



**Review**

# Biological Control to Maintain Natural Densities of Insects and Mites by Field Releases of Lady Beetles (Coleoptera: Coccinellidae)

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In the present study, the biological control of insects and mites to maintain their natural densities by field releases of lady beetles (Coleoptera: Coccinellidae) is analyzed. Female lady beetles may lay from 20 to more than 1000 eggs over a one to three month period, near prey such as aphids in protected sites on leaves and stems. Lady beetles have hefty appetites and one tiny alligator like larva can eat over two dozen aphids a day, and single adult can eat over twice of that much. In other words, one larva will eat about 400 medium-size aphids during its development to pupal stage and an adult lady beetle may eat over 5,000 aphids during its lifetime (about a year). Usually, reddish-orange lady beetles eat aphids, and darker ones more often eat spider mites, whiteflies and scale insects. The best time to release lady beetles into garden is late in afternoon or at sundown, which can encourage them to stay for night and find suitable food and protection. Dampen the ground or plants before releasing of lady beetles, can encourage them to stay and drink water. About 1000 lady beetles can rid an acre of ground from most of soft-bodied pests and release beetles at base of plants at 20 feet apart or more so that they can hunt for food. Ability of collected lady beetles to reproduce is suspended (reproductive diapause), so eggs are not produced for several weeks after release. Pre-fed lady beetles prior to release can allow some eggs maturation, but few researchers or companies also provide such pre-conditioned lady beetles. The trends of prey devouring demonstrate profound effects that lady beetle may have on target and non-target pests, and highlight their importance for initiating of biological control programs.

**Keywords:** Biological control agents, Biological invasion, Coccinellidae, Exotic species, Natural enemies, Predators

## INTRODUCTION

Biological control is use of predators, parasitoids and pathogens to control insect and mite pests. In the rural and urban environments there is a multitude of beneficial insects, mites and pathogens that prey on pests, and when these are not disrupted, they can do a good work of keeping pests under control. Biocontrol can help to reduce or eliminate insecticide use and although they can be more expensive than chemicals and do not work as fast, these are a lot of more fun to use. Biocontrol has been growing in popularity over the past few years because its prices come down and growers learn how to

use them effectively. Ladybugs are not bugs but are beetles, in the order Coleoptera having two pairs of sheath wings' and with a membranous second pair sheltered by a solid first pair. Beetle's two forewings have adapted into a hard cover, split down the middle and are collectively called the 'elytra', which allow them to tunnel under bark, soil, etc., without damaging their flying wings. They hold their elytra out to each side like fixed wings, while they fly with their membranous wings. But, the elytra make flying awkward and noisy and their landing is a bit rough. Adult ladybugs eat aphids, while larval

ladybugs also eat aphids, thus, it is uncommon in the world of complete metamorphosis (egg to larva to pupa to adult) for the larvae and adults to eat the same food in agricultural crops (Brown and Miller, 1998; Almedi et al., 2008; Sarwar, 2016).

Ladybirds are generally considered useful insects and one of the greatest allies of the farmers and the gardeners as many species feed on aphids or scale insects, which are pests in gardens, agricultural fields, orchards and similar other places. They are nature's own pest controllers and more effective than poisonous chemicals. Their bright color and pattern not only make them attractive visitors to the garden, but also help to protect them by warning potential predators of their distastefulness. They exude an unpleasant yellow substance (reflex blood) from their leg joints when attacked which is rich in toxic alkaloids. Their coloring is likely a reminder to any animals that have tried to eat their kind before. A threatened ladybird may play both dead and secrete the unappetizing substance to protect itself. Manipulative biological control aims to make use of the lady beetles already present in the environment by making conditions as favorable as possible for them and by avoiding spraying of chemicals that will interfere with their predation. An augmentative biological control recognizes that lady beetles may be present, but can be insufficient in numbers to control the pest species and seeks to make up this deficit. Classical biological control seeks to introduce a species that is not already present in the environment with the hope that it will become established and eventually control the pest. Therefore, culturing and supplies of the spotted lady beetle are available commercially for the manipulative, augmentative and classical biological control purposes (Sarwar, 2009; Sarwar and Saqib, 2010).

