beneficial Insects and Arthropods?

Tillage

Tillage is a tool often used to suppress weeds and to achieve consistent planting conditions. Unfortunately, much more is affected through the process of tillage. The physical disturbance of tillage breaks up soil structure and destroys aggregates and soil pores (inversion tillage is the most destructive), and can sometimes bring weed seeds to the surface. Soil structure is critical to water infiltration, root growth, and nutrient and gas exchange. Tillage can also reduce populations of soil invertebrates such as ground beetles, spiders, and earthworms, and can damage the nests of bees that nest underground. Limit tillage when possible, or reduce the impact of tillage by rotating areas that are tilled over time.

Pesticide Protection

Insecticides are a type of pesticide used to control insect pests. Unfortunately, these insecticides can also cause lethal and sublethal effects to beneficial insects. Many beneficial insect groups reproduce much more slowly than pest insects and have only one generation a growing season, so their populations require more time to recover from exposure to insecticides. Many types of insecticides will reduce pollinator and beneficial insect populations indirectly by reducing reproduction or decreasing their ability to find food. When predator and parasitoid populations decrease, their ability to provide pest control decreases as well, leading to secondary pest outbreaks (and a further reliance on insecticides).

Although fungicides and herbicides are not intended to directly impact insects, these chemicals may still be detrimental. Fungicides are used to treat plant pathogens; some can cause sublethal effects in beneficial insects, such as changes in behavior, immune health, or reproduction. Some fungicides are mixed with insecticides before application, amplifying the effects of those insecticides. Herbicides are used to treat unwanted plants, which may remove forage resources for beneficial insects or weaken or kill nontarget plants providing habitat. Some herbicides can harm adult and juvenile beneficial insects directly, disrupting their ability to find food.

Risks to beneficial insects can be reduced by developing and implementing Integrated Pest Management (IPM), a science-based framework that utilizes multiple strategies to prevent pests or to control pests when there is a demonstrated need, taking precautions to reduce hazards to people and the environment. IPM relies on pest outbreak prevention by reducing conditions that favor pests, scouting and monitoring pest populations to establish economic or damage thresholds to determine if pesticide interventions are necessary, and implementing the most targeted, least hazardous pest control methods. Increasingly, the IPM framework is also considering the effects of pest control measures on pollinators as well as on the

pests and incorporating pollinator protection strategies; this approach is referred to as Integrated Pest and Pollinator Management (IPPM).

An IPPM plan should include pest prevention techniques (e.g., floating row covers to exclude pests or planting resistant varieties), pest scouting and monitoring activities, and decision-making economic or damage thresholds used to guide pesticide applications. If pesticides should be used, seek the least-toxic, safest method available to control that particular pest, avoiding more hazardous formulations such as emulsifiable concentrate formulations of an active ingredient, and time applications to minimize impacts to nontarget insects (e.g., avoiding applications to blooming plants). Avoid pesticide exposure to habitat and nontarget areas, and reduce the risk of pesticide applications to cropped areas (aerial applications, within-row applications, and treated crop seed), with consideration for pest management needs of future crop rotations. Though implementation of IPPM can require planning, monitoring, and incorporating pest management with farm ecology, the benefits include reductions in pesticide use that reduce costs for growers, are safer for people and the environment, increase survival for pollinators and beneficial insects, and slow the development of pest resistance to pesticides.

Location

Additional considerations should be made when planting habitat on vacant or revitalized city lots. Have an understanding of the type of structures or businesses that previously occupied the site (i.e., residential or brownfield site), determine if obstructions have been buried (e.g., buried foundations or other debris from demolition), what soils were used to fill in the demolished area (sand and gravel are commonly used and will make planting difficult), and conduct soil tests to measure whether heavy metal contaminants are present. Heavy metal contamination is a risk for wildlife, as well as people.

Habitat on small-scale farms or within community gardens provides benefits to the community, wildlife, and the environment. (Photo: Xerces Society / Sarah Nizzi.)

6

How do I Access Technical and Financial Assistance Through the USDA?

Registering for a farm number with the Farm Service Agency (FSA) allows a farmer to apply for USDA programs such as FSA farm loans and disaster assistance. It also opens the door for eligible farmers to participate in Natural Resources Conservation Service (NRCS) programs, like the Environmental Quality Incentives Program (EQIP).

How to acquire a farm and tract number through the USDA:

1. Contact your local USDA Service Center to set up an appointment (find locations at offices.sc.egov.usda.gov/locator/app).

2. The following documents are needed for your visit:

    - Proof of identity
    - Proof of ownership or control of the land (copy of recorded deed)
    - Leases
    - Entity Identification Status (articles of incorporation, trust and estate documents, partnership agreements)

7

Further Reading

- Get Started at Your USDA Service Center (farmers.gov/working-with-us/USDA-service-centers)
- Get Started with Natural Resources Conservation Service (NRCS) (nrcs.usda.gov/getting-assistance/get-started-with-nrcs)
- *Farming For Bees: Guidelines for Providing Native Bee Habitat on Farms* (Xerces Society) (xerces.org/publications/guidelines/farming-for-bees)
- *Habitat Planning for Beneficial Insects: Guidelines for Conservation Biological Control* (Xerces Society) (xerces.org/publications/guidelines/habitat-planning-for-beneficial-insects)
- *Beetle Banks for Beneficial Insects: Conservation Biocontrol on Farms in the Upper Midwest* (Xerces Society) (xerces.org/publications/fact-sheets/beetle-banks-for-beneficial-insects)
- *Creating Perennial Pollinator and Beneficial Insect Habitat Using Plugs* (Xerces Society) (xerces.org/publications/fact-sheets/creating-perennial-pollinator-and-beneficial-insect-habitat-using-plugs)
- *Farming With Soil Life: A Handbook for Supporting Soil Invertebrates and Soil Health on Farms* (Xerces Society) (xerces.org/publications/guidelines/farming-with-soil-life)
- *Nesting and Overwintering Habitat for Pollinators and Beneficial Insects* (Xerces Society) (xerces.org/publications/fact-sheets/nesting-overwintering-habitat)
- *Guidance to Protect Habitat from Pesticide Contamination: Creating and Maintaining Healthy Pollinator Habitat* (Xerces Society) (xerces.org/sites/default/files/2019-10/16-024_01_XercesSoc_Guidance-to-Protect-Habitat-from-Pesticides_web.pdf)
- *Organic Pesticides: Minimizing Risks to Pollinators and Beneficial Insects* (Xerces Society) (xerces.org/publications/guidelines/organic-pesticides)
- *Organic Site Preparation for Wildflower Establishment* (Xerces Society) (xerces.org/publications/guidelines/organic-site-preparation-for-wildflower-establishment)
- Pollinator Conservation Resource Center (Xerces Society) (xerces.org/pollinator-resource-center)
- What to Know Before You Grow (EPA) (epa.gov/brownfields/urban-agriculture)

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Decision-making on farms can be a balancing act, often with limited time, labor, and resources. Installing native plants to support beneficial insects can provide stability for a small-scale farm or community garden. Many of the foods, vitamins, and minerals we consume on a regular basis are enhanced thanks to the free services of beneficial insects. They also contribute conservation biocontrol worth billions of dollars a year to farms. In addition, habitat for these wild animals boosts farm aesthetics and nutrient recycling, reduces farming costs, and acts as an alternative to insecticide use.

Photo: John Flannery, Flickr (CC BY 2.0).

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