Ladybirds lay hundreds of eggs in the colonies of aphids and other plant-eating pests. When they hatch, the ladybird larvae immediately begin to feed. By the end of its three to six week life, the alligator-like larvae [aphid wolf] may eat some 5,000 aphids. Lady beetles are usually red or orange with black markings and some lady beetles are black, often with red markings. They are commonly yellow, orange, or scarlet with small black spots on their wing covers, with black legs, head and antennae. However, a very large number are mostly, or entirely, black, grey or brown. Conversely, there are many small beetles that are easily mistaken for ladybirds, such as the tortoise beetles, and all ladybirds have not spots, but some are striped. Ladybugs in temperate areas usually hibernate through the winter as adults often in large groups. Millions of them may come together in few parts, where they cover the ground like a brilliant blanket. There are different species of ladybird resident in some regions and have been introduced to other areas of the world for the purpose of pest control. Therefore, a

better understanding of natural enemy's fate following introduction and its impacts on the new environment is essential for advancing theory and practice of biological control (Wright and De Vries, 2000; Al-Zyoud, et al., 2005).

The lady beetles can be seen wherever the insects on which they prey are found in many numbers and many crops get benefit from lady beetles. They are helpful for growers of vegetables, grain crops, legumes, strawberries and tree crops; however, any crop that is attacked by aphids may benefit from these beetles. Crops which support aphid populations include wheat, sorghum, sweet corn, alfalfa, soybeans, peas, beans, cotton, potatoes, brassicaceous crops, tomatoes, asparagus and apples. Besides aphids, they include in their diet adelgids, mites, insect eggs and small larvae. They also eat pollen which may constitute up to 50% of their food intake, nectar, water and honeydew. When normal prey is scarce, both adults and larvae sometimes exhibit cannibalistic tendencies, eating eggs, larvae and pupae of their own species. It has been found experimentally that inter-planting a crop susceptible to aphid attack with a flowering plant such as the dandelion *Taraxacum officinale* Weber, encouraged predation on aphids because the spotted lady beetles are attracted to their pollen-rich flowers. The spotted lady beetles commonly oviposit on the native weed *Acalypha ostrya efolia* Riddell, when it grows near sweet corn crop. A research study showed that the insect favored the weed over the corn even though it housed no prey insects. The first instar larvae may fall from the weed plants and crawl across the soil for a distance of up to eight meters a day before ascending a sweet corn plant or another weed plant. The presence of this weed, in close proximity to the crop, resulted in more beetle larvae on the crop than is the case when the weed is absent. Lady beetles can be found in many habitats, including back yard landscapes, vegetable gardens and commercial farms, fruit orchards and vineyards, and natural areas anywhere their food sources are abundant. The adult life stage of these beneficial insects can also feed on pollen, nectar and honeydew from garden plants. The twice-stabbed lady beetle (*Chilocorus stigma* Say) is a predator of aphids and scale insects in woodlands and orchards (Almedi et al., 2007; Bahlai et al., 2008).

### **Pests Attacked by Lady Beetles**

Most lady beetles found on crops and in gardens are aphid predators and some species prefer only certain aphid species, while others can attack many aphid species on a variety of crops. However, some prefer to mite or scale species for predation. If aphids are scarce, lady beetle adults and larvae may feed on the eggs of moths, beetles, mites, thrips and other small insects, as

well as pollen and nectar, or they may also be cannibalistic. Because of their ability to survive on other prey when aphids are in short supply, lady beetles are particularly valuable natural enemies. Research showed that spotted lady beetle larvae are an important cause of natural mortality for *Helicoverpa zea* (Boddie) eggs on sweet corn. A study identified the spotted lady beetle as a significant predator of the eggs of the European corn borer *Pyrausta nubilalis* (Hubner), with consumption averaging sixty eggs per day. Another study has shown that the spotted lady beetle reduced populations of eggs and small larvae of the Colorado potato beetle *Leptinotarsa decemlineata* (Say), on potatoes and that the rate of consumption is highly correlated with the air temperature (De Bach and Rosen, 1991; Evans, 1991).

### Relative Effectiveness of Lady Beetles

Lady beetles are voracious feeders and may be numerous where preys are plentiful and broad spectrum insecticide use is limited. Lady beetles are effective predators if aphids are abundant (high pest density), but are thought to be less effective at low pest densities. There may also be some crop damage before lady beetles have an impact on an aphid population. Lady beetles need to eat many aphids per day so that they can lay eggs. The convergent lady beetle may eat equal to its weight on aphids every day whereas a larva can consume as many as 50 aphids per day like an adult. Seven spotted lady beetle adults may consume several hundred aphids per day and each larva eats 200 to 300 aphids as it grows. Once the adults and larvae have eliminated an aphid colony, they will search for an additional food (Hironori and Katsuhiko, 1997).

### Reduction in Aphid Populations

For determining if releases of *Hippodamia convergens* Guerin-Meneville would control aphids, researchers compared aphid populations on release and no release plants. Lady beetles are released once and sampled on groups of aphid-infested potted chrysanthemums or roses. For controls, no releases are made on one to four groups each of five to eight pots of aphid-infested plants. For chrysanthemums, numbers of aphids are assessed by counting the total number on one middle leaf on each of the four plants in each pot before beetle release, and again 3 days after release. For roses, numbers of aphids are assessed by counting numbers on unopened flower buds (with an average of 3.5 buds per plant) before beetle release and again 3 days after release. Both of these sample units are based on previous research on these pests. The three chrysanthemums and one rose, significantly reduced aphid numbers compared to controls. A portion of the released lady beetles remained on infested plants, apparently feeding on aphids, until the final sample taken 3 days after release. Released adults

*H. convergens* typically dispersed within 24 hours, thus their effects on aphid densities tend to be minimal, unless adult movement is restricted within a glasshouse or conservatory (Grenier et al., 1994; Flint and Dreistadt, 2005).

Releases of aggregation collected *H. convergens* significantly reduced populations of melon aphids on potted chrysanthemums and of rose aphids on potted roses. The results apply only to small potted plants and there is not awareness of any studies showing that lady beetle releases are effective on a large scale. Most beetles left the plants within 1 or 2 days after release. Allowing beetles to fly and feed before releasing them, or releasing laboratory-reared beetles instead of aggregation-collected beetles from cold storage, may reduce dispersal, but this is uncertain and requires more research, and the economic return of such treatments needs to be examined carefully. If lady beetle releases are made in conjunction with insecticide sprays for other pests, substantial care should be taken in the choice of material to avoid killing of released beetles. Unfortunately, lady beetles have the tendency to disperse once they are released, even if food is abundant. Although they are extremely important natural enemies of aphids, their propensity to disperse makes it difficult for them to be used in inoculative or inundative biological control programs (Sloggett and Majerus, 2000; Majerus et al., 2007; Biddinger et al., 2009; Obrycki et al., 2009).

### Coverage and Release

Biological control agents are important parts of integrated pest management (IPM) in the greenhouse. For them to be effective, growers have to monitor their crops frequently for the first sign of insect pests. Once found, a pest must be quickly and accurately identified so that an appropriate biocontrol species can be purchased while the pest population is still low. If the pest population becomes high, then biocontrol rarely provides satisfactory control because they cannot reproduce as fast as the more numerous pests unless one is willing to pour a lot of money into the task. Before and after introducing a biocontrol, pesticides must be avoided or carefully selected so that good bugs are not killed along with pests (Flint et al., 1995; Obrycki et al., 1998). Many ladybugs in the greenhouse, for instance, the convergent lady beetle *H. convergens*, feeds on aphids and spider mites. However, ladybugs do not always provide successful and long-term control, but they are useful to knock down an infestation. These predators are collected in the wild and their availability is good, except during the early summer months when their supplies may be sold out. Ladybugs can be stored in the refrigerator for several weeks and released one handful at a time. They are usually thirsty when released, so plants should be misted prior to release. Accordingly, releasing them in the evening is

also important (Cottrell and Yeorgan, 1999; Cabral et al., 2006).

Lady beetles can remain in a garden if there is enough food to sustain them. A mild winter followed by a long growing season results in masses of ladybugs. If there is not enough food such as aphids or other soft-bodied pests, they may fly away or aggregate. Overwintering inside is important for insects that may live three years and seem poised to take over the world. Hibernating lady beetles released into a garden will not feed until they have burned off the fat they stored before hibernating. If growers purchase lady beetles that have been refrigerated and are hibernating, release a few dozen at a time allowing them to find food. If growers release several hundred beetles at once, they are likely to simply fly away. For helping to work them, the lady bugs need special care to control aphids in the garden or field.

Released adults typically disperse within 24 hours, thus their effects on aphid densities tend to be minimal, unless adults movement is restricted within a glasshouse or conservatory (Kajita et al., 2000). The best time to release lady beetles into the garden is late in the afternoon or at sundown; this will encourage them to stay for the night and find suitable food and protection. Dampen of the ground or plants before releasing of lady beetles, will encourage them to stay and drink water. Release lady beetles at the base of plants; as their instinct is to climb the nearest plant and hunt for food. Release groups of lady beetles at 20 feet apart or more so that they can hunt for food. About 1,000 lady beetles can rid an acre of ground of most soft-bodied pests (Evans and Richards, 1997).

### **Handling of Lady Beetles Properly**

Lady beetles deteriorate rapidly if these are not handled properly; these beetles need to be kept refrigerated until they are released. Live lady beetles on display in stores are attractive for customers, but beetles left out at room temperature rapidly deteriorate. Also, lady beetles are often dehydrated and need water, especially if they have been held at room temperature, even for a few hours. Stores or gardeners are advised to mist lady beetles with water in a squirt bottle before placing them in the refrigerator for storage, making sure not to let water puddle in containers. When purchasing lady beetles, inspect the container and make sure that almost all beetles are alive. Lady beetles purchased from primary suppliers (those who obtain beetles directly from collectors) may be healthier than those held in stores for several weeks (Hopper, 1998).

### **Need of a Good Supply of Aphids**

Ladybugs like to have large pest populations to eat, which helps to stimulate them forming and laying eggs. There is no point in releasing them on plants with few

aphids. Lady beetles are voracious aphid feeders and an adult beetle can eat 50 or more aphids a day. The convergent lady beetle, which is the species sold for release, feeds almost entirely on aphids and may not remain on plants with low aphid populations and will not control other garden pests (Evans et al., 1999).

### **Use of Adequate Release Rates and Release Time**

The research shows that high numbers of lady beetles are required to control aphids. One large, heavily infested rose bush in the landscape requires two applications of about 1,500 lady beetles each, spaced a week apart. Most packages sold in stores contain only enough lady beetles to treat one aphid-infested shrub or a few small plants. Larger quantities can be purchased from online lady beetle suppliers or these can be cultured personally. Lady beetles will fly away almost immediately if released during the heat of the day or where the sun is shining, so wait until evening to release them. Spray a fine mist of water on the plants before the release as giving to beetles a drink may keep them around longer. Place beetles at the base of plants or in the crotches of low branches. Lady beetles will crawl higher into the plant in search of aphids. Once lady beetles begin to fly, they are likely to fly a substantial distance, often outside the boundaries of a garden. Do not release lady beetles on plants that have been sprayed with insecticides. Residues from most of insecticides are likely to kill the beetles, however, insecticidal soaps and oils, once dry, would not leave toxic residues (Crowder, 2007).

### **Expect Lady Beetles to Fly Away in a Few Days**

Even when released with care, lady beetles will fly away within a few days. About 95 percent of released beetles in research studies flew away within 48 hours. The remainder are gone within 4 or 5 days and lady beetles are unlikely to lay eggs on the plants they are released on. If aphids return a week or two later, gardeners will need to release more lady beetles, hose aphids off with water, use insecticidal soap sprays or wait for other native aphid natural enemies to fly inside. When food is harder to find, adult ladybugs may fly off, but their eggs then hatch and provide further control. If desired, growers can keep ladybug adults to avoid from flying by gluing their wings to shut temporarily with a sugar-water solution. Half water and half sugared pop (Coke, Pepsi, etc.), in a spray bottle, can work fine. Spray it right in the bag the ladybugs come in, as soon as growers open it. Growers can easily coat most of them and after a week or so the glue wears off (Weber and Lundgren, 2009).

### **Keep Ladybugs Refrigerated (35-40°F) Until Use**

After receiving of package of live ladybugs leave the bag sealed and place them in a refrigerator, or other cool place. This can calm to ladybugs down from their shipping experience. When not being used, ladybugs

may be stored in the refrigerator, where they live on their body fat (keep the temperature between 35-45° F.). They appear almost dead in the refrigerator, but quickly become active when warmed up. Usually they can be stored for 2-3 months, but it depends on the time of year, and some losses can be expected for the longer they are stored. During early spring (March and April), they should be used somewhat sooner, as these are older ladybugs from the previous year. During May, ladybugs should be released immediately. The new ladybug crop comes in about June 1, and these young ladybugs actually seem to benefit from refrigeration 1-2 months as it simulates winter for them. For prolonged storage, the bags of ladybugs can be misted or sprinkled with water, perhaps every 2-3 weeks. Allow ladybugs to dry at room temperature until moisture is mostly evaporated, then replace ladybugs in refrigerator (Cottrell and Yeargan, 1998).

### **Decision to Try Lady Beetle Releases**

Early evening is the best time to release ladybugs and it gives them all night to settle in, find food and water, and realize they have found a good home (garden). Ladybugs are usually thirsty from their long journey and storage, and appreciate moist places to drink. If necessary, sprinkle some water around first before their release. Later on, they may get most of their moisture needs from eating aphids and other juicy plant pests. Suggested release rates for ladybugs vary widely and it has been seen recommendations varying from 1 gallon (72,000) for 10 acres, up to 3 gallons per acre. Growers cannot use too many ladybugs, but remember that they do need time to work and these need to be released early enough in the pest cycle so they can do their job, and regular, repeated releases of small amounts are often effective than one, very large release of ladybugs. For home use, 1500 ladybugs are usually enough for one application in a small greenhouse or garden. For larger areas, a quart (18,000) or gallon (72,000) of ladybugs may be desired. Many peoples can store ladybugs in the refrigerator and make regular repeat releases, perhaps weekly (Flint et al., 1995; Cranshaw, 2004).

### **Impact of Insecticide Residues**

If lady beetle releases are to be used in an integrated pest management program that includes insecticide applications for other pests, it is critical to know the impact of insecticide materials on lady beetles. In a research, it has been evaluated the effects of leaf residues of five common insecticides used on ornamental plants and found that residues of malathion and carbaryl on normally weathered foliage outdoors can kill newly exposed lady beetle adults for up to 2 weeks after application. In contrast, dried residues of insecticidal soap or oil have no effect 1hour after treatment.

Pyrenone residues have little or no effect after 1dayof treatment. These methods represented worst case mortality from these materials for lady beetle releases in all trials because beetles are confined with leaves in containers and exposed through a combination of ingestion, contact and inhalation. However, these results illustrate the need to consider the impact of previous pesticide treatments before releasing of ladybeetles for control (Liu and Stansly, 1996; Sarwar and Salman, 2015; Sarwar, 2015; Sarwar and Sattar, 2016).

### **CONCLUSION**

A wide variety of beneficial organisms are mass reared or offered for sale by several suppliers to assist in the management of insects and mites. Most lady beetles are predators of soft-bodied pests such as aphids and scale insects as well as insect eggs, immature insects and mites. Generally, prey of lady beetles includes mites, springtails, thrips, lace bugs, chinch bugs, leafhoppers, treehoppers, psyllids, whiteflies, aphids, scale insects, mealy bugs, plant-eating ladybugs, beetles, weevils, diamondback moth, leaf rollers, corn borer, sphinx moths, hornworms, cutworms, corn earworm, stalk borer and saw flies. In order for ladybugs to mature and lay eggs, they need nectar and pollen sources. This is normally supplied by a wide range of sources such as flowering plants and legumes (peas, beans, clover and alfalfa). Their eggs look like clusters of little orange footballs, each laid on edge and after hatching the larvae look like tiny black alligators, with orange spots and three pairs of prominent legs. The larvae of many species are gray or black with yellow or orange bands or spots. Larvae grow from less than 1 mm to about 1 cm in length and large larvae may travel up to 12 m in search of prey, they fully grow in 2-3 weeks, and then pupate usually on the top of the leaf, to emerge as another adult ladybug. The tiny alligators like larvae feed abundantly, with a single larva devouring up to several dozen aphids per day. There are several number of lady beetles species which have been used as biological controls for agricultural pests. Proper identification of predators and distinguishing of pests from natural enemies is essential for effective biological control. Carefully, observe the mites and insects on plants to help discern their activities. For example, some peoples may mistake syrphid fly larvae for caterpillars, however, syrphid fly larvae are found feeding on aphids and do not chew on the plant itself. If growers find mites on plants, then observe them with a good hand lens. Several hundred lady beetles are sufficient to rid a modest garden of insect pests and about 1,000 lady beetles can clear an acre of most soft-bodied insect pests. This system is usually disrupted when growers overuse pesticides that kill the beneficial insects rather than the pests. Being able to recognize the beneficial agents that naturally occur in urban landscapes

is necessary for taking advantage of biological control and maintaining their natural order.

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